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Fourth edition

REVIEW OF THE STATE OF THE WORLD FISHERY RESOURCES
INLAND FISHERIES

Cover photograph: Fisher in southern Malawi, ©FAO/Robert Arthur.

Fourth edition

REVIEW OF THE STATE OF THE WORLD FISHERY RESOURCES INLAND FISHERIES

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PREPARATION OF THIS DOCUMENT

The periodic FAO Fisheries and Aquaculture Circular No. 942 (C942) entitled *Review of the state of world fishery resources: inland fisheries* represents an ongoing commitment to improve global understanding of the role and value of inland capture fisheries. This fourth edition of the circular was initiated by the Fisheries and Aquaculture Division (NFI) of the Food and Agriculture Organization of the United Nations (FAO) and was made possible also thanks to the collaboration and technical contribution of the African Development Bank (AfDB). The document builds on previous versions, continuing to provide a summary of FAO inland fishery statistics and analysis of emerging thematic issues relevant to the assessment and management of inland fisheries.

This review, and the assessments it provides, have been developed in the context of commitments to developmental and environmental commitments, including the Sustainable Development Goals (SDGs) and Convention on Biological Diversity (CBD). It also reflects commitments to advancing the Code of Conduct for Responsible Fisheries through the Ecosystem Approach to Fisheries and the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (the SSF Guidelines), the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security (the VGGT) and the Rome Declaration on Responsible Inland Fisheries.

- This edition of the circular aims to improve global understandings of inland capture fisheries by considering the connections associated with inland fisheries looking beyond fish production to the relationship of inland fisheries with food systems and wider basin development contexts and beyond a focus on the ecological dimension of fisheries to be more inclusive of the social and institutional dimensions. These dimensions and connections are an important feature of inland fisheries, and the way that they are affected by dynamic and changing environments and societies, are both a strength of many inland fisheries, contributing to their adaptive capacity, and challenge to describe and quantify. Drawing on the diversity of inland fisheries and the many ways in which people live with, and experience them, C942 Revision 4 seeks to provide an assessment of the status of inland fisheries, the opportunities that they can provide and the challenges that they face. It therefore seeks to:
- describe and quantify global inland fisheries in terms of production, nutrition and economic contribution with particular respect to those countries/regions or subnational areas where they are particularly important;
- review existing approaches to the collection of production data and estimates to provide a methodological analysis of how statistical reporting can be strengthened through the implementation of different approaches;
- examine the role and contributions of inland fisheries from a food system perspective to assess the nature of the relationships between production, consumption and human nutrition to provide evidence of how considering these post-harvest connections can inform assessment and management priorities;
- consider inland fisheries from a basin management perspective, providing insights into the status of fisheries, key threats to fish stocks within basins and identifying important roles for fisheries monitoring as part of a basin approach to assess the status both of fish stocks and the basin; and
- draw on the empirical evidence from examples of enduring fisheries management arrangements, particularly those in fluctuating and changing inland fisheries environments, to identify key aspects of these arrangements that could have relevance for the assessment and management of inland capture fisheries.

The structure of the C942 Rev. 4 builds on the previous revisions of the circular (C942, C942 Rev. 1, C942 Rev. 2 and C942 Rev. 3) with the specific objectives to:

- update and expand the scope of previous reviews of the state of world fishery resources: inland fisheries, including C942 (FAO, 1999)[1], C942 Rev. 1 (FAO, 2003)[2], C942 Rev. 2 (Welcomme, 2011)[3] and C942 Rev. 3 (Funge-Smith, 2018)[4];
- review the status and trends of inland fisheries catch at global, continental and subcontinental levels;
- place inland capture fisheries in the context of overall global fish production, and call attention to the importance of inland capture fisheries with respect to food security and nutrition;
- explore methods that could be used to develop the assessment of inland capture fisheries, including through improved estimates of inland capture fishery production; and

examine alternative methods and models for the assessment and management of inland capture fisheries that could strengthen and accelerate commitments to an ecosystem approach to fisheries management and highlight the potential of these fisheries to in the context of integrated management.

These objectives are guided by the recommendations of the 2016 FAO Committee on Fisheries (COFI) that called for improved assessment of inland fisheries and their contributions to food security. This document focuses on the status of inland capture fisheries (referred to as inland fisheries) and follows the FAO Coordinating Working Party on Fishery Statistics (CWP) conclusion that brackishwater lagoons and low-salinity inland seas may be considered marine or inland waters by different countries. Identification of inland waters is provided by FAO member countries and FAO member countries should identify waterbodies or areas that might present problems of categorization and report these to FAO. This informs the scope within this review, a key consideration being to ensure that fish catches are not double counted.

Maps in this document were generated using the QGIS Geographic Information System (QGIS Geographic Information System. Open-Source Geospatial Foundation. URL http://qgis.osgeo.org) using the UN Country Boundaries of the World shapefiles (http://www.fao.org/figis/geoserver/ows).

1 **FAO.** 1999. *Review of the state of world fishery resources: inland fisheries*. FAO Fisheries Circular, No. 942. Rome, FAO.

2 **FAO**. 2003. *Review of the state of world fishery resources: inland fisheries*. FAO Fisheries Circular, No. 942, Rev. 1. Rome, FAO.

3 **Funge-Smith, S.J.** 2018. *Review of the state of world fishery resources: inland fisheries*. FAO Fisheries Circular, No. 942, Rev. 3. Rome, FAO.

4 **Welcomme, R.L.** 2011. *Review of the state of world fishery resources: Inland Fisheries.* FAO Fisheries and Aquaculture Circular, No. 942, Rev. 2. Rome, FAO.

ABSTRACT

The FAO Fishery and Aquaculture Circular C942 Revision 4 (C942 Rev. 4) builds on previous revisions of the circular and represents an important baseline document for current global understanding of the status of inland capture fisheries. This fourth revision reviews the status and trends of inland capture fisheries at global, continental and subcontinental levels. It places these fisheries in the context of overall global fish production, drawing on available information to highlight contributions in terms of food production, nutrition, employment, economies with respect to those countries, regions and subregions where they are particularly important. The information presented reveals the enduring and adaptive nature of inland capture fisheries and their continued relevance and potential in respect to meeting global development goals.

This revision uses the ecosystem approach to fisheries to highlight connectivity as a strong feature of inland fisheries. While connections are often recognized in relation in those between aquatic environments, other connections are also highlighted that are important in the context of the assessment and management of capture fisheries. These include connections between fishing and other livelihood activities, fish production and consumption, fisheries and other economic activities and between knowledge and practice in the management of fisheries. These connections and relationships are an important factor in how inland fisheries are assessed and managed. Chapters in this revision of the circular explore aspects of these connections from different perspectives to consider the opportunities for complementary methods and interventions that provide opportunities for improving statistical information, food security and nutrition and the assessment and management of inland fisheries, including in the context of integrated water resources management.

CONTENTS

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5 Kolonchin, K., Kulik, N.V., Belyaev, V.A., Bobyljov, A.B., Yanovskaya, N.V., Valbo-Jørgensen, J. & Funge-Smith, S.J., eds. 2024. *The inland fisheries of the Russian Federation: their current status for food provision and employment*. FAO Fisheries and Aquaculture Technical Paper, No. 701. Rome, FAO.

6 FAO. 2023. *Review of the inland fisheries of the People's Republic of China and the strengthening of capacity in the collection and analysis of inland fisheries statistics*. FAO Fisheries and Aquaculture Circular, No. 1264. Rome, FAO.

7 FAO. 2024. *A review of the inland fisheries of India*. FAO Fisheries and Aquaculture Circular, No. 1265. Rome, FAO.

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DEFINITIONS USED IN THIS REVIEW

Access	The ability to derive benefits from things. This definition of access includes a wider range of social relationships that constrain or enable benefits from resource use than property relations alone.	Ribot and Peluso (2003)
Culture-based fisheries	Fisheries on resources for which the recruitment originates or is supplemented from cultured stocks raising total production beyond the level sustainable through natural processes.	Garcia (2009)
Enhanced fisheries	Fisheries that are supported by activities aimed at supplementing or sustaining the recruitment of one or more aquatic organisms and raising the total production or the production of selected elements of a fishery beyond a level which is sustainable by natural processes.	FAO (1997)
Food security	Food security exists when all people have, at all times, physical, social, and economic access to sufficient, safe, and nutritious food that meets their food preferences and dietary needs for an active and healthy life.	World Food Summit (1996)
Habitat enhancement	A fishery management tool with the sole purpose of providing better environmental conditions for desired species of fish, such as the construction of brush parks as found in tropical Africa and Asia.	FAO (2024)
Inland capture fisheries	The removal of aquatic organisms from natural or enhanced inland waters.	FAO (1997)
Inland waters	This term refers to lakes, rivers, brooks, streams, ponds, inland canals, dams, and other landlocked (usually freshwater) waters (such as the Caspian Sea, Aral Sea, etc.).	FAO (2020)
Recreational fishing	fisheries conducted by individuals primarily for sport but with a possible secondary objective of capturing fish for domestic consumption but not for onward sale.	FAO (1997)
Stocking	The release of cultured or wild aquatic organisms at any life stage into an aquatic ecosystem for the purpose of enhancement, stock rebuilding or biological control.	FAO (2011)
Transhumance	Movement to seek fishing, often following set seasonal patterns, a livelihood adaptation similar to the movements of pastoralists.	Suttie and Reynolds (2003)
Translocations (transfers)	Movement of individuals of a species or population, intentionally or accidentally transported and released within their natural range.	FAO (2011)

EXECUTIVE SUMMARY

Inland capture fisheries are vital components of food systems, economies and societies worldwide, offering critical cultural, recreational benefits and providing nutritious food sources for millions, especially among vulnerable populations. With the global population projected to increase significantly, the need for sustainable food sources becomes ever more critical. In this context, inland fisheries can make crucial contributions to combating hunger and malnutrition. The importance of inland fisheries is recognized and this edition of the status of inland fisheries circular provides a global overview of inland fisheries based on FAO statistics and other relevant sources, together with a series of chapters that consider different aspects of the assessment and management of inland fisheries.

Inland fisheries: catch, catch trends and roles

Inland capture fisheries are estimated to have produced 11.4 million tonnes in 2021. This represents over 12 percent of global capture fisheries production but was produced using less than 1 percent of available freshwater – and with a far lower environmental footprint compared to other protein-dense foods. Furthermore, the direct contribution to human well-being is significant, with around 90 percent of the fish produced being used for direct human consumption. Importance is therefore placed on who benefits from inland fisheries and how. In this respect, the diverse and dispersed nature of these fisheries enables them to deliver quality food to some of the world's most vulnerable populations in a manner that is both accessible and affordable. Almost three-quarters of inland fish and other aquatic animals are harvested from seasonal waterbodies, wetlands, small streams, paddy fields and locations less than 5 km from the shores of permanent rivers, waterbodies and wetlands and over 99 percent of inland fisheries are small-scale. These fisheries supply local economies through both formal and informal mechanisms to provide fish for household consumption and important sources of income. This is particularly important in land-locked and least developed countries and for specific groups in other countries. Over half of the undernourished people in the world live in Asia and more than one-third in Africa, regions where inland fisheries production can be significant. Asia, including China, accounts for nearly two-thirds of the global total catch, while Africa has the second-largest catch volumes and higher annual per capita production than Asia.

Inland small-scale fisheries provide important livelihood opportunities with around 14.6 million people employed in fish harvesting and an additional 36 million people participating in inland subsistence fisheries. Almost half of all fish is harvested on occasional foraging trips, which also demonstrates how fishing is often combined with other livelihood activities or, within household livelihood strategies, represent forms of part-time or occasional employment. Recreational fisheries are also important in many parts of the world, and retained catches from recreational fisheries may be consumed by fishers or shared with others, providing important but often overlooked nutritional contributions.

Despite the importance and relevance of inland fisheries to global development and conservation goals, they are often overlooked or marginalized in development debates. There is therefore a need to make the case for greater recognition of the contributions that inland fisheries make and the important opportunities that they can provide – particularly for poorer and otherwise marginalized groups. This edition of the fisheries circular C942 seeks to highlight the potential and identifies pathways for improving fisheries assessments, fisheries management, and the inclusion of inland fisheries in food security, nutrition and basin development strategies consistent with an ecosystem approach to fisheries.

The opportunities and potential provided by well-managed inland fisheries

The productivity of inland fisheries ensures they remain central to efforts to address poverty, hunger and malnutrition. Inland fisheries make significant contributions to several Sustainable Development Goals (SDGs), including SDG 2 (Zero Hunger), SDG 6 (Clean Water and Sanitation), SDG 14 (Life below Water) and SDG 15 (Life on Land). These fisheries are integral to various livelihood opportunities, linking fish production and processing with the sharing and consumption of fish, as well as connecting fisheries productivity with aquatic environments and other economic activities. Consequently, inland

fisheries are part of a range of activities that take place within inland aquatic environments and normally coexist with other activities occurring both at the local and basin scales. This reality underscores the importance of the traditional practices and knowledge of local communities dependent on these fisheries, which remain critical for their assessment and management. It also serves to highlight that realizing the potential of inland fisheries is about ensuring not only that the fisheries are well managed, but also that contributions and potential are considered in the context of integrated resources management and advancing an ecosystem approach to fisheries. This gives rise to two specific challenges that are addressed in this edition of circular C942: assessing and managing dispersed and dynamic small-scale fisheries; and identifying opportunities for integrating fisheries into development and conservation plans and policies related to integrated water resources management and broader development planning processes.

The management of inland fisheries has been influenced by conventional forms of fisheries management associated with marine fisheries, focusing primarily on fish stocks, responses to fishing effort and management measures to control productivity and fishing effort. However, due to the small-scale, dispersed and dynamic nature of inland fisheries – often related to changes in water – these forms of management can face difficulties. A critical challenge for many inland fisheries is identifying forms of fisheries management that can support the implementation of an ecosystem approach and that are better aligned with the nature and practical realities of inland fisheries. In this respect, traditional management practices and knowledge of the social and environmental contexts in which these fisheries operate can offer valuable alternative starting points that are consistent with an ecosystem approach to fisheries.

Another reality for many inland fisheries is that fishing is often not the primary driver of change in wetlands and aquatic landscapes. Fish and the aquatic environments they depend on are frequently impacted by water abstraction, habitat fragmentation and reduced flooding resulting from activities such as irrigated agriculture, hydropower and flood control. While fisheries management can mitigate some of these impacts, it is also critical that fisheries and their contributions to livelihoods and economies are recognized and included in debates and decisions related to development and basin planning. Inland fisheries are often considered to have limited potential, partly due to a narrow focus on the volume and value of production that tends to underestimate their scale and fails to recognize the diversity of roles they play and the full range of contributions that they make. Fisheries represent more than just the fish produced: they are critical components of livelihoods, food systems and economies – and need to be considered and valued as such.

Addressing these challenges to support positive transformations requires new understandings that are inclusive of fishers and others involved in inland fisheries. Contributing to more just transformations, this enhances the evidence base, enabling management to draw on different knowledge, perspectives and ways of valuing inland fisheries and the contributions they make to sustaining and improving lives, livelihoods and environments.

Improving the quality of inland capture fisheries statistics

The dispersed and dynamic nature of inland fisheries make comprehensive catch assessments costly and complex to carry out. Additionally, changes in fish habitats and shifts in dietary sources – including the availability of fish from marine capture fisheries and the development of aquaculture, enhanced and culture-based fisheries – further complicate the accurate reporting of fish production. Insufficient data collection systems may result in underestimation, and in some cases overestimation of catches from inland waters. Recreational and subsistence fisheries, which can be substantial and locally significant, are in many cases missing entirely from official statistics.

Recent experiences have highlighted opportunities to improve existing statistics and established catch assessment methods through complementary methodologies. These complementary methodologies include predicting potential yields using models based on fish habitats and aquatic environments, estimating catch per fisher, and assessing fish consumption patterns. Such methods provide opportunities to strengthen the information base for inland fisheries.

Analysis to date suggests that the selection of methods for complementing official fisheries statistics and how they can be combined depends on issues such as information needs, data availability, model robustness, error tolerance, and resource capacities. This emphasizes the need to consider various criteria when selecting and combining methods for assessing catches.

Inland fisheries food systems

Addressing food insecurity, malnutrition and poverty involves more than just increasing fish production: it also concerns access and who benefits from the fish produced and how. This highlights the need to shift the focus from aggregate fish production to food security and nutrition. For both low-income and land-locked countries in particular, inland fisheries make significant contributions to addressing global challenges related to malnutrition and food insecurity. Inland fisheries play crucial roles by providing essential nutrients, employment, and food security for millions of people. These roles are based on complex interactions between production, provisioning (the processing and distribution of fish), consumption, and food security and nutrition outcomes in food systems. Therefore, a food systems perspective emphasizes the importance of understanding the nutritional implications of the species produced, post-harvest activities, and the role of market and non-market mechanisms such as social enterprises, cooperatives, gift-giving, bartering, in-kind payments, and commons in supplying and sharing aquatic foods.

While often overlooked in policy discussions, aquatic animal-sourced foods, particularly fish, make a significant contribution to protein intake for billions of people globally. Due to their accessibility, inland fisheries often act as vital safety nets for food security and nutrition, especially during shocks and emergencies, by providing affordable and nutritious food. It is important to consider activities beyond fish production. Inland fisheries' supply chains are diverse and play critical roles in ensuring not just availability but also nutritional quality of fish products. There are significant opportunities related to transforming food systems. For example, promoting fish consumption among specific groups such as pregnant women and children can lead to positive health outcomes, as demonstrated by experiences in different regions.

To inform fisheries management in addition to broader integrated resources management and development policies and plans, there is a need for more explicit recognition of the nutritional outcomes of fisheries management and the role and value of social structures, cultural norms, and arrangements (both market and non-market) and relationships in inland fisheries food systems. Such recognition can support improved food security and nutrition outcomes and contribute to more sustainable fisheries and integrated water resources management. Furthermore, the degradation of inland aquatic environments underscores the need to incorporate inland fisheries into nutrition-sensitive development and conservation policies to improve overall food security and nutrition outcomes.

Strengthening the management of inland fisheries

Across the world people fish in a diverse array of aquatic environments, including lakes, ponds, streams and marshes. They also catch fish in different ways, at different times and for different purposes. This variability, along with the dispersed and dynamic nature of these environments and activities, contributes to the challenge of managing these fisheries. Conventional fisheries management, which focuses on the regulation and control of fishing effort, can be difficult to implement in many inland fisheries, particularly in the uncertain and dynamic contexts that characterize many inland fisheries and in circumstances where fishing is one of many inter-dependent livelihood activities. The different roles that inland fisheries play and their connection both to environmental processes and livelihood activities support the need to advance an ecosystem approach to fisheries. Fishing is often not the main threat to fish stocks in inland waters and sustainable inland fisheries have endured under traditional management arrangements. There are therefore opportunities to learn from these traditional practices to potentially offer insights into how they can contribute to advancing the ecosystem approach and for promoting environmentally and socially responsible practices.

Drawing on examples from inland fisheries around the world, forms of management based on traditional practices have demonstrated how people have been able to successfully balance access, environmental stewardship, and different social and economic interests to achieve positive outcomes. Key to these management arrangements is the consideration of activities beyond harvesting, including the roles of both informal and formal mechanisms and practices such as gifting, reciprocity and collective fishing. These practices – which often include consideration of equitable outcomes, social cohesion and environmental stewardship – are consistent with the ecosystem approach to fisheries. What is notable is that these practices represent forms of stewardship but extend this beyond care for fish stocks and fisheries environments to include care for traditions, institutions, relationships and the needs of those associated with the fisheries. Underpinning these practices of stewardship and care are traditional knowledge, cultural traditions and a combination of formal and informal institutions and tenure arrangements that support and enable access rather than focusing on control and restriction. Rooted in local cultures and livelihoods, these practices and enduring forms of fisheries management offer an alternative entry point to conventional fisheries management and can perform complementary roles in achieving sustainable fisheries.

Recognizing stewardship and care as a basis for managing fisheries can provide the basis for a more pluralistic ecosystem approach, providing practical opportunities and ways to integrate traditional practices, local knowledge, and values into management. While sometimes seen as anachronistic, many traditional management arrangements have successfully endured, adapted, and remain relevant to contemporary contexts. Forms of fisheries management based on stewardship and care can contribute to environmentally and socially responsible practices and enhance sustainability and social well-being. These forms of management are especially necessary and relevant where management based on external forms of control of fish production may be less applicable or relevant.

Methods for assessment of inland fisheries at the basin scale

It is important to recognize that at larger landscape, basin or watershed scales, fisheries are one of many activities that are occurring. While global inland fishery statistics are typically reported at the national level, many fisheries are dependent on activities within lake and river basins, with about 80 percent of inland fisheries catch coming from 50 major basins. Fisheries within these basins are influenced by numerous factors, including climate change, hydropower, land use change, and urbanization – all of which necessitate improved assessment methodologies. To address this, basin level assessment methods have the potential to be able to identify and prioritize amongst the multiple drivers affecting inland fisheries across different scales: Results show that almost all inland fisheries are threatened by multiple drivers and by categorizing these threats (into habitat degradation, water pollution, fishing pressure, invasive species, and climate change), the relative threats to inland fishery production posed by various drivers operating across different scales can be evaluated. Results show that almost all inland fisheries are threatened by multiple drivers. Globally, applying the basin assessment methods reveals that about 47 percent of the basins assessed face low threat levels, 40 percent moderate, and 13 percent high.

When used at individual basin or sub-basin scales, this basin assessment method aids in identifying priority locations, drivers and measures to be included within basin management plans. This can facilitate more integrated forms of water resources management and contribute to transboundary assessment and management. This is highlighted through specific examples of basin reports for Lake Malawi, the Mekong River, the Senegal River, and the Magdalena River, which illustrate the key drivers, threat rankings and spatial distribution of major threats in each basin. By incorporating global datasets and local knowledge, basin assessments can help prioritize management responses and conservation actions, underscoring the importance of understanding the impacts of different drivers on fish stocks. The basin assessment method can also be used to identify potential indicator fisheries within basins that can serve as a basis for continuous monitoring and informed decision-making. Moreover, the basin assessment method can help support efforts to achieve global sustainable development and conservation goals, including the United Nations Sustainable Development Goals (SDGs) and the Global Biodiversity Framework (GBF).

Subregional and national assessments of the status of inland fisheries

Subregional and country summaries are provided for countries in the regions of Africa, Asia, the Russian Federation, Europe, America, Oceania and Arabia. The subregional and country and territory reports reinforce the global picture. Inland fisheries provide critical livelihood opportunities and welfare functions, although in practice, these benefits can be specific to particular populations and locations. Often, fisheries are particularly important at certain times of the year, such as during the productive flood recession period. There are also significant links and interdependencies with other livelihood activities such as agriculture.

Inland fisheries and their management fulfil roles beyond food production alone. For instance, recreational fisheries are important in many countries and the catches retained from these fisheries can sometimes be significant, also making important contributions to food security. Fisheries for ornamental fish can also be important in parts of the world. Given the nature of inland aquatic environments, fishers often employ adaptive strategies such as using different gears at different times of the year and moving in response to changes in fish abundance and distribution.

Examples from around the world highlight how inland fisheries can provide opportunities to maintain and restore environments, enhance environmental connectivity, and improve water quality and nutrient flows. Changes resulting from human intervention, including infrastructure development and irrigated agriculture, can also create new water bodies such as reservoirs and canals. These waterbodies can become the sites of new fisheries, supported through stocking and the creation of enhanced and culture-based fisheries. In some locations, restoring fish and fisheries is part of the justification for initiatives to remove or modify water infrastructure and restore watercourses. In both cases, there are opportunities to increase the contributions of inland fisheries for food and/or recreation, illustrating the continued role and relevance of inland fisheries around the world.

As many of the country reports indicate, the dispersed and dynamic nature of many inland fisheries means that they are often not fully documented or recognized, remaining invisible and thus at risk of being overlooked. There continues to be a need to improve the information base for inland fisheries.

Subregional country groups used in this review

An ongoing challenge for assessing the status of inland fisheries is that boundaries may be delineated differently depending on the information source. For basin assessments, FAO fishery statistics are recorded at neither fishery nor basin/sub-basin level as they are reported to FAO as a national aggregate statistic compiled from a range of fisheries. National inland fisheries statistics therefore represent the aggregate of fisheries from different habitats, basins, and fisheries.

In addition to the national statistics, following C942 Rev. 3, countries and territories reporting inland fisheries can be grouped into subregional clusters that reflect common climatic characteristics, or their shared water resources (e.g. countries within a basin). These subregional groupings are as follows:

Region	Subregion	Countries and territories
Africa	Northern	Algeria; Libya; Morocco; Tunisia
	Sahel	Burkina Faso; Chad; Gambia; Mali; Mauritania; Niger; Senegal
	Nile Basin	Egypt; Ethiopia; South Sudan; Sudan
	Eastern Coast	Djibouti; Eritrea; Somalia
	Western Coast	Benin; Cameroon; Côte d'Ivoire; Equatorial Guinea; Ghana; Guinea; Guinea-Bissau; Liberia; Nigeria; Sierra Leone; Togo
	Great Lakes	Burundi; Kenya; Malawi; Rwanda; Uganda; United Republic of Tanzania
	Congo Basin	Central African Republic; Congo; Democratic Republic of the Congo; Gabon
	Southern	Angola; Botswana; Lesotho; Madagascar; Mozambique; Namibia; South Africa; Eswatini; Zambia; Zimbabwe

Region	Subregion	Countries and territories
Asia	Southeast	Brunei Darussalam; Cambodia; Indonesia; Lao People's Democratic Republic; Malaysia; Myanmar; Philippines; Singapore; Thailand; Timor-Leste; Viet Nam
	Southern	Bangladesh; Bhutan; India; Nepal; Pakistan; Sri Lanka
	China	China; China, Hong Kong SAR; China, Macao SAR; Taiwan Province of China
	Eastern	Japan; Democratic People's Republic of Korea; Republic of Korea
	Western	Iran (Islamic Republic of); Iraq; Israel; Jordan; Lebanon; Palestine; Syrian Arab Republic; Türkiye
	Central	Afghanistan; Armenia; Azerbaijan; Georgia; Kazakhstan; Kyrgyzstan; Mongolia; Tajikistan; Turkmenistan; Uzbekistan
Russian Federation	–	Russian Federation
Europe	Eastern	Belarus; Bulgaria; Czechia; Hungary; Republic of Moldova; Montenegro; Poland; Romania; Serbia; Slovakia; Slovenia; Ukraine
	Northern	Denmark; Estonia; Finland; Iceland; Latvia; Lithuania; Norway; Sweden
	Western	Andorra; Austria; Belgium; Channel Islands; Faroe Islands; France; Germany; Ireland; Liechtenstein; Luxembourg; Netherlands (Kingdom of the); Switzerland; United Kingdom of Great Britain and Northern Ireland
	Southern	Albania; Bosnia and Herzegovina; Croatia; Cyprus; Greece; Italy; North Macedonia; Malta; Portugal; Spain
Americas	South	Argentina; Bolivia (Plurinational State of); Brazil; Chile; Colombia; Ecuador; French Guiana; Guyana; Paraguay; Peru; Suriname; Uruguay; Venezuela (Bolivarian Republic of)
	Central	Belize; Costa Rica; El Salvador; Guatemala; Honduras; Mexico; Nicaragua; Panama
	Northern	Canada; United States of America
	Islands	Cuba; Dominican Republic; Falkland Islands (Malvinas); Haiti; Jamaica
Oceania	–	Australia; Fiji (Republic of); French Polynesia; Micronesia (Federated States of); New Zealand; Papua New Guinea; Samoa; Solomon Islands
Arabia	–	Bahrain; Kuwait; Oman; Qatar; Saudi Arabia; United Arab Emirates; Yemen

Not covered in this review:

American Samoa; Anguilla; Antigua and Barbuda; Aruba; Ascension, Saint Helena and Tristan da Cunha; Bahamas; Barbados; Bermuda; British Virgin Islands; Cabo Verde; Cayman Islands; Comoros; Cook Islands; Curaçao; Dominica; Greenland; Grenada; Guadeloupe; Guam; Kiribati; Maldives; Marshall Islands; Martinique; Mauritius; Montserrat; Nauru; New Caledonia; Niue; Northern Mariana Islands; Palau; Pitcairn; Puerto Rico; Réunion; Saint Kitts and Nevis; Saint Lucia; Saint Vincent and the Grenadines; San Marino; Sao Tome and Principe; Seychelles; Sint Maarten (Dutch part); Tokelau; Tonga; Trinidad and Tobago; Turks and Caicos Islands; Tuvalu; United States Virgin Islands; Vanuatu; Wallis and Futuna Island.

1. GLOBAL INLAND FISHERIES

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Inland capture fisheries play important roles in food systems and economies around the world. They contribute to and support cultural, recreational, relational and nutritional outcomes as part of sustainable aquatic ecosystems across the world. The circular series on the status of inland fisheries recognizes the importance of these fisheries and provides a more in-depth assessment to complement the global state of fisheries and aquaculture (FAO, 2024). This edition of the status of inland fisheries circular provides a global overview of inland fisheries based on FAO statistics and other relevant sources, including regional and national summaries that describe, for each country reporting inland fisheries statistics to FAO. These summaries are complemented by a series of chapters that were commissioned to examine different aspects of the assessment and management of inland fisheries. These chapters describe methods and ways of considering inland fisheries that can contribute to more pluralistic means to achieve this. Collectively, these chapters build on and advance the analysis provided in previous editions of this circular (e.g. Funge-Smith, 2018), addressing priorities identified in the ten steps to responsible inland fisheries (Taylor *et al.*, 2016), including methods to improve inland fisheries information and valuation, strengthening fisheries and integrated management and governance and cross-sectoral communication and collaboration.

With global population projected to rise to around 8.5 billion people in 2030 and 9.7 billion by 2050 (DESA, 2022), feeding growing populations in a sustainable manner requires transformative action. The recent State of Food Security and Nutrition in the World report (FAO *et al.*, 2023) reaffirms the important need for action. Global hunger has risen above pre-pandemic levels with between 690 and 783 million people in the world facing hunger in 2022 and with almost 600 million expected to still face hunger in 2030 (FAO *et al.*, 2023). Around 2.4 billion people did not have access to nutritious, safe and sufficient food in 2022, the majority of them women and people living in rural areas and in low income and food deficit countries. Furthermore, millions of children under 5 years of age continue to be malnourished (FAO *et al.*, 2023).

1.1 THE CONTRIBUTIONS OF INLAND FISHERIES TO GLOBAL CHALLENGES AND A BLUE TRANSFORMATION AGENDA

Inland capture fisheries have an important role to play to address these global challenges that are central to a Blue Transformation agenda (Coates, McInnes and Davidson, 2023). They are highly efficient producers of nutritious foods, producing over 12 percent of global capture fisheries production from less than 1 percent of total freshwater and with a far lower resource-use footprint when compared with production of livestock or other protein dense- foods (Funge-Smith and Bennett, 2019; Mittermeier *et al.*, 2011). Around 90 percent of fish produced from inland fisheries is for human consumption (Welcomme *et al.*, 2010), which includes nutritious small fish (Bavinck *et al.,* 2023) that can be eaten alone or in combination with other foods, making crucial contributions to addressing hunger and malnutrition.

These contributions relate to the realities of inland fisheries: that they are diverse and dispersed. These are strengths, enabling them to deliver quality food to some of the world's most vulnerable populations in a manner that is both accessible and affordable. Almost all inland fisheries are small-scale, supplying local economies through formal and informal economic activities to provide fish for household consumption. Recent global studies estimated that on average between 2013 and 2017 small-scale fisheries accounted for over 99 percent of total inland catches and these fisheries contributed almost one third of total global catches from small-scale fisheries (FAO, Duke University and WorldFish Center, 2023). Underlining the importance of these fisheries, nearly 60 percent of total small-scale fish catches in least developed countries are from inland fisheries (FAO, Duke University and Worldfish Center, 2023). In land-locked countries as well as where there are substantial freshwater resources and large rural populations, the contributions to nutrition for poor people can be greater than that of fish from either marine fisheries or aquaculture (McIntyre, Liermann and Revenga, 2016).

Their accessibility can make them particularly important for poorer people and underpins critical welfare roles and the importance of these roles in times of shocks and crises. More generally, fishing is often integrated into diverse livelihoods, one of several activities that households are engaged in. In higher-income countries, inland fisheries can still play important roles – roles which are of importance not only culturally but also in providing foods and other benefits for particular groups. As well as being a strength, this creates challenges for both their assessment and management, creating a need to address both the management of fisheries but also integrate fisheries into wider landscape planning at both the local level and basin scale. Responding to these challenges, this edition of the fisheries circular considers these challenges in terms of progressing the implementation of an ecosystem approach to fisheries for inland fisheries, using this perspective to highlight and address the connections that exist between fish, fisheries, and the environments and societies in which they are located.

The world is also changing, and the environments and societies in which inland fisheries are situated are being transformed. Globally, aquatic environments are facing increasingly rapid rates of ecosystem change, primarily driven by anthropogenic pressures and are among those most at risk of degradation. Where data are available, they suggest that 35 percent of wetlands have been lost since 1970 – a rate three times greater than that of forests (Ramsar Convention on Wetlands, 2018). Economies and societies are also changing, and it is projected that the global population living in cities will have risen from the current 56 percent to almost 70 percent by 2050 (FAO *et al.*, 2023). This has important implications for the nature of food systems and the demands upon them. For inland fisheries these changes can affect all aspects from the production, processing and distribution of fish to its consumption. Navigating such changes in ways that are equitable, ensure that they continue to meet critical development needs, and provide livelihood opportunities for the poor, create important new challenges for management and governance that need to be addressed through the Blue Transformation agenda.

The Blue Transformation agenda also emphasizes the possibilities that well-managed inland fisheries can provide. The productivity of inland fisheries, as well as the potential opportunities for increasing production and strengthening management, mean that inland fisheries continue to be central to efforts to address poverty, hunger and malnutrition (Lynch *et al.*, 2020). Of the 17 Sustainable Development Goals (SDGs) (UN Department of Economic and Social Affairs, 2015), inland fisheries make important contributions to SDG 2 (Zero Hunger), 6 (Clean Water and Sanitation), 14 (Life below Water) and 15 (Life on Land). FAO is well positioned to holistically address the targets within these goals, given the Blue Transformation agenda that supports better production, better nutrition, a better environment, and a better life, leaving no one behind.

The aspects of connectivity and integration highlighted by an ecosystem approach are key to how inland fisheries need to be considered and the ecosystem approach to fisheries (FAO, 2003) is used as a guiding framework. Connectivity, integration and the need for more pluralistic approaches to assessment and management are therefore elaborated in different ways throughout this edition of the circular. These include the connections between fishing activities and how these are documented and presented through fisheries statistics, as well as how we can improve understandings of connections between the production of fish and its processing, sharing and consumption. Critical to these latter connections are the traditional practices and knowledge of local people and communities that underpin them. Collectively, these have important implications for the knowledge base and how this informs the management of inland fisheries. Connections to other activities are also important. This circular therefore also highlights the ways in which fisheries often coexist and the interdependencies with other activities occurring both at the local level and basin scale. These are important not only in relation to the decisions made about fishing but also to the contributions that fish make to livelihoods, food security and nutrition. As well as considering the assessment methods and management processes, the circular additionally highlights the continuing importance and relevance of inland fisheries, making a case for the contributions that inland fisheries can continue to make and the important livelihood opportunities they can provide – particularly for poorer and otherwise marginalized groups. These opportunities are also a feature of the basin assessments, emphasizing the need to be more inclusive of the place and role of inland fisheries in the management of dynamic and changing aquatic landscapes.

1.2 INLAND FISHERIES: THE GLOBAL OVERVIEW

This edition of the circular begins with a summary of the overall status of inland fisheries in Chapter 2. Monitored and estimated catches from inland fisheries stands at 11.4 million tonnes, with an estimated value of around USD 19 billion (FAO, Duke University and WorldFish Center, 2023), although it is widely recognized that this is likely an underestimate. But it is not just a case of how much food is produced – over half of the undernourished people in the world live in Asia and more than one-third in Africa (FAO, 2023a), regions where inland fisheries production can be significant. Asia, including China, produces nearly two-thirds of the global total catch, while Africa has the second-largest catch volumes. However, it is also significant that annual per capita production in Africa (2.39 kg) is much greater than Asia (1.49 kg) or China (1.77 kg).

Inland small-scale fisheries provide important livelihood opportunities, with estimates from 2016 suggesting that there are around 14.6 million people employed in fish harvesting and an additional 36 million people participating in inland subsistence fisheries, representing 68 percent of all (marine and inland) subsistence fishing (FAO, Duke University and WorldFish Center, 2023). The nature of inland aquatic environments contributes to this, with almost three-quarters of inland fish catches harvested from seasonal waterbodies, wetlands, small streams, paddy fields and locations less than 5 km from the shores of permanent rivers, waterbodies and wetlands (FAO, Duke University and WorldFish Center, 2023). Furthermore, almost half of all fish is harvested on occasional foraging trips, evidence also of how fishing may be combined with other livelihood activities. Fishing can also be part of adaptation strategies that can include seasonal transhumance, similar to pastoralism, and participation may therefore represent forms of part-time or occasional employment for many (Funge-Smith and Bennett, 2019). Ornamental fisheries and recreational fishing can also provide important economic opportunities. Additionally, recreationally caught fish may be consumed by fishers or shared with others and continues to make important nutritional contributions to some groups.

The regional and country reports reinforce this global picture. Inland fisheries provide critical livelihood opportunities and welfare functions; however they also demonstrate how these benefits and opportunities can relate to particular populations and locations. Inland fisheries and their management fulfil roles other than food production alone. As examples from around the world illustrate, inland fisheries provide opportunities to maintain and restore environments and environmental connectivity as well as improve water quality and nutrient flows. As many of the country reports note, changes resulting from human intervention (including infrastructure development and irrigated agriculture) can create new water bodies such as reservoirs and canals. These waterbodies can become the sites of new fisheries, supported through stocking and the creation of enhanced fisheries. In other places, the restoration of fish and fisheries are part of the justification for initiatives to remove or modify water infrastructure and the restoration of watercourses. In both cases there are opportunities to increase the contributions of inland fisheries for food and/or recreation, illustrating the continued role and relevance of inland fisheries around the world. Yet the nature of inland fisheries creates challenges in doing so: As many of the country reports indicate, the dispersed and dynamic nature of many inland fisheries mean that they are often not fully documented or recognized. There continues to be a need to improve the information base for inland fisheries.

1.3 PRIORITIES FOR BETTER INLAND FISHERIES STATISTICS

When realizing the contributions of inland capture fisheries towards global goals through the Blue Transformation agenda, part of the challenge lies in ensuring they are visible and that their roles and potential are recognized. Inland fisheries statistics can therefore have an important role to play in shaping national and regional policy and strategy development, as well as for fisheries management planning and evaluation. Statistics for these purposes are also submitted to FAO and publicly disseminated through FishStatJ (FAO, 2023a. Countries, however, face several challenges in collecting data on inland fisheries and inland fish production. These challenges are examined in Chapter 3, which considers the priorities for improving inland fisheries data and information – including using complementary assessment methods.

1.3.1 Recognizing the need to improve catch statistics

In many cases official fisheries statistics may overestimate or underestimate yields from inland fisheries. This is particularly the case regarding the contribution of low-monetary-value, but locally important, catches from subsistence fisheries and recreational fisheries that tend to be underestimated and which may even be excluded entirely. This is partly a reflection of the practical challenges associated with the dispersed and dynamic nature of inland fisheries as well as the costs of undertaking comprehensive catch assessments and frame surveys. In other cases, changes in aquatic fish habitats and productivity, as well as improvements to surveys and reporting can mask long-term catch trends. The significant growth in production from aquaculture and enhanced fisheries in recent decades has also made the task of correctly identifying and reporting sources of fish production ever more important and demanding.

To address this, FAO has proactively begun to develop further guidance and support that could be provided to countries to improve the quality of inland fish catch statistics. Recent improvements in the knowledge base and application of complementary catch estimation methods have the potential to be combined with conventional catch assessment survey methods. However, there are currently few examples that can be drawn on to provide guidance how they can be combined in practice. Chapter 3 therefore focuses on some of the complementary methods that have been used to estimate catches in inland fisheries as well as the issues encountered in applying them.

1.3.2 Complementary methods for estimating inland fisheries catches

Complementary methods that do not rely on direct catch sampling include methods to estimate potential yield based on major fish habitat category (e.g. Lymer *et al.*, 2016) or catch per fisher (e.g. Kolding and van Zwieten, 2012). These methods can incorporate remote sensing data of the extent of aquatic habitats or fisher numbers and combine these with empirical areal and fisher productivity estimates. As predictive models, these methods can provide some useful estimates of aggregate potential yields depending on the robustness of the available data but have a high degree of uncertainty. Care must also be taken in applying results to predict catch from individual waterbodies as well as those of different size. However, such methods can be useful in large lakes, reservoirs and floodplains where fishing and landing sites are dispersed and where catch sampling may be most challenging, provided they are combined with ground truthing methods.

Assessments of fish consumption provide the basis for another complementary method to estimating catch that can be particularly useful for geographically dispersed fisheries where it can be difficult to accurately monitor or survey fish landings. However, consumption-based estimates can also be affected by seasonal and interannual variability as well as by other sources of fish, including aquaculture and marine capture fisheries, such that it can be difficult to estimate or to extrapolate beyond the local level. Despite this, fish consumption as a source of information for estimating catch does have the advantage that it relates more closely to nutrition and may therefore be incorporated in the routine work of national statistics agencies, for example rural, agricultural, or national household censuses (Hortle, 2007). These can also provide useful insights related to health and nutrition, including threats to health such as heavy metals, that can also be valuable and may not typically be part of catch assessment surveys or other method that are focused only on fish production.

The most suitable method to improve the quality of reported fisheries statistics will depend upon the types of information required, the availability of data and robust model parameter estimates, acceptable levels of error, and the resources and capacity available. Chapter 3 discusses criteria that can be used as a basis for assessing the appropriacy of alternative methods.

1.4 IMPORTANCE OF INLAND FISHERIES WITHIN FOOD SYSTEMS

The importance of inland fisheries in areas where there is food insecurity, malnutrition and poverty highlights the importance of shifting the focus from aggregate fish production to include the role of inland fisheries in relation to food security and nutrition. Such a shift means greater attention to the connectivity and relationships that exist within post-harvest supply chains and to other parts of food systems. Chapter 4 addresses these aspects and considers the roles and contributions of inland fisheries to food security and nutrition from a food systems perspective. Food systems encompass the entire range of interconnected activities and actors – from production through processing and distribution, to the consumption of fish products in combination with other foods. In doing so, it places these activities and actors within the broader economic, societal and natural environments in which they are embedded (e.g. Ingram, 2011).

1.4.1 Contributions to food security and nutrition

While often not a focus of fisheries management, changes in the food security and nutritional condition of poorer or more vulnerable groups remain a global priority and a key indicator of fisheries policy success (FAO *et al.*, 2023; Arthur *et al.*, 2022). Despite this, Koehn *et al.* (2022) found that less than half of fisheries policies include improved nutrition as a key objective, and just over 40 percent of nutrition policies recognized the importance of aquatic foods. Aquatic animal-source foods provide at least 20 percent of animal protein to over three billion people (FAO, 2022). Nearly three-quarters of aquatic foods supplied are fish (specifically vertebrate fish and not including other aquatic animals), and freshwater and diadromous species account for 40 percent of per capita aquatic food consumption – more than from marine fish – to which inland fisheries make important contributions (FAO, 2023b). Despite the foods inland fisheries can provide, global discourses on fisheries, food and nutrition policies, and research priorities still tend to focus exclusively on marine capture fisheries (Lynch *et al.* 2020).

The roles of inland fisheries differ but they have been found to be particularly important as a nutritional safety net. The accessibility of inland fisheries makes important contributions to this since they are often located close to where people live and work, and fish can be caught and processed using simple and low-cost equipment. This is important, given that about 3.14 billion people in the world (42 percent of the global population) were unable to afford a healthy diet in 2021 (FAO *et al.*, 2023). The role can be particularly important for some populations – for example, in the Lao People's Democratic Republic 97 percent of people working in small-scale fisheries (or 17 percent of the country's population) are subsistence fishers (Virdin, *et al.*, 2023). Recreational fisheries can also be an important source of fish for consumption and exchange.

While fisheries management has typically focused on fishing and fish production, less focus has been given to food supply chains that not only contribute to the availability of fish but also nutritional quality. The nature of what is produced and how it is made available can also be important: Small indigenous fish species and aquatic foods from inland waters are often directed to local consumption and are typically sold for low prices, available in small quantities and exported less often (Bavinck *et al.*, 2023). While the role of formal markets is recognized, the important and sometimes extensive roles informal exchanges, gifting fish and shared consumption also play in enabling people to benefit from inland fish and fisheries should also be recognized. Post-harvest, simple improved equipment such as raised drying racks and improved fish smoking kilns can reduce losses in fish supply chains (Ibengwe and Kristófersson, 2010), and new technologies can assist development of fish products based on underutilized species, bycatch or byproducts (FAO, 2022).

1.4.2 Improving food security and nutrition through food systems transformations

Enabling and promoting fish consumption for key groups can also have important benefits. For example, maternal consumption of freshwater fish and shellfish in rural China was associated with decreased risk of low birthweight (Wei *et al.*, 2023). Similarly, children in Zambia consuming freshwater fish had a reduced risk of stunting (Marinda *et al.*, 2018), and in the Amazon region freshwater fish consumption was positively associated with haemoglobin concentration in children (Carignano Torres *et al.*, 2022). In Nigeria, children suffering from rickets – a condition that softens and weakens bones, typically due to a severe and prolonged vitamin D deficiency – were treated with ground catfish. This treatment aimed to enhance their vitamin D and calcium levels and the treatment proved to be an effective alternative to expensive supplements, since vitamin D facilitates the absorption of calcium and phosphorus. (Thacher *et al.*, 2015). The importance of maintaining viable and productive inland capture fisheries is underlined by the fact that, where they are weakened through environmental degradation, populations may be compelled to migrate, potentially reducing their connection to the fisheries and increasing vulnerability (e.g. FAO *et al.*, 2023).

Taking a food systems perspective can contribute towards an ecosystem approach to fisheries management, helping to identify entry points and measures to support and accelerate positive transformations, including opportunities to increase production of nutrient-rich fish. From this perspective, processing, distribution and food preparation are also factors that can enhance access as well as nutritional outcomes and therefore should be considered in relation to management measures. Adopting a food systems perspective also draws attention to the impacts of the degradation of inland aquatic environments. Resulting shifts in ecology, productivity and management can have important implications for access that, in turn, can have a marked impact on nutrient availability. At the same time, this also highlights opportunities wherein nutrition-sensitive fisheries policies and management measures could also play a key role in helping to improve nutrition outcomes.

1.5 MANAGEMENT OF INLAND FISHERIES

A food systems perspective on inland fisheries highlights the importance of the social as well as the environmental connections that exist in inland fisheries. This is recognized in the ecosystem approach to fisheries and Chapter 5 considers how the interconnectivity and relationships that exist between fishing, aquatic environments, livelihoods and cultures can translate into practical fisheries management. The starting point for this is the ways in which people already experience living with inland fisheries, including how they can use this experience to navigate uncertainty and change. This perspective informs the chapter, which explores some of the ways in which traditional fishing and fisheries management practices reflect these relationships. In doing so, this highlights the importance of the social and institutional dimensions and of the role of knowledge, experience, customs and creative capacities that people possess and continue to develop and apply to the management of inland fisheries.

People engage in fishing for many reasons, and fishing can often be one of several livelihood activities – taking place at certain times of the year or alongside other activities. Fishing can be more than an individual or household pursuit, with inland fisheries also being valued for their contributions to local economies and cultures, providing contributions to social welfare and development, and reducing conflict. Far from being anachronistic or "backward", inland capture fisheries continue to play important roles and provide important opportunities within peoples' livelihood strategies. How existing opportunities can be supported, and new opportunities created and realized is an important focus of fisheries management.

The management of larger inland fisheries in many countries has been strongly influenced by forms of fisheries management derived from marine fisheries management, with a resulting focus on diagnosis and planning and measures relating to prediction and control. In inland fisheries, where fisheries are dispersed and dynamic, often with limited external capacity and resources, there have been mixed results. Failures of inland fishery management, including co-management, are often attributed to either the failure to establish control that suggests a need to redouble existing efforts, or to the inherently problematic nature of inland fisheries themselves (Friend, Arthur and Keskinen, 2009). Yet it is also recognized that there are enduring forms of management that support sustainable fisheries. This reality provides the basis for considering forms of management that take as their starting point existing practices and the livelihoods, knowledge and lived experiences of those depending on inland fisheries for their livelihoods.

1.5.1 Managing fisheries as one of several livelihood activities: access and tenure

The realities of inland fisheries and fishing livelihoods are often that inland fisheries are one of several focal points for decision-making within households and communities, situated within wider environmental and social landscapes. Livelihoods where people are engaged in multiple activities and maintain multiple livelihood options also represent important adaptations to environmental variability and change. The nature of the environment and the opportunities it can provide – combined with individual and collective capabilities – mean that fisheries can develop and play different roles. Based on these roles, they can afford different opportunities and benefits to different people (Hamerlynck *et al.,* 2019; Garaway *et al.*, 2006; Smith, Nguyen-Khoa and Lorenzen, 2005).

Where fisheries are important, including in relation to social protection and welfare or as a “safety net”, management that restricts access in terms of the ability to benefit (Ribot and Peluso, 2003) can represent a form of impoverishment. Maintaining rather than restricting access can often represent an important consideration and, for this reason, many traditional inland fisheries management arrangements allow for or even enable access by different groups from both within and outside a community. Within these enabling strategies access can be conditional, including through forms of regulated open access (Arthur, 2020). Access is also about more than just fishing, as customs of giving and sharing fish can also support strong social norms, encouraging wealthier households to help the poorer. It is therefore important to consider how these formal and informal relationships and institutions function to accommodate diverse interests and promote responsible practices in ways that extend beyond formal regulation.

The dispersed nature of inland fisheries, fluctuating and changing environmental, social and economic conditions and even the fact that people fishing may not identify as ‘fishers’ represents a common context for fisheries management. Consequently, uncertainty and disagreements remain intrinsic and enduring features of many inland capture fisheries, especially in the context of rapidly changing aquatic environments. The ecosystem approach to fisheries and need for alternative forms of management are highly relevant given the important connections between inland capture fisheries and livelihoods and cultures and inherent uncertainty. Conventional forms of management that identify uncertainty and disagreement as problematic aspects of fisheries to be minimized can be less well suited to these realities. Furthermore, the focus on the ecological dimensions, including the role of local ecological knowledge, can limit the extent to which management is advancing an ecosystem approach to fisheries that recognizes the importance of ecological, social and institutional dimensions. In considering how an ecosystem approach can be advanced in circumstances where devolved forms of management are likely to continue to be a reality, existing forms of management and management practices, many based on accepted traditional practices, can provide a useful alternative starting point and perspective on management challenges.

The same set of realities face local managers but, in contrast to conventional management, there is far greater inclusion of social concerns and recognition of different and often competing interests and acceptance of inherent uncertainty and environmental variability that are reflected in institutional arrangements and adaptive management strategies. Within these, ambiguous, dynamic and overlapping tenure and governance arrangements can have an important and positive role for less powerful actors, contributing to preventing elite capture and exclusion, thereby facilitating and even enabling access and participation in inland fisheries. Management and governance can include both formal and informal institutions that play important roles not just in relation to fishing, but also to the relationships and benefit sharing associated with fishing and fisheries. Uncertainty can also be found to have benefits: the risks for investment that might be considered an obstacle for increasing efficiency can provide a safeguard or deterrence against enclosure and capture by locally powerful interests, exclusion or restrictions on poorer fishers. This is important in situations where the wrong kind of secure tenure may be harmful. Uncertainty related to management priorities and fisheries dynamics can also play a positive role where it fosters creative responses, experimentation and collective action to live with dynamic and changing environments, with an emphasis on restoring degraded environments, traditions, practices and knowledge.

1.5.2 From control to stewardship and care in the management of inland fisheries

Underpinning many traditional management arrangements and the way that these can address and navigate uncertainty and disagreement are practices that provide a central role for stewardship and care rather than control. Practices of care include notions of environmental stewardship that are recognized in the traditional management of small-scale fisheries (e.g. Charles, Macnaughton and Hicks, 2024). However, consistent with the need to advance the ecosystem approach to fisheries, care can extend beyond environmental stewardship to include practices that reflect social and institutional aspects, such as prioritizing subsistence over commercial fishing or maintaining cultural traditions and knowledge.

Thus, practices of care can attend to the needs and interests of both environments and people. Critically, stewardship and care are based on the knowledge and experience of users and managers, drawing on both formal and informal institutions and diverse economic practices (Charles, Macnaughton and Hicks, 2024; Gibson-Graham and Dombrowski, 2021; Nightingale, 2019). Experiences suggest that these practices – as well as the knowledge, traditions and rights on which they are based – can also contribute to sustainable management where they are supported through formal recognition. However, for this to be the case, it is important that these practices are recognized for what they are, and how they reflect values and cultures and the role that fisheries play within societies. To achieve this requires more explicit recognition of existing practices and more pluralistic forms of management that provide space for different perspectives and understandings of what the fisheries are and represent. In contracts to this acceptance, failure to be inclusive or downplaying the importance of cultures and values can risk misunderstanding existing practices and institutions and subjecting them to interventions that be inappropriate or undermining (e.g. Mol, Moser and Pol, 2010). The complex and diverse nature of inland capture fisheries and resulting variety in management arrangements provides important examples and opportunities to understand the dynamics, logic and ethos of practices of stewardship and care and how these can be supported together with environmental stewardship to enable positive transformations and advance the ecosystem approach to fisheries management.

1.6 ASSESSING FISHERIES IN BASIN CONTEXT

Well managed fisheries can provide important social and environmental benefits. However, a key challenge for inland fisheries is that many of the drivers that affect inland fisheries (including climate change, hydropower, land-use change and economic development) often occur at larger scales, including transboundary, or affect connected aquatic habitats. Such drivers and activities can restrict the effectiveness of management measures and even potentially undermine management. Consequently, they may need to be addressed through decision-making that is inclusive of other sectors and measures beyond those associated only with fisheries management. The challenges that this creates are considered in Chapter 6, in particular how a basin-level assessment methodology that is inclusive of inland fisheries can draw on the principles of an ecosystem approach and help prioritize which drivers need to be addressed at different scales.

Currently, global inland fishery statistics compiled by FAO are reported at a national level and represent an aggregated amount from a range of fisheries based on different aquatic environments, yet many fisheries are more dependent on what happens within basins. Indeed, some 80 percent of inland fisheries catch comes from 50 major basins. Building on the basin assessment approach introduced in Funge-Smith (2018), the analysis presented takes the concept further to demonstrate how basin assessments using a basin threat mapping tool can prioritise interventions or to provide a basis for indicator, or "sentinel", fisheries that could generate information on the state of the basin to inform decision-making and integrated water resources management.

1.6.1 Uncertainty and multiple drivers: the utility of threat mapping and basin assessments

The complex and widespread distribution of freshwater bodies, coupled with the transboundary nature of many inland fisheries, makes sustaining multiple ecosystem benefits challenging and monitoring costly and time-consuming (FAO, Duke University and WorldFish Center, 2023; Khan *et al.*, 2019). Focusing on localized trends can also be misleading as local changes, including local declines or improved management, could be concealing a markedly different picture across multiple fisheries within a basin. Many inland fisheries are also naturally fluctuating, with productivity often linked to basin-scale hydrological processes. Furthermore, fishing is often not the main driver of change in inland fish stocks and in inland aquatic environments, being that they are also frequently affected by water abstraction, habitat fragmentation and reduced flooding due to activities such as irrigated agriculture, hydropower and flood control. Indeed, estimates of human-induced impacts on inland waters suggest that more than 65 percent of inland habitat is moderately or highly threatened by anthropogenic stressors (Vörösmarty *et al.*, 2010). Combining basin productivity assessments with assessments of the potential impacts of human pressures (such as climate change, hydropower, land use, or human development) on inland fish populations can increase the utility of basin assessments by providing a means to assess the relative importance of different drivers. Such assessments can also be used to identify priority locations and measures within basin management plans, which also often require a transboundary coordination and cooperation. Basin assessment methods could therefore be of particular utility and relevance for lake or river basin organizations involved in basin planning.

Threat-mapping allows for the evaluation of threats to inland fishery production from the global level to the scale of individual basins or sub-basins (Stokes, 2022). For the purposes of this evaluation, the 28 major threats are classified into five major categories: habitat degradation, water pollution, fishing pressure, invasive species, and climate change (Stokes *et al.*, 2021). Overall, the latest results from the global assessment show that around 47 percent of all global basins are under *low threat*, 40 percent are under *moderate threat* and 13 percent are under *high threat*. Collectively, nearly all inland fisheries are threatened by more than one stressor, and most are threatened by numerous stressors (Stokes *et al.*, 2021). However, not all changes are negative, as there are efforts around the world to introduce effective riparian protections, to manage water to include fisheries, and to remove barriers to increase aquatic ecosystem connectivity (e.g. Thieme *et al.*, 2023; Gregory, Funge-Smith and Baumgartner, 2018).

The utility of the basin threat assessment at a global scale is that it provides a framework to compare basins around the world and identify the relative influence of individual threats and threats by major categories. The value of downscaling assessments to individual basins enables more practical application to management as it allows users to generate more localized assessments with input from local stakeholders to produce summarized metrics and assessments for individual basins or sub-basins. This can include metrics related to the basin and its uses, such as the percentage of forest cover and loss, number of planned and operational dams, or protected area coverage that may be useful for fishery and basin managers. Examples are provided to illustrate how assessment methods can be applied to Lake Malawi as well as the Magdalena, Mekong and Senegal Rivers.

In the context of the Global Biodiversity Framework targets and United Nations Decade of Restoration, environmental managers are seeking ways to restore and conserve biodiversity. Understanding how fish stocks are affected by external pressures, as well as which basins and activities are priorities, can help in the prioritization of management responses. The ability to use global datasets and combine them with local knowledge of stocks and threats ensures that the tool is applicable across a range of scales, contributing to integrated water resources management and basin governance, including in transboundary basins.

Basin level assessments can also be used to identify potential indicator fisheries within basins that can be used to provide continuous information on the overall state and health of a basin and its fisheries. Such indicator fisheries can help address the limitations of national aggregated catch data and help to inform conservation priorities through identifying: the impact and extent of basin threats, biodiversity hotspots, important areas of fish production, as well as future pressures using threat predictions. This can be particularly valuable where capacity to monitor is limited and there are fisheries that can provide representative information. Indicator fisheries across a subset of basins could also provide the basis for a “sentinel” fishery monitoring programme as proposed in Ainsworth, Cowx and Funge-Smith (2023).

1.7 FISHERIES MANAGEMENT AND INTEGRATED RESOURCES MANAGEMENT

Inland fisheries remain hugely important and relevant to many local livelihoods and economies. In the context of rapid environmental and social change, the attributes of inland fisheries as accessible and widespread mean that they can play critical roles in relation to food security, nutrition and vulnerability, providing important livelihood opportunities. These roles are underpinned by the ecological and social nature of inland fisheries and this edition of the status of inland fisheries explores the connectivity associated with inland fisheries in different ways. In doing so, it also reveals the resilience of these fisheries and their continued relevance to global development objectives in a changing world. As FAO *et al.* (2023) emphasize, recognizing the connections and linkages inherent in food systems provides opportunities for economic development and access to affordable healthy diets.

Inland fisheries are connected in different senses. Fish are linked to water and move through it, connected to different habitats including freshwater and marine, but fisheries are also social and economic arenas. Examining fisheries from this perspective reveals important connections between people, their livelihoods and markets. From a food system perspective, fishing is linked to processing, trading and consumption, often with critical roles for market and non-market economies. This then reveals another connection: that which exists between formal and informal institutions. Ultimately, relationships between people can play critical roles in how people access, and consequently are able to benefit from, fish and fisheries. Examining the plates of the poor also reveals how fish is also connected to the production and consumption of other foods: Bengalis often say that *"mache bhate Bangali"* (fish and rice make a Bengali), highlighting both the relationships that exist between the physical and the cultural as well as the connections between fish, other foods and human nutrition. The role of fish in these relationships can be both critical and easily overlooked. For example, in the Lao People's Democratic Republic – where rice and fish are also important dietary components – research has shown that while there are coping strategies for rice crop failures, there are no such coping strategies for dealing with periods of fisheries failures (Meusch *et al.,* 2003).

1.7.1 The importance of connectivity in managing inland fisheries

While these realities and connections are recognized in the ecosystem approach to fisheries, there is still more to do to advance management practice and they can still be downplayed in food security and development policies. Social and cultural aspects, including issues of wealth and gender, can affect how management strategies are developed and implemented. These can provide opportunities but also risk reinforcing or enabling systemic inequalities. Limited success in effectively establishing state-led control has resulted in inland fisheries frequently appearing to be of restricted developmental potential, associated with narratives of doom and an all-too-common acceptance of a limited future for capture fisheries (e.g. Friend, Arthur and Keskinen, 2009). Faced with this prognosis, solutions to the threats from environmental degradation, climate change and economic development can take the form of conservation, mitigation and alternative livelihoods. Those concerned about sustaining viable inland fisheries can struggle to demonstrate the significant opportunities associated with well-managed fisheries when the likelihood of achieving this result is itself presented as challenging. This becomes significant in the context of development policy and choices between alternative objectives for the integrated management of aquatic environments and water resources.

The representation of the difficult nature and limited future potential for inland fisheries is open to challenge. As the chapters in this edition of the circular seek to establish, the nature, role and importance of inland fisheries are still not fully captured in the statistics, and representations of these aspects are often limited. To date, a large part of the effort has been on the elusive goal of quantifying production, yet this provides only a small part of the picture and can be misleading when combined with assumptions about how fishers behave. Looking at the connections and relations associated with inland fisheries from the perspectives of food systems, basins and livelihoods reveals them to be about much more than just fish production. Examples from the lived realities show that the values and connections associated with inland fisheries can potentially provide an alternative basis and motivation for collective action and caring practices, which can then result in the maintenance or even restoration of inland fisheries and social relationships. It is recognized that it is often people that determine the ultimate success of fisheries management (e.g. Hilborn, 2007), and evidence is presented for how management outcomes might be improved when placing people, together with their knowledge, skills and creative capacities, more centrally in assessment and management.

1.7.2 Achieving positive transformations

Inland fisheries remain relevant in a changing world. Far from being of secondary importance to local livelihoods or an "activity of last resort", fishing is central to many local economies and provides a range of collective and individual benefits, not only to the poor (Arthur, Friend and Béné, 2016; Garaway *et al.*, 2006; Smith, Nguyen-Khoa and Lorenzen, 2005). Despite a lack of formal monitoring or control, many inland fisheries endure and are managed according to local rules – often derived from traditional rules and practices. This highlights more important connections: those between the traditional and the contemporary as well as between knowledge and practice. Economies and environments are changing, and such change is not always predictable. However, people linked to inland fisheries have learned to live with change and have developed creative and adaptive strategies, enabling them to take advantage of different environmental conditions. This responsiveness, derived from knowledge and experience, is central to many people's capabilities and can represent an important focus for strengthening fisheries management in dynamic and changing environments.

Yet inland fisheries also face many external pressures, often at the basin scale, to which fishers, fishery managers and the fish themselves have limited ability to control or adapt. A significant challenge to the assessment and management of inland fisheries is therefore to address this apparent mismatch between continued local relevance (and importance), and wider perceptions of a limited future. This requires that the roles and contributions can be better demonstrated to ensure that the opportunities that inland fisheries can provide can be recognized and realized (e.g. Coates, McInnes and Davidson, 2023). The evidence and insights that are presented in this edition of C942 suggest the potential for more pluralistic forms of assessment and management. These stress the relevance and opportunities that are presented by alternative methods for assessment, for example those that use data on habitats and flows to estimate production. This also extends to the management and governance of inland fisheries along with the need to recognize, and work with, different legal systems and regulatory frameworks – both formal and informal (Jentoft and Bavinck, 2019). It also means considering more explicitly the different people and interests that are at play, the multiple livelihood activities and strategies (Smith, Nguyen-Khoa and Lorenzen, 2005), and the different knowledges and values associated with these.

Some of the key challenges to support positive transformations that maintain and strengthen the role and benefits from inland capture fisheries relate to developing new and appropriate methods for assessment and forms of management that can draw on this plurality and these capabilities as strengths (e.g. Reid *et al.*, 2021; Arthur, Friend and Béné, 2016; Chapman, 2016). The Code of Conduct for Responsible Fisheries (FAO, 1995), the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (the SSF Guidelines) (FAO, 2015), the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security (the VGGT) (FAO, 2012), the Global Biodiversity Framework, and the Rome Declaration on Responsible Inland Fisheries (FAO and MSU, 2016) collectively provide an enabling framework within which these alternatives can be developed. Improving management and governance can start by focusing on the existing knowledge, capabilities and creative capacities of those who are living with these fisheries in addition to the benefits that they derive from sustainable fisheries connected to healthy environments and cultures.

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2. SUMMARY OF GLOBAL INLAND FISHERIES

Robert Arthur and Varun Tandon

SUMMARY

Inland capture fisheries are productive and efficient food sources, providing food security and nutrition and other contributions to livelihoods especially in low-income and land-locked countries. Catches from inland fisheries in 2021 stood at 11.4 million tonnes, representing 12.5 percent of total global capture fisheries production of aquatic animals with an estimated value of USD 19 billion. This can under-represent the significance of inland fisheries that deliver quality food and important sources of protein, fats and other essential nutrients to some of the world's most vulnerable populations in a manner that is both accessible and affordable. Further analysis indicates that inland fisheries production is concentrated in a smaller set of countries and territories, seventeen of which, with aggregate catches ranging between 151 000 and 1.8 million tonnes, producing 79 percent of this total.

The nature of inland aquatic environments and inland fisheries contributes to their accessibility. Over 80 percent of catches are harvested without mechanization. There is limited use of ice in inland fisheries operations and other preservation methods, including drying, smoking, salting and fermentation, are common in fish value chains. Furthermore, almost half of all fish is harvested on occasional foraging trips, evidence also of how fishing can potentially be combined with other livelihood activities. Indeed, most inland fisheries are small-scale operations supplying local economies through formal and informal economic activities to provide fish for household consumption.

Recreational fisheries are also widespread and retained recreational catches could make significant contributions to overall catches. Retained recreational catches are frequently consumed by fishers or shared with others, although their contribution to food and nutrition is yet to be adequately quantified. While fish are predominantly caught for food or recreation, fishing for the ornamental aquarium trade can be significant in parts of Africa, Asia and South America. Nevertheless, 90 percent of fish from inland capture fisheries is for direct human consumption and inland fisheries are particularly important in Africa and Asia, where the contribution of fish – be it on its own or in combination with other foods – can play crucial roles in addressing hunger and malnutrition.

The global population now stands at 7.6 billion and is projected to rise to around 8.5 billion people in 2030 and 9.7 billion by 2050 (DESA, 2022). Feeding this growing population in a sustainable manner is a recognized challenge that requires transformative action (FAO *et al.*, 2023). Inland capture fisheries[9] have important roles to play in addressing this global challenge, producing an estimated 11.4 million tonnes in 2021 according to official statistics (FAO, 2023). This represents 12.5 percent of global capture fisheries' production of aquatic animals from less than 1 percent of available water, with an estimated average value of approximately USD 19 billion annually between 2013 and 2017 (FAO, Duke University and WorldFish Center, 2023). In addition, inland capture fisheries represent an efficient food source, with a far lower land and water use footprint when compared with production of livestock or other protein-dense foods (Funge-Smith, 2018). Moreover, inland fisheries deliver quality food that represents important sources of protein, fats and other essential nutrients to some of the world's most vulnerable populations in a manner that is both accessible and affordable (FAO, Duke University and WorldFish Center, 2023; Arthur *et al.*, 2022). These nutritional and food security benefits are an integral part of the landscapes and livelihoods within these countries. However, both aquatic landscapes and economies in many parts of the world are changing, and with them livelihoods

9 Inland capture fisheries refers to the extraction of living aquatic organisms from natural or artificial inland waters, including enhanced fisheries but excluding those from aquaculture facilities.

and the roles and contributions of inland fisheries. This chapter provides an overview of the status of inland fisheries based on available global datasets. Additional information and detailed descriptions from subregional and national assessments can be found in Chapter 7.

Recognizing the contributions of inland fisheries and the ways these are connected to aquatic environments, economies and livelihoods through the relationships and practices associated with inland fisheries is vital for ensuring their sustained contribution to food security. Furthermore, such connections also reveal how changes in land and water use affect inland fisheries and the related food and livelihood opportunities (see Chapter 4 of this volume). In some cases, change creates possibilities for increased fish production, as well as for the co-existence of inland fisheries alongside other economic activities. However, change can also alter the roles that these fisheries play and even lead to the degradation of some fisheries and aquatic environments, with important implications for those dependent upon them. The critical challenge in navigating change is to be fully aware of the implications of decisions for present and future generations in terms of how they might be affected in terms of livelihood options and opportunities, food security and nutrition.

2.1 GLOBAL INLAND FISHERIES CATCH

FAO reported inland fisheries catch of 11.4 million tonnes in 2021 (see Annex 2-1 for details). Across all the countries and territories reporting inland fish catches, 17 of these, with aggregate catches ranging between 151 000 and 1.8 million tonnes, produced 79 percent of this total (Table 2-1). A further 12 percent of global catch is produced by another 14, with catches in the range of 50 000–150 000 tonnes. The next 6 percent is produced by 23, with catches in the range of 20 000–50 000 tonnes. The remaining 3 percent comes from a further 95, with national catches ranging between 1–20 000 tonnes.

Table 2-1: Summary table of global inland fisheries catch (2021)

Global total (%)	Total inland fishery catch (tonnes) (2015)	Range of national catch (tonnes)	Countries and territories
78.85	8 960 427	150 000 to 1 847 000	India; Bangladesh; China; Myanmar; Uganda; Indonesia; Tanzania; Cambodia; Nigeria; Egypt; Russian Federation; Brazil; Democratic Republic of the Congo; Philippines; Malawi; Mexico
12.02	1 365 711	50 000 to 150 000	Pakistan; Viet Nam; Thailand; Iran (Islamic Republic of); Mali; Zambia; Kenya; Chad; Mozambique; Ghana; Lao People’s Democratic Republic; Sri Lanka; Ethiopia; Uzbekistan
6.10	692 955	20 000 to 50 000	Niger; Guinea; Kazakhstan; Congo; Iraq; Türkiye; South Sudan; Rwanda; Sudan; Côte d’Ivoire; Cameroon; Burkina Faso; Benin; Central African Republic; Senegal; Angola; Ukraine; Finland; Zimbabwe; Venezuela (Bolivarian Republic of); Canada; Colombia; Nepal
1.95	221 973	10 000 to 20 000	Burundi; Poland; Japan; Peru; Paraguay; Argentina; Germany; Morocco; Turkmenistan; Mauritania; United States of America; Papua New Guinea; Gabon; Uruguay
0.93	105 347	1 000 to 10 000	31 countries and territories
0.15	17 282	1 to 1 000	50 countries and territories

The Asia region had the largest inland fishery catch at just over 50 percent of the global total (Table 2-2). Additionally, China contributed an additional 10.5 percent of the global total. Inland capture fisheries in Asia are highly productive based on the extensive available freshwater. This water is distributed in several large rivers, including the Ganges, Indus, Irrawaddy (or Ayeyarwady) and Mekong, and as well as their tributaries, floodplains and deltas – including extensive paddy field landscapes. China similarly has several large river systems, including the Yangtze River (Chang Jiang), Tarim, Yellow River (Huang He), Pearl River (Xun Jiang) as well as the Bei and Hsi rivers. In addition to inland capture fisheries, countries and territories in Asia and China are also major producers of freshwater aquaculture products.

The Africa region had the second largest catch in 2021, while the annual per capita production from inland fisheries (2.39 kg) was higher than that of Asia (1.5 kg) or China (1.8 kg) (Figure 2-1, Table 2-2). This highlights the potential importance of these fisheries to food security and income in Africa.

Table 2-2: Summary table of regional contributions to global inland fisheries catch (2021)

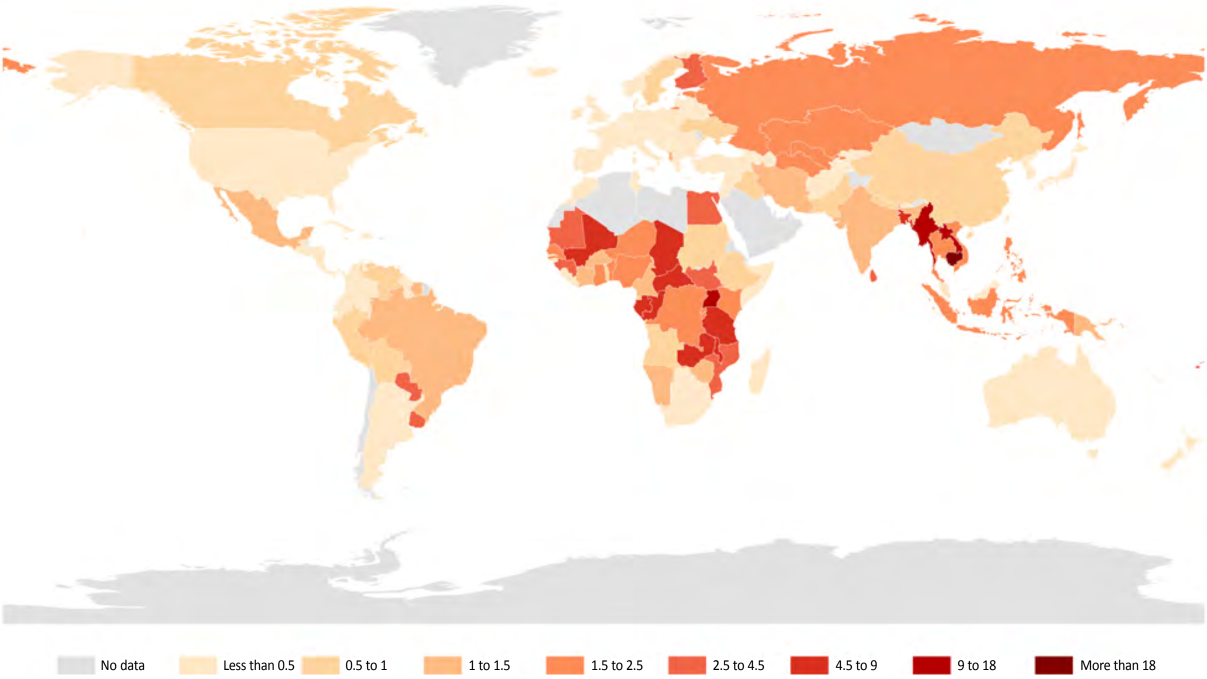
Region	**Inland capture fishery catch (tonnes) (2021)**	**Annual inland fishery production (kg/capita) (2021)**	**Global inland fishery catch (%) (2021)**
Asia	5 881 576	1.49	51.76
Africa	3 313 611	2.39	29.16
China	1 197 835	1.77	10.54
Americas	549 186	0.54	4.83
Russian Federation	271 795	1.87	2.39
Europe	133 122	0.22	1.17
Oceania	16 569	0.39	0.15
Arabia	0	0.00	0.00
GLOBAL	**11 363 695**	**1.43**	**100**

The Americas had the fourth-highest regional production representing almost 5 percent of global inland catches, with much of this production coming from the South and Central America subregions. Europe and the Russian Federation contributed 1.2 and 2.4 percent of global inland fish catches respectively. Oceana contributed 0.15 percent (16 569 tonnes) mainly from Papua New Guinea, New Zealand, Australia and Republic of Fiji. Arabia had no reported inland fishery catch.

Due to the dispersed and fluctuating nature of inland fisheries, catch statistics are challenging to collect and can lead to over- and under-estimation of fish catches (see Chapter 3 of this volume). Recent studies such as FAO, Duke University and WorldFish Center (2023), Ainsworth, Cowx and Funge-Smith (2021), and Fluet-Chouinard, Funge-Smith and McIntyre (2018) have suggested that catches from inland capture fisheries may be underestimated. FAO, Duke University and WorldFish Center (2023) suggest that missing catches could be in the region of 3.4–4.8 million tonnes. Based on the distribution of catches, the two regions where the bulk of this potentially underestimated landings are most likely to occur are Africa and Asia.

Regionally, the annual average per capita inland fisheries catch ranged from 0.0 kg in Arabia to 2.4 kg in Africa. Asia and China had values of 1.5 kg and 1.8 kg respectively. These figures were close to the Russian Federation's figure of 1.9 kg. Elsewhere the figures were lower, with the Americas at 0.5 kg and Oceania at 0.4 kg. Europe had the lowest average at 0.2 kg. The Illuminating Hidden Harvests project (FAO, Duke University and WorldFish Center, 2023) identified higher annual yields per capita in least-developed countries (5.7 kg) compared to other developing and developed countries or territories (0.8 kg).

Figure 2-1: Global inland fishery annual catch, per capita of population (kg).



Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties. Final boundary between the Republic of Sudan and the Republic of South Sudan has not yet been determined.
Source: FAO, 2023, the map was generated using the QGIS Geographic Information System (QGIS Geographic Information System. Open Source Geospatial Foundation. URL http://qgis.osgeo.org) using the UN Country Boundaries of the World shapefiles (http://www.fao.org/figis/geoserver/ows).

2.2 TRENDS IN REPORTED NATIONAL CATCHES 2012 TO 2021

For several reasons, trends in aggregate fish catches can be misleading, including due to methodological adjustments over time and uneven distribution of inland fisheries and fish catches. While aggregating catches can help overcome the effects of variability, particularly where fish catches are sourced from fluctuating environments, production is often not a good indicator of the status of inland fisheries (Ainsworth, Cowx and Funge-Smith, 2021) or fisher behaviour. Implicit in generalized fishery development models (e.g. Grainger and Garcia, 1996) are assumptions about the objectives and responses of fishers to changing productivity and, in particular, how these translate into fishing capacity and fishing effort to drive the fishery towards overexploitation. These assumptions may not hold in inland fisheries (see Chapter 5 of this volume).

Notwithstanding these issues, an analysis was made of individual catches across reporting countries and territories for the decade 2012–2021 grouped based on catch trends. This analysis can indicate the catch trends of individual countries and territories and the influence this has on the global inland fishery catch trend. This allows those countries and territories that are contributing positively to growth in inland fisheries to be identified, as well as those for which inland fishery catches may have no clear trend or are declining.

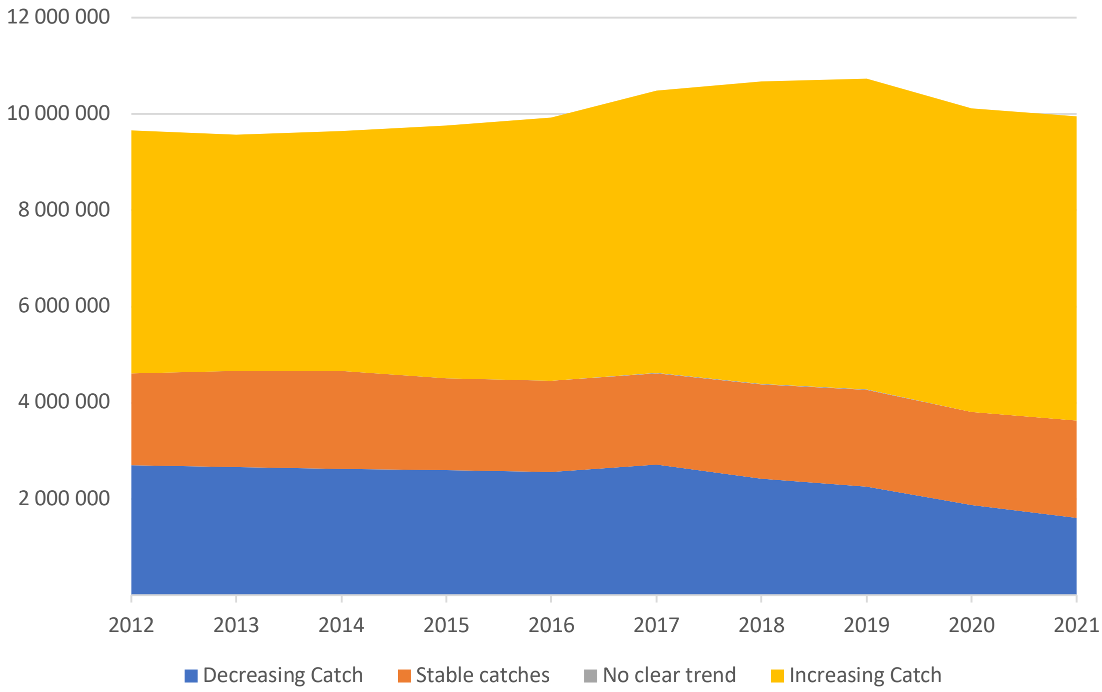
It was not possible for this analysis to include all 149 countries and territories that had an inland fishery catch in 2021. This is because several do not report with sufficient regularity to FAO, requiring estimation of their national catch. To base the trend analysis on national reports only, the analysis excluded those countries or territories that reported inland fishery catch to FAO five or fewer times over the decade, or if the figures appeared to have been repeated (60 in total). These 60 excluded from the analysis represented 12.5 percent (1 414 367 tonnes) of the global inland fish catch for 2021. Of the remaining 89 countries and territories, a Mann–Kendall trend analysis (with a 90 percent confidence level) was performed to establish the trend in reported production (Table 2-3).

Table 2-3: Production trends and the relative contribution to the global catch

Catch trend over 2012–2021	Number of countries and territories	Aggregate catch in 2021 (tonnes)	Percentage of global catch	Countries and territories having a significant effect on the group (>1% of total catch of group)
Increasing catch	25	6 320 601	55.62	India (29%); Bangladesh (21%); Myanmar (12%); Indonesia (7%); United Republic of Tanzania (7%); Egypt (5%); Malawi (3%); Mexico (3%); Pakistan (2%); Islamic Republic of Iran (2%); Mali (2%); Zambia (2%); Mozambique (2%); Sri Lanka; Ethiopia; Kazakhstan; Congo; Burkina Faso; Argentina; Uruguay; Togo; Albania
Decreasing catch	21	1 606 029	14.13	China (75%); Thailand (7%); Kenya (6%); Ghana (5%); Türkiye (2%); Japan; Peru; United States of America; Madagascar; Republic of Korea; Hungary; Serbia; Slovakia; Switzerland; Lithuania; El Salvador; Gambia; New Zealand; Iceland; Australia; Guyana
Stable catch	41	2 022 455	17.80	Uganda (31%); Cambodia (19%); Russian Federation (13%); Philippines (10%); Viet Nam (7%); Niger (2%); Iraq (2%); Rwanda (2%); Cameroon (2%); Benin; Angola; Ukraine; Finland; Zimbabwe; Canada; Burundi; Poland; Germany; Morocco; Sweden; Malaysia; Czechia; Romania; Estonia; Cuba; Panama; Israel; Jamaica; United Kingdom of Great Britain and Northern Ireland; Belarus; Nicaragua; North Macedonia; Jordan; Ecuador; Croatia; Norway; Latvia; Denmark; Slovenia; Ireland; French Guiana
No clear trend	2	243	0.002	Taiwan Province of China (63%); Bulgaria (37%)
Excluded from analysis	60	1 414 367	12.45	Nigeria (26%); Brazil (16%); Democratic Republic of the Congo (16%); Chad (7%); Lao People's Democratic Republic (5%); Uzbekistan (4%); Guinea (3%); South Sudan (2%); Sudan (2%); Côte d'Ivoire (2%); Central African Republic (2%); Senegal (2%); Venezuela (Bolivarian Republic of) (2%)

There are 25 countries and territories that indicated an increasing production trend over the decade, representing 55.6 percent of global inland fish catch (Figure 2-2). This compares to 37 (representing 58.7 percent of the catch) that were reported for the decade 2006–2015 (Funge-Smith, 2018). For the current reported period, the major drivers of this trend were due to changes in reported catches in India, Bangladesh and Myanmar (Table 2-3).

Figure 2-2: Global catch trend for the decade 2012–2021 (tonnes).



Source: FAO, 2023.

There were 21 countries and territories for which the data indicated a decreasing production trend, representing 14 percent of global inland fish catch, and of this group the trend was driven by China, Thailand and Kenya (Table 2-3). There were 41 that demonstrated stable catches, indicating that there is little or no variation in their reported catch trend. The major contributors to global catch in this group were Uganda, Cambodia, the Russian Federation and the Philippines (Table 2-3). The group with stable catches represents 17.8 percent of global catch. Taiwan Province of China and Bulgaria had no discernible trend in their catch. The conclusion of this analysis is that growth in global inland fisheries is driven by 25 countries and territories and, of these, about 5 relatively large producers are the majority drivers of this trend. The 21 countries and territories that reported declining catches represent a low contribution to global production except for China.

2.3 OVER- AND UNDER-REPORTED CATCH

The challenges of collecting reliable statistics for inland fisheries are widely recognized (Funge-Smith, 2018; Bartley *et al.,* 2015). Monitoring of inland fisheries can be biased towards fisheries where catch volumes are significant (such as reservoirs or large natural waterbodies) or easily accessible. The methods of capture and processing also contribute to the challenges. As FAO, Duke University and WorldFish Center (2023) report, around three-quarters of catches from inland capture fisheries are harvested using either no vessel or non-motorized vessels. Furthermore, over 80 percent of catches are harvested without mechanization. There is limited use of ice in inland fisheries operations and other preservation methods, including drying, smoking, salting and fermentation are common in fish value chains (FAO, Duke University and WorldFish Center, 2023).

Catches of subsistence fisheries that are often locally important may be included as estimates or excluded entirely. Where they are estimated, reported catch figures may be repeated over several years, leading to systematic under- or over-reporting, while improvements to surveys and reporting can also mask long-term trends. In the latter case FAO produces estimates which are subject to uncertainties. At a global level, in different estimates of aggregate catch this means that inland fisheries may be over or underreported, as highlighted in Table 2-4, which provides a summary of recent global estimates of inland fish catches.

Table 2-4: Global catch estimates for inland fisheries

Estimate of production*	Catch (million tonnes)	Source
FAO Fishstat total annual catch for 2021	11.4	FAO (2023)
Total catch including adjustments of 42 extrapolated to a total of 80 countries and territories based on consumption data from 1994 to 2014 and modelling	16.6	Fluet-Chouinard, Funge-Smith and McIntyre (2018)
Total catch compiled from fisheries within major hydrological basins from the literature and FAO FishStat data outside basins	15.2	Ainsworth, Cowx and Funge-Smith (2021)
Catch consumption studies in 58 countries and territories supplemented with FAO FishStat data averaged over the period 2013-2017	11.8	FAO, Duke University and WorldFish Center (2023)

* Issues associated with estimating inland fish catch are considered further in Chapter 3 of this volume.

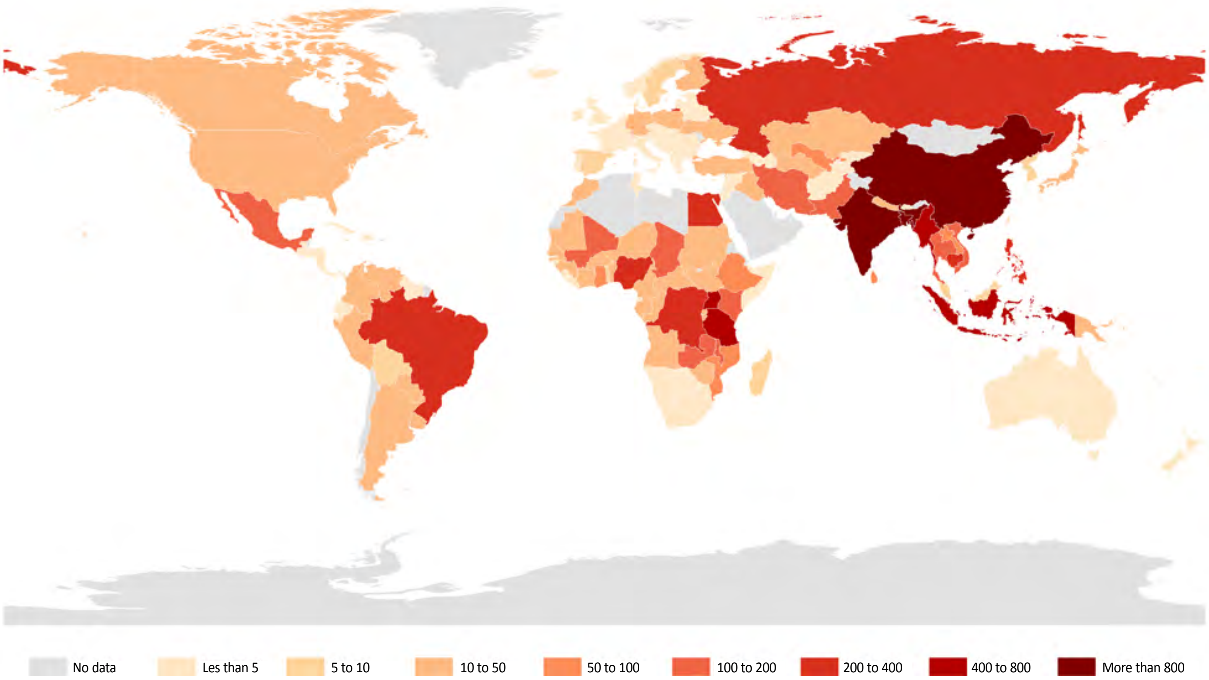
2.4 LOCATIONS AND CHARACTERISTICS OF INLAND CAPTURE FISHERIES

Inland capture fisheries are not distributed evenly around the world, with Asia having the highest level of production (Table 2-2). Inland fisheries are particularly important for land-locked and least-developed countries, given that nearly 59 percent of catch from small scale fisheries in least-developed countries is from inland fisheries (FAO, Duke University and WorldFish Center, 2023).

2.4.1 Distribution of inland capture fisheries

While there are inland fisheries on every continent aside from Antarctica, the world's inland capture fisheries are particularly concentrated in the tropical and subtropical latitudes of the world, with a few notable exceptions e.g. Russian large lakes, the Volga and Yenisei rivers, Paraguay/La Plata River in South America, Chinese large rivers (Figure 2-3). In general, inland fisheries are concentrated around productive waters, typically where there are also large rural populations (Ainsworth, Cowx and Funge-Smith, 2023; Funge-Smith, 2018).

Figure 2-3: Map of annual inland fisheries production by countries and territories (in tonnes).



Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties. Final boundary between the Republic of Sudan and the Republic of South Sudan has not yet been determined.
Source: FAO, 2023, the map was generated using the QGIS Geographic Information System (QGIS Geographic Information System. Open Source Geospatial Foundation. URL http://qgis.osgeo.org) using the UN Country Boundaries of the World shapefiles (http://www.fao.org/figis/geoserver/ows).

The database developed by Lehner and Grill (2013), based on the hydrosheds database, identifies 3 210 hydrological basins. Many of these basins are rather small and may not contain significant hydrological resources to support fisheries. The Global Runoff Data Centre (GRDC) database[10] identifies more than 405 major river basins in the world with an estimated 263 international or transboundary river basins. The major basins tend to be large river basins and can encompass a range of different aquatic environments, including upland headwaters (some at high altitude), floodplains and deltas. With hydrological basins widely distributed, basins span temperate–arctic and temperate–tropical environments.

Across the globe, 45 major hydrological basins that have significant inland fisheries have been identified (Chapter 4 this volume; Ainsworth, Cowx and Funge-Smith, 2021). In addition, there are many smaller hydrological basins where inland fisheries may also contribute significantly to national fishery catches. The majority of these are in tropical regions, although fisheries in cold regions can also be important locally, although the production from these basins may be low. This can be due to issues of accessibility (such as some of the North American and Siberian lakes and rivers) or that they mainly feature recreational fisheries. Nevertheless, these fisheries can play important roles in food security and nutrition in particular locations and for particular groups who retain, share and eat fish (Chapter 5 this volume; Embke *et al.*, 2022; Cooke *et al.*, 2018).

Within the basins, fisheries occur across a range of different aquatic environments. Through a global assessment, Lymer *et al.*, (2016) categorized the aquatic environments into permanent lakes, floodplains (including freshwater marshes), rivers (including streams), reservoirs, and other wetlands (including swamp forest, flooded forest, bogs, fens, mires, intermittent wetlands, and lakes and paddy fields). Globally, water surface areas were identified as composed of 30.7 percent lakes, 30.9 percent floodplains, 4.2 percent rivers, 2.8 percent reservoirs, and 31.4 percent as other types of wetlands (Lymer *et al.,* 2016). The productivity of these different habitats varies between the types and with location. Contributing to productivity is the connectivity of aquatic environments because reductions in connectivity can alter fish assemblages, reduce population resilience to environmental disturbances and reduce genetic mixing (King, de Jong and Cowx, 2023).

2.4.2 Characteristics of inland fisheries

The distribution and nature of aquatic environments affect the nature of inland fisheries, their productivity and accessibility and, consequently, livelihood opportunities. FAO, Duke University and WorldFish Center (2023) estimated that almost three-quarters of inland fish catches are harvested from seasonal waterbodies, wetlands, small streams, paddy fields and areas less than 5 km from the shores of permanent rivers, waterbodies and wetlands. This contributes to the nature of operations, with an estimated 13.9 percent of small-scale inland fish catch being harvested using no vessel, compared to less than 2 percent in small-scale marine fisheries. Furthermore, almost half of all fish is harvested on occasional foraging trips, evidence of how fishing can potentially be combined with other livelihood activities. Indeed, most inland fisheries are small-scale operations, supplying local economies through formal and informal economic activities to provide fish for household consumption. These fisheries vary in the types of gears that are used, which may also vary seasonally and amongst different users depending on wealth, gender or other variables. It is important to establish the significance of small-scale fisheries in inland waters in the context of international processes, of which the SSF Guidelines are an important part, in order to recognize and prioritize small-scale fisheries.

A global study estimated that catches from inland small-scale fisheries accounted for over 99 percent of total inland catches (FAO, Duke University and WorldFish, 2023). While, globally, large-scale inland fisheries are estimated to account for only 0.03 percent of total inland fish production, these can be locally significant (FAO, Duke University and WorldFish Center, 2023) as they can range in size from a few thousand tonnes to a few hundred thousand tonnes. Large-scale and commercialized inland fisheries are not always at risk of overexploitation and large-scale and commercial operations can operate alongside small-scale fishing.

10 Available at http://www.bafg.de/GRDC/

While the economic value of inland fish catches is estimated to be approximately USD 19 billion, this total is just an estimate of the landed value of the fish caught, that is fresh fish, and therefore does not capture the significant value of both pre- and post-harvest activities (FAO, Duke University and WorldFish Center, 2023). Critically, for inland fisheries where fishing may represent one of several livelihood activities, this form of valuation captures only the value of the fish and not other aspects of the fishery, including the products, the institutions, and investments made to maintain commons. That the relationships – including trade, processing and other forms of provisioning – associated with them are not typically included in valuations can downplay both the variety of roles and the contributions that they make. This can be important where fish and fisheries play roles supporting other economic activities and provide welfare functions.

Fish trade can play an important role in the accessibility of inland fish to consumers in developing countries or areas within them and it has been estimated that almost 14 percent of the contribution from inland small-scale fisheries is generated by other developing countries or areas (FAO, Duke University and WorldFish Center, 2023). With respect to trade, some inland fisheries also engage in specialized marketing techniques, most notably ecolabels and local branding, that ostensibly support sustainable fisheries governance. For example, fisheries in Europe (such as the Lake Hjälmaren, Lake Mälaren and Lake Vänern pike-perch fishery) and in Northern America (the Lake Erie multi-species commercial fishery) have all obtained certification by the Marine Stewardship Council (MSC), a market-based sustainable seafood certification scheme.

2.4.3 Enhanced fisheries

Fish stock enhancement lies at the interface between extensive aquaculture and inland capture fisheries, especially when the fish have been cultured in aquaculture hatcheries and released to open waters. Large-scale stocking programmes have been undertaken for the enhancement of, for example, salmonid fisheries in rivers and lakes, carps in South and Southeast Asia and sturgeon in the Caspian Sea. There are different incentives for stocking that include enhancing stocks for increased food production, to support recreational fisheries and for conservation purposes (e.g. Cowx, Funge-Smith and Lynch, 2023). In addition to stocking, capture fisheries may also be enhanced through use of aggregation devices as well as habitat management and enhancements such as brush parks or management of the habitat in breeding grounds.

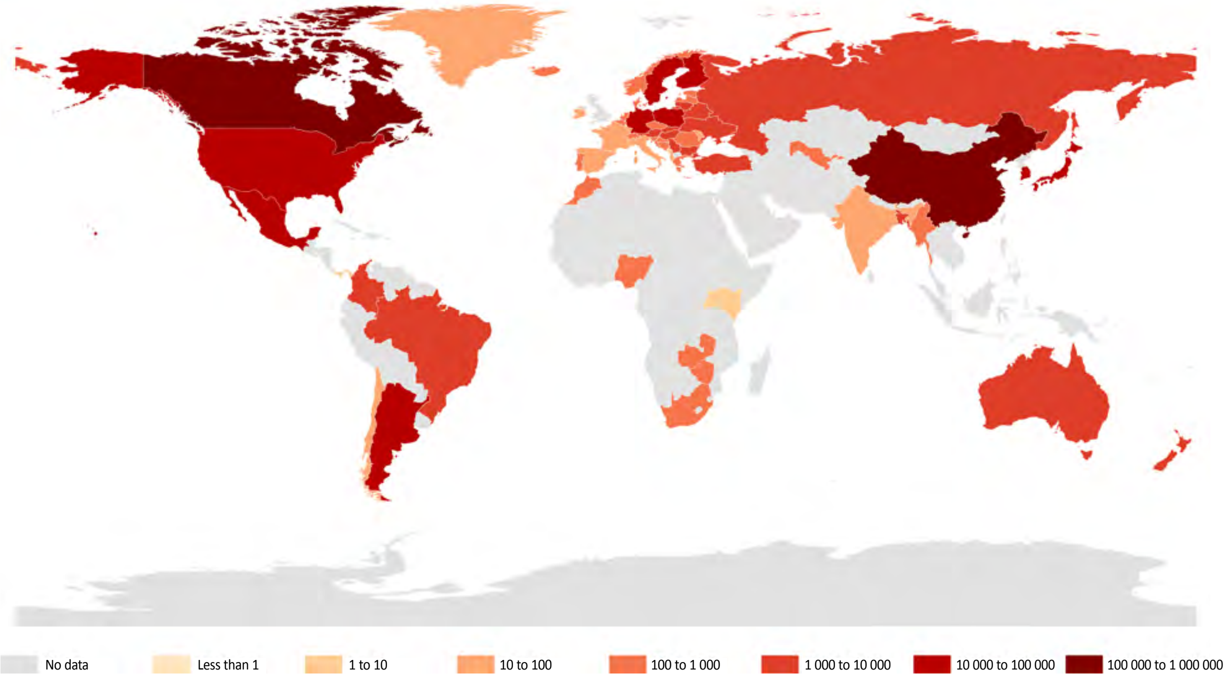
Reporting of enhanced fisheries can be problematic. Many stocking events are ad hoc and remain unrecorded or, where there are records, both stocking and yields from stocked waters may be treated as aquaculture. Production is often a mixture of stocked and wild, naturally recruited fish and, where native species are stocked, it can be difficult to distinguish stocked from wild.

2.4.4 Recreational fisheries

As with other types of inland capture fisheries, inland recreational fisheries are widespread and take place in rivers, streams, lakes (including frozen lakes), reservoirs and other natural and man-made waterbodies. Globally, it is estimated that around and almost 200 species are targeted (Embke *et al.,* 2022). Recreational fishing is not always a function of a shift away from subsistence fishing, since in many Eastern European countries and the Russian Federation there is a long tradition of recreational fishing to provide fish for consumption. This is classified as neither subsistence nor artisanal fishing and is sometimes referred to as “amateur fishing” (such as Kolonchin *et al.*, 2024). Recreational fishing can be an important activity in many countries and territories around the world. While participation and catches remain extremely hard to quantify, Lynch *et al.* (2024) and Embke *et al.* (2022) have recently estimated the catches for 80 major countries to be 1.3 million tonnes (equivalent to 11.3 percent of all reported inland fish catches) with 286 million people participating in recreational fisheries in these countries. As Lynch *et al.* (2023) indicate, participation in recreational fisheries is not limited to countries with more industrialized economies, for example it is estimated that there are over one million people fishing recreationally in inland waters in South Africa alone (Potts *et al.,* 2021).

Crucially, recreationally caught fish are frequently harvested and consumed by fishers or shared with others, making contributions to food security and nutrition that have not yet been adequately quantified, and that may be particularly important for certain populations. Embke *et al.*, (2022) have provided some estimates of catches retained for consumption, suggesting that this can be as much as 69 percent of the catch (see Figure 2-4. Beyond limited global harvest estimates, few have explored species-specific harvest or consumption patterns. While catch-and-release is a common practice, behavioural differences have been documented between countries and subregions such as recreational fishers in Scandinavia, Eastern Europe and the Russian Federation more likely to retain and consume fish than those in Northern America (Cooke *et al.*, 2018).

Figure 2-4: Map of the recreational fisheries regions, in terms of numbers of the amount of catch (tonnes) that is retained for consumption.



Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties. Final boundary between the Republic of Sudan and the Republic of South Sudan has not yet been determined.
Source: Elaboration based on Embke *et al.*, 2022, the map was generated using the QGIS Geographic Information System (QGIS Geographic Information System. Open Source Geospatial Foundation. URL http://qgis.osgeo.org) using the UN Country Boundaries of the World shapefiles (http://www.fao.org/figis/geoserver/ows).

2.4.5 Ornamental fisheries

While fish are predominantly caught for food or recreation, there are also inland fisheries where fish are caught for the ornamental aquarium trade. Mainly found across Africa, Asia and South America, such fisheries are often poorly documented but nevertheless can be significant. It is estimated that more than 300 species of ornamental fish are obtained from inland capture fisheries in Southeast Asia and similar numbers reportedly collected from the wild in India (Tapkir *et al.*, 2021). Lake Malawi, which has large numbers of endemic species (predominantly cichlids) also has important ornamental fisheries targeting hundreds of species that supply the international aquarium trade (Msukwa, Cowx and Harvey, 2022). On average, around 30 000 fish are exported annually from Lake Malawi for this purpose, with an export value estimated at almost USD 220 000 (Msukwa, Cowx and Harvey, 2022). In the Brazilian Amazon, cardinal tetra (*Paracheirodon axelrodi*) is an important target for the trade, with export to Asia, Europe and North America. This trade is economically significant and employs thousands of people (Ruffino, 2014). The importance to local economies and livelihoods is illustrated by Monticini (2010), who reports that ornamental fish trade accounts for over 60 percent of the economy in the municipality of Barcelos, in the Brazilian Amazon.

2.5 EMPLOYMENT IN INLAND FISHERIES

Participation in inland fisheries for food production can take a range of different forms. It can constitute the primary work activity; be an activity conducted in parallel with other work activities not related to fisheries, for example when using passive gears; or be a complementary effort that either generates additional income, for example during agriculture off-seasons, or income that is invested in and enables other activities such as the necessary purchase of agricultural inputs (Béné and Friend, 2011; Arthur, Friend and Béné, 2016). Fishing may also be part of adaptation strategies that can include seasonal migrations and participation may therefore represent forms of part-time or occasional employment for many (Funge-Smith and Bennett, 2019). Recent estimates for inland small-scale fisheries suggest that around 14.6 million people were employed in fish harvesting in 2016 with an additional 36 million people participating in inland subsistence fisheries, representing 68 percent of total subsistence fishing (FAO, Duke University and WorldFish Center, 2023). Participation rates by gender suggested that 20.1 percent of those employed in small-scale fish harvesting were women and 44.3 percent of subsistence harvesting and processing was undertaken by women (FAO, Duke University and WorldFish Center, 2023).

The diversity of livelihoods makes describing and quantifying employment challenging. Many small-scale fishing activities are not counted as employment because they are informal or not otherwise market-oriented (FAO, Duke University and WorldFish Center, 2023). The nature of participation and categorization of livelihood activities as “primary” or “secondary” can also serve to obscure the significance of subsistence and part-time contributions to economies. FAO, Duke University and WorldFish Center (2023) highlight the case of the Lao People’s Democratic Republic, where an estimated 16.9 percent of the national population participate in subsistence harvesting or processing activities, being even higher in certain areas.

2.6 FISHERIES, FOOD SECURITY AND NUTRITION

Most fish is ultimately food, and it is important therefore to consider inland fisheries in terms of their contributions to food supply. In particular, to recognize the diversity also in the connections that exist between capture and consumption and relevance of a food system perspective (see Chapter 4). Inland fisheries are particularly important in Asia and Africa, with over half of the undernourished people in the world living in Asia, and more than one-third in Africa (FAO, 2021).The contribution of fish, be it on its own or in combination with other foods, can play crucial roles in addressing hunger and malnutrition as estimates suggest that 90 percent of fish from inland capture fisheries is for human consumption (Welcomme *et al.*, 2010).

In terms of supply of fish for food, inland capture fisheries provide nearly 15 percent of global food fish from capture fisheries (FAO, 2022). Although 15 percent may seem modest, this aggregate figure disguises the fact that contributions of inland fisheries to food systems can be especially important for particular regions of the world (FAO, Duke University and WorldFish Center, 2023) and for certain populations (Bennett *et al.*, 2018). In such cases, the contribution to nutrition for poor people can be greater than that of fish from either marine capture fisheries or aquaculture (McIntyre, Liermann and Revenga, 2016).

The dispersed nature of many inland fisheries can be beneficial in this regard as it has been found that households living within 5 km of waterbodies supporting small-scale fisheries eat fish about twice as frequently per week as those living further away (FAO, Duke University and WorldFish Center, 2023). Nutrition for women and young children has been identified as particularly important, yet these groups are amongst those who can find it most challenging to benefit nutritionally from fisheries (O’Meara *et al.*, 2021; Medard, 2015). Nutritional value is generally highest in smaller fish, particularly when consumed whole, and these fish can also be widely available as dried or fermented fish products (e.g. Bavinck *et al.,* 2023; Kolding *et al.*, 2019).

The aggregated catches can hide some of the detail and as such catch per capita (that is, the total catch divided by total population) can go some way towards providing a better representation of the importance of catches across countries and territories. Given that many inland fisheries are located within low-income food-deficit countries (LIFDCs) and land-locked developing countries (LLDCs) where there are lower total catches or where there are for example in land-locked countries and where there are substantial freshwater resources, catches become much more significant when viewed as catch per capita. When considered this way (Table 2-5), the importance of inland fisheries in LIFDC and LLDC countries becomes clearer. Notable exceptions are Finland and Estonia.

Table 2-5: Inland fisheries catch per capita population (2021)

Annual catch per capita of population (kg)	Countries and territories
10 to 35	Cambodia; Myanmar; Uganda
5 to 10	Lao People’s Democratic Republic; Malawi; Bangladesh; Congo; United Republic of Tanzania; Chad; Zambia; Central African Republic
2 to 5	Mali; Gabon; Finland; Mauritania; Uruguay; Mozambique; Guinea; South Sudan; Egypt; Sri Lanka; Fiji (Republic of); Paraguay; Ghana; Rwanda; Turkmenistan; Democratic Republic of the Congo; Benin; Kazakhstan; Estonia
1 to 2	Kenya; Russian Federation; Niger; Philippines; Indonesia; Nigeria; Thailand; Senegal; Burundi; Uzbekistan; Viet Nam; Zimbabwe; Suriname; Papua New Guinea; Burkina Faso; India; Mexico; Albania; Iran (Islamic Republic of); Cameroon; Côte d’Ivoire; Namibia; Brazil
0.1 to 1	Iraq; China; Venezuela (Bolivarian Republic of); Sweden; Togo; Sudan; Angola; Nepal; Pakistan; Bolivia (Plurinational State of); Equatorial Guinea; Canada; Ukraine; Peru; Ethiopia; Poland; Hungary; Morocco; Colombia; Türkiye; Argentina; Lithuania; Slovakia; Serbia; Czechia; Iceland; Jamaica; Gambia; Madagascar; Armenia; North Macedonia; Tajikistan; Panama; Montenegro; Sierra Leone; French Polynesia; Germany; Democratic People’s Republic of Korea; Dominican Republic; Switzerland; Romania; Malaysia; Japan; Azerbaijan; El Salvador; Guatemala; Cuba; Syrian Arab Republic; Latvia; Republic of Korea; Israel; Liberia

The top 30 countries and territories (listed in Table 2-6) represent 10.6 percent of the global population, including 18 in Africa, 5 in Asia and 2 in the Americas. Cambodia has the highest per capita production from inland capture fisheries at 23.1 kg. Based on the catch per capita data, inland capture fisheries appear particularly important in African land-locked countries (including the Central African Republic, Chad, Malawi, Mali, Uganda, and Zambia) and for LIFDCs.

Table 2-6: The top 30 countries and territories with high per capita catch of inland fish

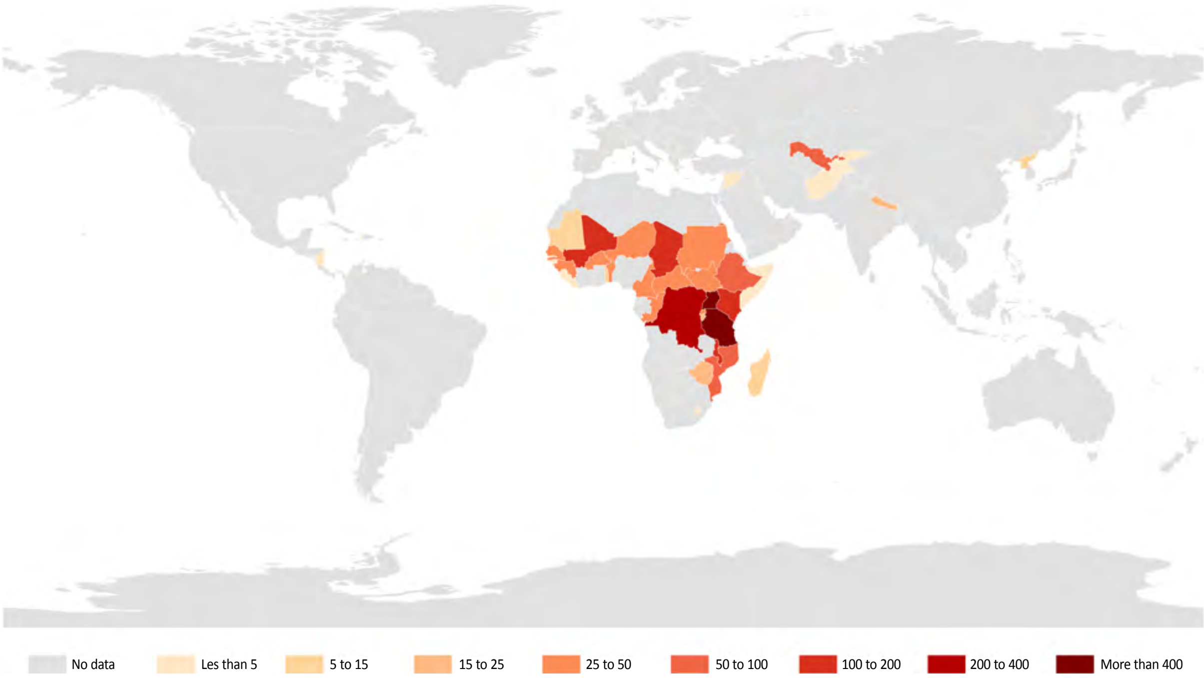
Countries and territories	Inland fish catch (tonnes) (2021)	Population (2021)	Inland fish catch per capita of population (kg)	LIFDC
Cambodia	383 050	16 589 023	23.09	–
Myanmar	786 110	53 798 084	14.61	–
Uganda	621 987	45 853 778	13.56	Yes
Lao People’s Democratic Republic	71 000	7 425 057	9.56	–
Malawi	170 560	19 889 742	8.58	Yes
Bangladesh	1 301 244	169 356 251	7.68	–
Congo	39 128	5 835 806	6.70	–
United Republic of Tanzania	414 105	63 588 334	6.51	Yes
Chad	103 000	17 179 740	6.00	Yes
Zambia	105 125	19 473 125	5.40	–
Central African Republic	28 000	5 457 154	5.13	Yes
Mali	107 100	21 904 983	4.89	Yes
Gabon	11 160	2 341 179	4.77	–
Finland	23 574	5 535 992	4.26	–
Mauritania	15 000	4 614 974	3.25	Yes
Uruguay	10 910	3 426 260	3.18	–

Table 2-6: The top 30 countries and territories with high per capita catch of inland fish

Countries and territories	Inland fish catch (tonnes) (2021)	Population (2021)	Inland fish catch per capita of population (kg)	LIFDC
Mozambique	100 000	32 077 072	3.12	Yes
Guinea	42 000	13 531 906	3.10	Yes
South Sudan	32 500	10 748 272	3.02	Yes
Egypt	330 142	109 262 178	3.02	–
Sri Lanka	62 157	21 773 441	2.85	–
Republic of Fiji	2 600	924 610	2.81	–
Paraguay	17 560	6 703 799	2.62	–
Ghana	81 000	32 833 031	2.47	–
Rwanda	32 094	13 461 888	2.38	Yes
Turkmenistan	15 042	6 341 855	2.37	–
Democratic Republic of the Congo	220 500	95 894 118	2.30	Yes
Benin	29 000	12 996 895	2.23	Yes
Kazakhstan	41 457	19 196 465	2.16	–
Estonia	2 795	1 328 701	2.10	–

Based on the available catch data, 13 of the countries with the highest per capita catches are also categorized as LIFDCs. Overall, LIFDCs contribute 21 percent of the total global inland fish catch (Figure 2-5). This highlights the continued importance of the inland fish catch as a contributor to food security and nutrition in these countries. The reduction in the overall contribution of LIFDCs to the global inland fish catch - from 44 percent reported in Funge-Smith (2018) to 21 percent in this publication – is principally due to the removal of India, Pakistan and Bangladesh from the list of LIFDC countries.

Figure 2-5: LIFDCs (indicated by shading according to annual inland fish catch in tonnes) contribute over 20 percent of global inland fish catch.



Source: FAO, 2023, the map was generated using the QGIS Geographic Information System (QGIS Geographic Information System. Open Source Geospatial Foundation. URL http://qgis.osgeo.org) using the UN Country Boundaries of the World shapefiles (http://www.fao.org/figis/geoserver/ows). Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties.

2.7 CONCLUSIONS

Inland fisheries are important in terms of production, productivity and efficiency. Their contributions to livelihoods include food security and nutrition as part of food systems but extend beyond this (see Chapter 5). These contributions are particularly important for certain countries, including LIFDC and LLDC, and for certain populations, including those associated with recreational fishing. Inland fisheries are also important because they are dispersed, and the nature of the waterbodies also means that people can often participate in fishing at low-cost and with simple, unmechanized gears. The accessibility of inland fisheries plays an important role in the variety of ways in which they can contribute to and support livelihoods, and this is also reflected in frequently high participation rates.

The nature of inland fisheries also underpins the roles that they can play in food systems. Fish from inland fisheries is often consumed fresh or processed through drying, smoking or fermenting. These processing methods are typically traditional, not energy intensive and can be important in fluctuating fisheries. Processing in these ways allows fish to be stored and remain available for consumption when fish are less abundant and the creation of fish products such as fish powder and fish sauce that enable fish to be purchased in small quantities and used as supplementary ingredients or condiments in dishes.

While the nature of inland fisheries enables people to benefit from them, it can also create challenges for the assessment and management of these fisheries. Being dispersed, with high participation rates and with fish often eaten or processed soon after capture means that it can be difficult to directly measure catches and fishing effort. For some specialized non-food products, in particular ornamental fish, data may go unreported because trade occurs outside of established food value chains. An emphasis on the aggregate volume and value of fish landings can also lead to issues of distribution and nutritional benefit, as well as the role and contribution of fisheries within local economies being undervalued. This is particularly important in the context of management and investment decisions between alternative uses and within wider economic and development policies.

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3. AN ASSESSMENT OF THE QUALITY OF INLAND CAPTURE FISHERIES STATISTICS REPORTED TO FAO

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SUMMARY

While the quality and completeness of inland capture fisheries statistics has improved significantly in recent decades years, there continues to be persistent issues with the routine collection or reporting of inland fisheries statistics to FAO. This chapter provides an overview of the current status of FAO's inland capture fisheries production data and explores the use of some of the potentially complementary methods for estimating and predicting inland water production that do not rely on direct observation commonly associated with the monitoring of landed catches.

We examine the extent to which these complementary methods can potentially be used to address gaps in the official inland fisheries production data submitted to FAO and identify selected countries where improvements may be needed based on the comparison with official statistics. We also consider the potential of these methods to be combined with more well-established data collection mechanisms such as catch assessment surveys, particularly to improve the monitoring of dispersed, smaller or less formal types of inland fisheries – which have been historically neglected or excluded entirely from official inland fisheries production statistics.

Despite the importance of inland fisheries for livelihoods and their critical role in national and global food security, especially in low-income food deficit countries (LIFDCs) and land-locked developing countries (LLDCs) – see also Chapter 2 and Chapter 4 – inland fisheries statistics are not routinely collected or reported by many countries to FAO. This is despite their utility in national and regional fisheries policy and planning, as well as in fisheries management and conservation.

The official data that are reported to FAO are often incomplete in terms of the coverage of fisheries or list of reported species. In many cases the contribution of low-value, but locally important, catches of inland subsistence fisheries are excluded entirely. In other cases, improvements to catch surveys or reporting by countries mask long-term trends, creating breaks in the time series or year-on-year increases in catches as an artifact of improvements in the data collection.

These issues are largely driven by the practical challenges of monitoring inland fisheries: that they are predominantly small-scale, often highly dispersed, and dynamic in terms of fishing operations. These operations are occurring in diverse environments including large lakes, reservoirs, rivers and floodplains. For many inland fisheries, particularly those that are locally important economically and a critical source of nutrition, these practical challenges are compounded by limited resources available for monitoring and management of inland waters.

Consequently, a proportion of catches for inland fisheries are estimated or adjusted by FAO using diverse methods, in some cases based on limited alternative information of the prevailing trends occurring within the fisheries in question. Catch estimates may also be repeated over several years, potentially leading to systematic under- or over-reporting. The development and application of what we term "alternative estimation methods" – those which do not rely on direct observation of landed catches – present opportunities to reflect on the estimates provided in the official data collected by countries and derived from the application of alternative estimation methods. This can help identify opportunities and methods that could be used to complement catch assessments and address gaps in the inland fisheries production data, including in the estimates provided to FAO. In addition, consideration may be given to the role alternative estimation methods might play in providing estimates of catches for the dispersed, subsistence and otherwise invisible fisheries that may be more challenging to assess using routine direct catch sampling. Furthermore, on their own or in combination with frame surveys and catch sampling, such alternative methods offer the potential to collect information on additional and complementary indicators to production statistics, generating evidence of the social and economic importance of inland fisheries and connectivity between fish production and consumption of fish that can be used to inform the management of inland fisheries.

Consequently, FAO has proactively begun an assessment of the quality of the inland fisheries production data that are publicly disseminated (FAO, 2023) and to identify opportunities to strengthen the collection of data on inland fisheries statistics and the role of conventional catch assessment surveys alongside alternative estimation methods. The assessment has so far focused on countries in Africa and Southeast Asia, which collectively account for around 45 percent of global inland fisheries catches in recent years (FAO, 2023).

3.1 FAO INLAND CAPTURE FISHERIES STATISTICS QUALITY ASSESSMENT

The assessment of FAO's inland capture fisheries statistics considered both official data submitted by member states and FAO estimates for countries and territories in Africa and Southeast Asia. However, evaluating the quality of official data submitted to FAO is generally problematic. Publicly available information on the data collection, coverage of fisheries, and methodologies used by member states to produce inland fisheries statistics is limited, while "metadata" requested by FAO from countries and territories when submitting their annual questionnaires is often completed with minimal details or simply not completed.

Indicators were instead formulated to quantitatively assess and compare the quality of inland capture fisheries statistics for countries in Africa and Southeast Asia. These indicators were grouped into three important dimensions of data quality: (i) completeness, (ii) resolution, and (iii) accuracy, using a ten-point ordinal scale according to the distribution of values of each indicator. Scores were then summed for each country across each indicator and all three dimensions to rank countries in terms of the status of their official data submissions. Countries where potential improvements to the quality of their inland capture fisheries statistics may be needed – according to the data that are reported to FAO – were identified as those with the lowest scores. This assessment was further qualified by additional information obtained through literature reviews or online interviews with national fisheries institutions in the case of selected African countries. Alternative published estimates of inland capture fisheries production for each country were also collated and compared against the official estimates. The correlation between the official statistics and the unofficial production estimates derived using alternative estimation methods was also examined.

It was found that where data quality scores were low, it was generally associated with not undertaking routine catch assessment surveys, or where surveys were judged to be incomplete with respect to coverage of sectors and aquatic habitats. In one case, the official statistics appear to reflect policy targets rather than actual production. In some cases, capture production may be underestimated due to the incorrect assignment of capture production to aquaculture, particularly in the case where species are captured from the wild and also produced in various aquaculture systems.

Low scores also occurred where -production was not reported at species level, but rather under high-level aggregated groups such as "Freshwater fishes nei"[11] (*Actinopterygii*). In the case of Southeast Asia, almost 70 percent of total inland fisheries catches in 2021 were reported under this category, compared to 32 percent in Africa. The lower proportion of total catch reported this way masks the fact that, for 19 countries or territories in Africa, inland fisheries catches are available for Actinopterygii only. Similarly, often no production is reported for other aquatic animals, or only for those within economically important taxa such as "Freshwater crustaceans nei" (*Crustacea*). The high species diversity that generally occurs in inland capture fisheries contrasts with the relatively low number of species reported. This suggests that in many cases only major target or commercial species are being routinely monitored. This contrasts with aquaculture reports where reporting is generally at the species level.

11 Not elsewhere included

While high scores were associated with fulfilment of the FAO data reporting requirements, this does not however necessarily guarantee the reliability of the data. Likewise, there may be cases where the underlying methodologies used to collect inland fisheries statistics are relatively robust, but these data are not reported to FAO and the countries consequently score low according to the assessment that was conducted. Without detailed knowledge of the methods used to collect data in each country, the status of official statistics is often not fully transparent, although it is generally accepted that catch and effort data collection systems in many countries in Africa and Southeast Asia have variable or low coverage across the range of inland aquatic environments present within countries.

3.2 IMPROVING INLAND CAPTURE FISHERIES STATISTICS

Different methods and models can be applied to estimate national inland fisheries catches (Figure 3-1). These methods can be placed into three broad categories that are described in turn in the following sections:

1. Observation
2. Prediction
3. Inference

Categories 2 and 3 are those related to the "alternative estimation methods". The purpose is not to provide an exhaustive review of all methods that can be used for estimating inland fisheries catches but serve to highlight some of the alternative methods and associated models that have been applied. Critically, the predictive alternative estimation methods provide estimates of *potential* productivity rather than the actual catches. Such estimates need to be adjusted using data on effort or, additionally, examples of actual catches. Nevertheless, potential productivity can provide useful indications of the potential yields that might be possible from a given fishery or inland aquatic environment but need to be used with caution.

Estimating inland capture fisheries catches, regardless of the method used, is also affected by changes in fishing technologies and practices. The significant growth in production from aquaculture and enhanced fisheries (for example, those created by stocking in reservoirs or paddy field fisheries that are common in Asia), combined with advances in related technology in recent decades, has made the task of correctly identifying and reporting sources of production – from aquaculture or capture fisheries – more important and demanding across all the methods. These types of environmental and technological changes mean that there is an ongoing need for advice on survey design to address issues such as distinguishing catches from capture fisheries from aquaculture production. FAO technical guidelines are planned for 2024 that will explore these issues and assess the methods available potentially to minimize bias that can lead to both under- and over-reporting of capture fisheries production.

3.2.1 Observation

Catch can be observed by means of catch assessment surveys (CAS). These commonly involve trained enumerators directly recording catches at landing sites or onboard vessels using survey forms, or by fishers or intermediaries using logbooks (Lorenzen *et al.*, 2016; Stamatopoulos, 2002; Sparre *et al.*, 1998). For example, community-based (participatory) data collection activities have shown to be particularly successful for monitoring seasonal and part-time foot fishers (FAO, Duke University and WorldFish Center, 2023) and have been used successfully in the Lower Mekong Basin, where fisheries monitoring is undertaken almost exclusively by trained, equipped and renumerated members of fisher communities using logbooks. Catch assessments may also be conducted by enumerators through interviews with fishers using respondent recall to provide estimates of catches (Castello *et al.*, 2023; Garaway and Arthur, 2020). This can be particularly useful where fish are eaten, sold or processed shortly after capture.

A fundamental component of a CAS is the "sampling framework design" used for data collection. This defines the fishing units to be sampled (such as vessels, gears, fishers or households) and the field operations to follow based upon their numbers, characteristics, and distribution. It includes the sampling strata to be used that can be based on the required precision of the catch estimate. Examples of sampling strata are gear size and type; vessel-gear type; fisher type (such as full-time, part-time, occasional, recreational[12], or foot-fishers); household type (for example fisher, fisher-farmer, recreational fisher, or non-fishing); geographic region; habitat type; and season, among others. Similarly, enhanced fisheries should be recorded as capture fisheries production and treated as a separate sampling stratum in the sampling framework design. Other potentially relevant sampling strata for inland catch assessment surveys are described in the "characterization matrix" for inland fisheries in Table A4 of FAO, Duke University and WorldFish Center (2023). The sampling framework design will also specify the information necessary to plan the sampling activities and raise the sampled catch to provide the total catch estimate.

Logically, many inland fisheries monitoring programmes focus upon locations where catch volumes are significant (such as reservoirs, large natural waterbodies, or large trap fisheries). However, this can result in the dispersed catches from smaller or less formal fisheries being missing entirely from official statistics or estimated using crude approximation methods. To address this, pragmatic sampling designs can prioritize the major fisheries present, whilst not omitting minor fisheries that may cumulatively account for significant catch quantities. Resulting sampling framework designs can include a combination of different sampling strata and data collection methods. This might include, for example, a census of catch from all large, fixed gears where operators record their daily catch using logbooks as a condition of their fishing licence, combined with national agency enumerators employing interview methods to collect catch data from a sample of fishing households operating small-scale gears on randomly selected days of each month.

The information required for the sampling framework is collected using frame surveys which are census-type surveys conducted periodically, usually every one to five years. They seek to locate, enumerate and characterize all fishing units and their operations, and to identify appropriate sampling locations (such as fishing grounds, waterbodies, landing sites, or processing plants). Field or aerial remote-sensing surveys may be employed, supplemented with data from other sources including other government or municipal departments. Frame surveys can also provide an opportunity to periodically collect important socio-economic information about fisher communities and participation in fishing and post-harvest activities (see Box 3-1).

Box 3-1: Inland fisheries Frame surveys in West African Economic and Monetary Union countries.

Between 2011 and 2013, the eight member countries of the West African Economic and Monetary Union (UEMOA), including four countries in the Sahel region (Burkina Faso, Mali, the Niger and Senegal) and four in the Western Coast subregion (Benin, Côte d'Ivoire, Guinea-Bissau and Togo), carried out a programme to build national capacity in fisheries statistics. Frame surveys on inland fisheries were carried out in each country using a harmonized methodology based on stratified sampling at three levels: geographical area, housing sites and household. This made it possible not only to provide estimates of production but also to identify and characterize the level of involvement of household members in fishing activities and in the fisheries value chains.

Part of the survey also aimed to estimate annual catches by fishery based on declarations by heads of household concerning fishing seasons, fishing effort per season and catches per unit of effort per season. Estimates were then made by further stratifying the fishing year into a high fishing season, a low season and an intermediate season. The estimates proposed follow three models with different weightings for each season. In general, the estimates made were very close to the data reported to the Food and Agriculture Organization of the United Nations (except in the case of Benin, where the estimates were affected by the extent of sampling in the most densely populated lagoons). The results were published in the form of national reports (see also Chapter 7) in addition to Chavance and Morand (2021).

12 If they are present and the catch is retained.

Following the completion of this frame survey on inland fisheries, a monitoring system was set up in all the countries in the UEMOA zone. This system has two components: regular monitoring of effort and landings at sites where fishing is a regular activity using pirogues, and occasional surveys at sites where fishing is seasonal, and catches are made by foot and fixed gear. This monitoring was carried out until 2015 or 2016, depending on the country.

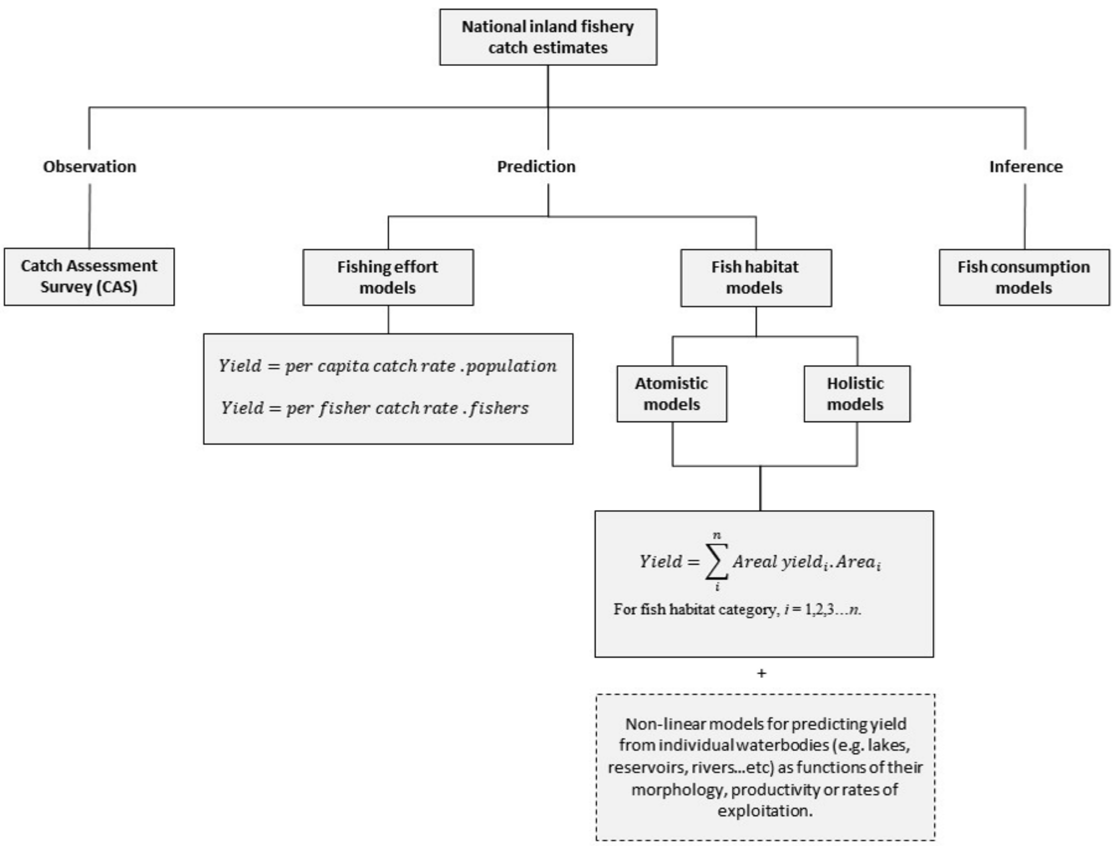
*Source***:** Chavance and Morand, 2021.

Many of the challenges to implementing a systematic, reliable, and comprehensive CAS for inland fisheries are practical in nature and are reported in FAO *et al.* (2023). These include:

- Lack of technical capacity and resources to design and implement surveys and monitoring programmes, as well as to curate and analyse the data and information obtained.
- Lack of cooperation among fishers to participate in surveys and data collection programmes for financial or management-related reasons.
- Inadequate financial resources allocated for surveys or data collection activities because of the perceived low importance of inland fisheries and the characteristics of them that make surveys complex and expensive to implement in practice (e.g. the fisheries may be highly dispersed, remote and informal in nature).

These challenges can be addressed by drawing upon existing technical guidelines and the support and guidance available from government, and relevant institutions including FAO (see Section 3.3.3). When these issues can be overcome (or moderated to an acceptable level of pre-determined relative error or other quality standards), then direct methods can generate estimates of catch comparable to, or with higher levels of accuracy than, the alternative methods described below.

Figure 3-1*:* Methods to estimate national inland fish catch.



Source: Authors' elaboration.

3.2.2 Prediction

Two main categories of model used to predict inland fisheries catches are described in turn below: fish habitat models and fishing effort models. Estimates from these models serve as predictions or indications of potential catch that can also be used as a check on observed catches.

Fish habitat models

Predictive fish habitat models can be used to estimate the *potential* national inland fisheries catch by summing expected catch estimates made for each major fish habitat category that exists in the country (Equation 3-1). Examples of major inland fish habitat categories include rivers, floodplains, lakes, reservoirs, swamps, canals, ponds and paddy fields. From empirical observations, predictions can be made on the potential catch of each habitat category averaged over a range of catch observations from each habitat category, based on the assumption that each has its own productive capacity. Additional information is required to determine whether, and to what extent, potential catch is also realised by an actual fishery. The catch for habitat category, i, is the product of the combined area of each habitat category in the country and an estimate of the mean catch per unit area (CPUA) for each fish habitat category, typically derived from catch observations reported in the literature:

$$Catch = \sum_{i}^{n} CPUA_i . Area_i \qquad \text{Eq. 3-1}$$

Predictive fish habitat models can be subdivided into atomistic and holistic types and these are described in turn.

Atomistic fish habitat models

Atomistic fish habitat models assume each aquatic habitat is an independent source of fish production. This assumption is reasonable for habitats that are hydrologically discrete with no connections to other aquatic habitats – for example, large permanent lakes and reservoirs outside the flood zone, as well as rain-fed paddy fields and wetlands. For other aquatic habitats this may not be a reasonable assumption, particularly for those with seasonal connections to the main river, lake system or flood zone, such as floodplains, rivers, canals, floodplain lakes, swamps, recession paddy fields and other wetlands.

Production in connected habitats can be interdependent and hence a more holistic alternative is necessary, to avoid the risk of double counting production, particularly in systems with extensive floodplains that later become permanent or seasonal lakes, rivers, swamps, or other wetlands as floodwaters recede. The estimates of the mean areal yield (and 95 percent confidence interval [CI]) for five major fish habitat categories are available for six continents, described by Lymer *et al.* (2016), and can be used to predict *potential* national inland fish production when atomistic model assumptions can be met. However, the results of atomistic models should be interpreted with caution. As with other types of fish habitat models, the estimates predict the potential yields associated with each habitat, rather than realized catches that are highly dependent on additional variables that include fishing effort, rates of exploitation, and levels of abundance associated with each habitat. As such, there is the possibility of considerable divergence between the predicted potential yields of fish habitat models and actual production levels.

Holistic fish habitat yield models

In contrast to the atomistic models, holistic fish habitat yield models seek to account for seasonal hydrological connections between habitats, thereby avoiding the risk of the production double counting associated with atomistic modelling. An advantage of these models is that they allow for explicit consideration of rain-fed fish habitat types that have until recently been overlooked, despite their significance and contribution to inland fisheries catches. As with atomistic models, the estimates provide an indication of the potential catch and not the observed catch.

Determining the area of these hydrologically connected fish habitats requires mapping to identify the maximum flood extent of the river or lake flood zone in a basin-by-basin manner. Production in the flood zone area can then be calculated by applying an overall areal yield estimate to the area. Production from rain-fed habitats and permanent waters outside the flood zone can then be added to give the national production estimate.

The simplest holistic models assume that areal yields (CPUA) from each major habitat category remain constant irrespective of the size (area) of each habitat or rates of exploitation measured in terms of fisher density. These assumptions can be relaxed by incorporating non-linear sub models into the assessment – particularly for permanent fish habitat lying outside the flood zone (see Figure 3-2 and description below).

Hortle and Bamrungrach (2015) pioneered the development of this modelling technique to estimate the yield of fish from the Lower Mekong Basin. Land cover in the basin was determined from satellite images, aerial photos, topographic maps and ground truthing data digitized into a Geographic Information System (GIS). The land cover classifications were simplified, and areas aggregated into three major categories of fisheries habitats:

(i) Flood zone: Includes permanent waterbodies including most major rivers, seasonally flooded land, and recession paddy fields in the flood zone.
(ii) Rain-fed: Mainly paddy fields, other wetland crops and associated habitats outside the flood zone. In most cases these areas were formerly forested.
(iii) Permanent waterbodies: typically, large lakes and reservoirs outside the flood and rain-fed zone.

A fourth category of "aquaculture" outside the flood zone was identified and quantified but not considered in yield figures.

Low, medium and high estimates of the mean areal yield for each major habitat category were selected from within the range of published estimates for small-scale inland fisheries in Southern and Southeast Asia. These were then multiplied by the area estimates for each habitat category to provide yield estimates of between 1.3 and 2.7 million tonnes per year for the same region. Again, these models provide an estimate of *potential* fish production.

Employing submodels to improve catch prediction from habitat models

Atomistic or holistic assessments of inland fisheries catches employ mean areal yield values for habitat categories. These can also be from observations in other locations or countries, usually from the same region or continent. The variance in observed values of areal yield between waterbody type reflect natural differences in productivity and/or differences in rates of exploitation among waterbodies. Models can also be developed that can incorporate temporal aspects such as the duration of flooding that can also influence productivity and production (Bruckmann, 2021; Kodio *et al.*, 2002).

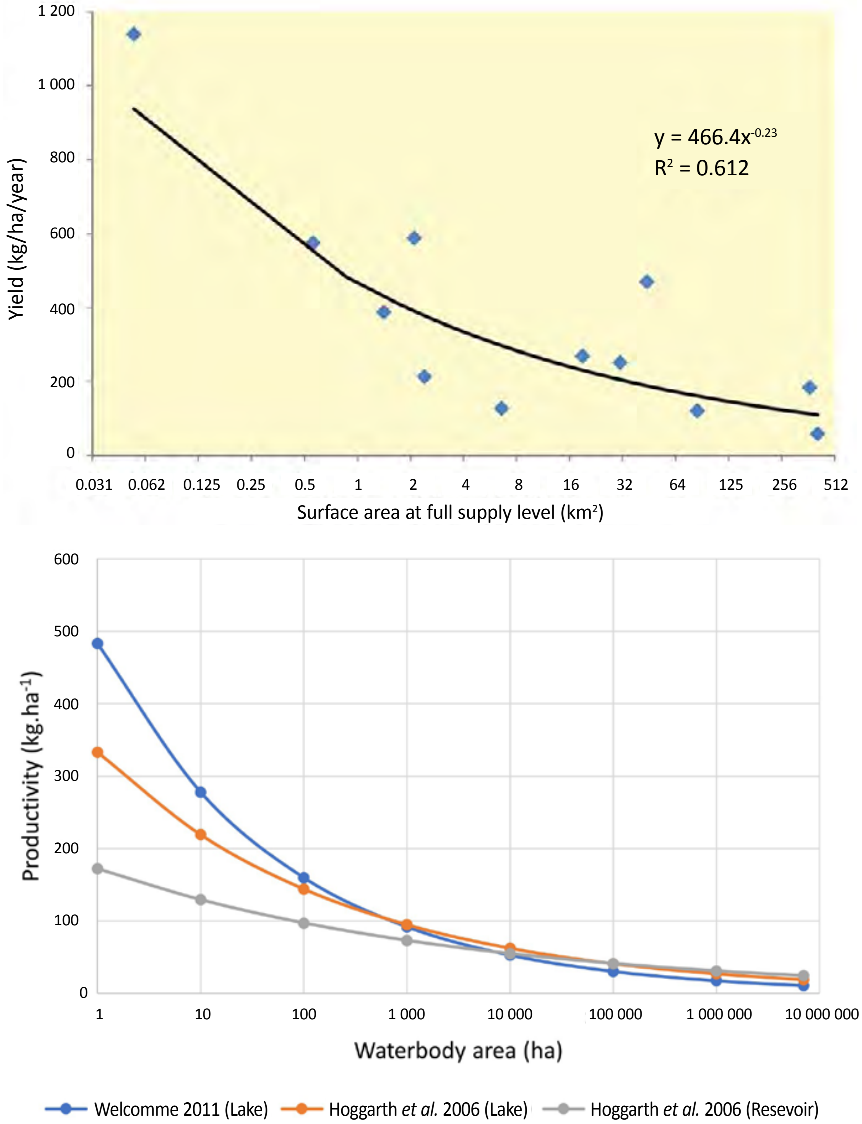
Differences in productivity and hence catch or CPUA are often observed to vary non-linearly with habitat area or waterbody size, for example with increasing reservoir or lake surface area (Figure 3-2a). Smaller reservoirs and lakes are more likely to be stocked and may be more accessible and easier to fish due to a greater length of shoreline relative to area. This implies that smaller waterbodies are more productive than larger waterbodies, which has strong support from the general literature (e.g. Downing and Plante, 1993; Downing, 2010). They are also less likely to thermally stratify and lock up nutrients, again increasing potential productivity compared to larger waterbodies (Hortle and Bamrungrach, 2015).

Empirical non-linear models that can be integrated into holistic or atomistic habitat yield models have been extensively described in the literature and improve the accuracy of areal yield predictions by accounting for differences in CPUA among individual waterbodies arising from variations in their size, productivity and rates of exploitation. They are likely to be most relevant for improving the accuracy of yield predictions from individual large permanent waterbodies outside the "flood zone", meaning lakes and reservoirs. They can also be applied to one or more river–floodplain systems in the country to improve catch predictions from each system in response to rates of exploitation (fisher density). It is important that the assumptions underlying these models are understood and the confidence around predictions reported where possible as they can typically be wide.

Figure 3-2*:* (a): The relationship between areal yield and reservoir surface area in the Lower Mekong Basin (b): the relationship between productivity (kg/ha) and waterbody (ha) area for several morphology-based models.

(a)

(b)



Sources: (a): Hortle and Bamrungrach (2015) and (b): Hoggarth *et al.* (2006); Welcomme (2011).

If these submodels to predict catch for individual waterbodies belonging to each habitat category are integrated into national catch assessments, then Equation 3-1 becomes:

$$Catch = \sum_{i}^{n}\sum_{j}^{n} CPUA_{i,j} Area_{i,j} \qquad \text{Eq. 3-2}$$

Where $CPUA_{i,j}$ is the submodel predicted CPUA for waterbody *j*, belonging to habitat category *i,* and $Area_{i,j}$ is the area of that waterbody. Some of the submodels described below predict catch rather than CPUA for individual waterbodies, thereby removing the need to calculate the catch from CPUA and area.

Morphology and production index-based models

Annex 1 of Hoggarth *et al.* (2006) contains details of more than 20 non-linear models for predicting catch or CPUA from stocked and non-stocked lakes, reservoirs, river–floodplains, floodplain lakes and coastal lagoons in African, Asian and South American countries from morphological variables and indices of potential production. Likewise van Zwieten *et al.* (2011) calculated similar models for reservoirs in a range of Asian and Latin American countries, as well as for African lakes (Annex 3-1). Catch observations used to fit these models generally were single observations per waterbody that were assumed to reflect the potential yield of the waterbodies, as opposed to fishing effort models that can be applied to account for the effects of variation in rates of exploitation and production.

It is also important to note that the observations used to fit these models were, in some cases, made 20–30 years ago and may no longer be applicable due to changes in the productivity of the waterbodies caused by factors such as habitat degradation, changes in fishing patterns (Costello, 2017; Kolding *et al.*, 2016; Kolding *et al.*, 2019; Law *et al.*, 2012), habitat modification and stock enhancement. This leads to the following caveats regarding the extent to which fish-habitat models available in the literature can be applied to estimate the potential catches from inland fisheries:

- The non-linear relationship between area and potential production are derived empirically from observed catches in relation to the areal extent of waterbodies. In most cases these observations are from decades prior to the analyses presented above – generally from the 1980s and 1990s, or even earlier (Welcomme, 2011). Given the likelihood of changes in the fisheries in the last 20–30 years, the underlying parameters used to estimate CPUA require updating. African fisheries in particular have developed small pelagic fisheries in last 20 years that are not reflected in the analyses highlighted above, and area-based methods are likely to underestimate the potential production for these fisheries. It is also not known whether this is a systematic bias.
- Most of the catch data available at the time the models were formulated were taken from larger waterbodies, and while it is known that smaller waterbodies tend to be more productive, the limited number of observations available for the full range of aquatic environments raises questions about the potential bias of productivity estimates towards larger (and often less productive) waterbodies.
- Potential production estimates are highly dependent on accurate and comprehensive estimates of the areal extent of freshwater environments such as lakes, reservoirs, seasonal waterbodies (floodplains, swamps) and rivers. Ottaviani, De Young and Tsuji (2017) provides an assessment of the quality of the areal estimates (poor, medium, good), but in other cases the quality the estimates was not known, and this is thought to especially be a problem for seasonally flooded areas.

To apply fish habitat models that use area in their estimation procedure requires two important elements: information on the areal extent by waterbody and aquatic environment type, and information on waterbody productivity.

Estimating the surface area or extent of waterbodies or aquatic habitat categories can be achieved with GIS employing satellite images, aerial photos, topographic maps, and ground truthing data. The Global Lakes and Wetlands Database (Lehner and Döll, 2004) provides possibly the most globally comprehensive source of existing polygon shapefiles for lakes, reservoirs, rivers and wetlands for this purpose. Even so, in many cases the data are relatively old and there is no indication of seasonal coverage which can be highly variable and the database may not include smaller waterbodies. Indeed, smaller waterbodies are often much more productive than larger waterbodies and fishing may be highly seasonal. While these are generally not included in country catch statistics, without data that can account for the extent of smaller water bodies, including braided small streams, tributaries and seasonal waterbodies, it is likely that habitat-based models will greatly underestimate catches particularly in the case of tropical developing countries.

Assessments of the catch productivity by habitat type may also be required to accurately predict production. Fishing can vary seasonally, and production may depend on how fisheries fit within livelihood portfolios (see Chapter 5). Thus, realized production or catches may in some cases be less than the predicted potential and in other cases, including many lakes but likely floodplains as well, appear more productive than the estimates implied from fish-habitat models that are based on average production.

Fishing effort models

Fishing effort can be used as an alternative to habitat modelling to estimate catches, calculated as the product of a country's population size or number of fishers, and the estimate of the mean annual catch per capita or mean annual catch per fisher derived from observations:

$$Catch = per\ capita\ catch\ .population \qquad \text{Eq. 3-3}$$

$$Catch = per\ fisher\ catch\ rate\ .fishers \qquad \text{Eq. 3-4}$$

Estimates of mean per capita or per fisher catch rates may be available from national or regional statistics and may be stratified where data allow, such as by type of fishing vessel (Table 3-1). In practice, confidence intervals around the estimates are likely to be wide due to the variability in catchability among gears used by fishers and natural variations in fish production in different habitats. Mean per-fisher catch rates may also be subject to considerable error in cases where employment statistics are used to derive their values – particularly where these do not distinguish between full, part-time, and occasional fishers. The level of precision can result in an order-of-magnitude approximation of the true value but may still be of value for "triangulating" with estimates from other model types or where other estimates are not available.

Table 3-1: Annual catch per fisher (kg) for small-scale inland fisheries by region and fleet type, based on average annual values, 2013–2017 in selected case study countries.

Region	No vessel (kg)	Non-motorized vessel (kg)	Motorized vessel (kg)	Number of countries
Africa	70	1 810	11 350	14
Americas	–	1 610	3 660	4
Asia	140	4 280	6 640	8

Source: FAO, Duke University and WorldFish Center, 2023.

On an individual lake level, Kolding and van Zwieten (2011; 2012) reported annual per fisher catch rates of 2 100 kg for Lake Kainji in Nigeria for the period 1996–2001, and 3 000 kg for 16 other African lakes for the period 1989–1992. The latter was based on a regression model that suggested that catch per unit area (CPUA, tonnes/ha/yr) was related to fisher density in numbers per hectare (FD, n/ha) with the relationship $CPUA = 3 \times FD$. The resulting estimate of 3 tonnes per fisher annual catch, irrespective of the lake, is within the range for non-motorized vessels reported by FAO, Duke University and WorldFish Center (2023) and of catch rates implied by the model of Halls, Welcomme and Burns (2006). It also suggests that effort density is driven by the productivity of the lake which may, as mentioned, need to be considered when using area-based models.

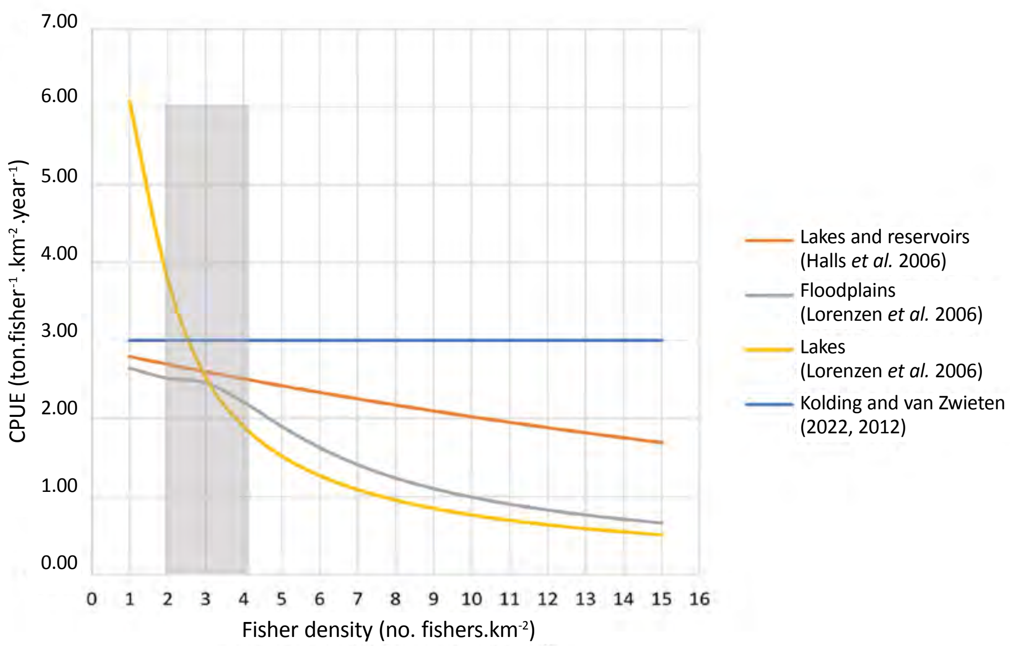
Models have been described to predict catch per unit area (CPUA) for major fish habitat types (for example river–floodplains, lakes or reservoirs) using only fisher density i, of fishing effort E, as predictors. These types of models may be relevant when fishing effort (and hence catch) varies significantly among individual waterbodies. Examples of these type of models are described by Halls, Welcomme and Burns (2006) and Lorenzen *et al.* (2006). However, care should be exercised in applying these effort-based empirical models to predict catch from an individual waterbody. The following issues are highlighted:

- Changes in the estimated model parameter fits to observations (q or r or K or their equivalents) are likely to have occurred over time. Many of the models are now 20 years old and, as with habitat models, observed fisheries production used to fit the models may have changed. Whenever possible, the catch or CPUA prediction intervals should also be reported.
- Effort-density-based methods are highly dependent on the accuracy of estimates of water body area, and the remarks concerning area-based methods apply here as well. Most of the fishing effort models available in the literature are empirically derived from catch, effort (numbers of

fishers) and area data from the 1980s and 1990s and require revisiting with extended datasets. In many cases these data are scarce and generally only available for major fisheries, if at all. Nevertheless, they are still useful as a check on area-based or other estimates of fisheries (potential) production.

- Care should also be taken in applying these models in their implied relationship between catch per unit effort (CPUE) and fisher density, as the models can vary widely in their implied CPUE trajectory over fisher density (see Figure 3-3 below). For example:
  - In the case of the Lorenzen *et al.* (2006) models, the two methods are highly sensitive to fisher density estimates. For what are here identified as intermediate effort densities (that is, 2–4 fishers per hectare) they also give the most conservative estimates of the models shown below.
  - In Halls, Welcomme and Burns (2006), CPUA ranges between 2.8–1.8 tonnes per hectare with effort densities ranging from 1–14 fishers per hectare and is generally more conservative than the Kolding and van Zwieten (2012) estimate of 3 tonnes per hectare irrespective of fishing density.
  - The method by Kolding and van Zwieten (2012) has a different assumption than the other effort-density methods, that assumes CPUA decreases with increased effort density, as it claims that effort in small-scale fisheries with limited technology is driven largely by the productivity of a system. Especially at high effort densities Kolding and van Zwieten (2012) methods may give higher estimates of potential production.

Figure 3-3*:* Implied relationships between CPUE (tonnes/fisher/km^2/yr) and fisher density (n/km^2). Three effort density models are shown as well as a model relating lake productivity and effort density. The grey area indicates a common range of effort densities found in African lakes though higher densities have been found in some instances.



Source: Kolding and van Zwieten, 2011.

3.2.3 Catch inference from observations of fish consumption

Fish consumption studies are an example of how catches can be inferred from available data. Fish consumption data are often collected to assess food security and nutrition aspects of fisheries but also provide another alternative method that can be used to estimate inland fisheries catches. These data can be particularly relevant for geographically dispersed fisheries where it can be difficult to accurately monitor landings. Additionally, in many small-scale and dispersed fisheries fish may be processed, sold or otherwise distributed or consumed shortly after capture and therefore be less amenable to direct observation methods. Consumption surveys have the advantage that they can be included in the routine work of national statistics agencies, for example rural and agricultural censuses or national household censuses, providing a potential mechanism for ensuring that fisheries are considered in health policies (Hortle, 2007). As such, they offer the means of generating information on both nutritional and health related indicators in addition as well as catches (albeit indirectly), and in this sense offer some advantages over catch surveys. Estimates of inland fisheries catches that can be derived from consumption data could also be a useful way to validate catch estimates derived from methods of direct observation and identify where direct observation efforts should be focused.

Fish consumption is calculated as the product of mean per capita consumption and population size. Mean per capita consumption is usually estimated using household consumption and expenditure surveys that typically require household respondents to recall their consumption during the previous 24 hours through interview or by completing a questionnaire. This may be used to account for different food types – an important consideration where fish may be processed or eaten in combination with other foods.

Mass balance models (Equation 3-5), for example, can be used to estimate inland fisheries catch (Y_i) from national fish consumption (C) after accounting for quantities lost during processing and preservation, as well as aquaculture production (A), marine fish production (Y_m), fish imports (I) and exports (E) and in some cases waste and other utilization, such as fertilizer or aquaculture feed (W and O respectively) if they are considered significant:

$$Y_i = C - I - A - Y_m + E + W + O \qquad \text{Eq. 3-5}$$

Variants of Equation 3-5 have been developed depending upon data availability and assumptions. For example, Fluet-Chouinard, Funge-Smith and McIntyre (2018) used the following variant which excludes non-food uses and waste:

$$Y_i = C \cdot F_i - I_i - A_i + E_i \qquad \text{Eq. 3-6}$$

Where is the fraction of inland provenance estimated empirically; I_i , A_i and E_i denote imports, aquaculture production, and exports of fish of inland provenance, respectively.

The variance in per capita fish consumption is relatively small compared to fishing effort models (such as mean annual catch per capita, or per fisher catch rate described above in Section 3.2.2), due to the physical limits of a person's capacity to eat. Per capita or fisher catch rates, on the other hand, can vary by orders of magnitude depending upon the proportion of the population engaged in fishing, the biomass of the stock and the catchability of the gear employed.

In addition, fewer samples (and therefore less survey effort and cost) are required to derive national estimates of per capita fish consumption compared to catch rates with the same relative error. For example, national estimates of mean fish consumption with a relative error of 5 percent can be achieved by randomly sampling less than 200 households, assuming a mean annual per capita consumption of 60 kg and a variance of 400 (Hortle, 2007). This compares to some household surveys reported in the literature which have sampled, on average, around 13 000 households (Fluet-Chouinard, Funge-Smith and McIntyre, 2018), albeit in the context of nutrition and food security-related indicators rather than catch estimation purposes.

Nevertheless, in many cases the application of consumption-based methods to estimate catches remains highly problematic and prone to significant overestimation of catches due to the difficulties of isolating and accurately quantifying each of the elements required to identify the quantities consumed originating exclusively from domestic inland water production. Potential sources of error when considering fish-consumption based models include the following:

- Seasonal variation can introduce significant error into estimates of catch. For consumption methods, changes in household consumption patterns should be fully captured by the survey (Fluet-Chouinard, Funge-Smith and McIntyre, 2018).
- Edible portion weights of fish reported consumed must be converted to live-weight equivalent using a preprocessing factor coefficient (Hortle, 2007). For preserved portions a preservation factor can be applied which varies according to the type of preservation method (salting, drying, smoking, etc.). Fluet-Chouinard, Funge-Smith and McIntyre (2018) reported these sources of error to be more significant than the uncertainty concerning fish provenance.

Additional errors may be introduced when deriving estimates using the mass balance model. These include:

- Determining the provenance (that is, inland capture fisheries, aquaculture, or marine capture fisheries) of fish consumed is often difficult, particularly when cultured and imported species are also caught in the wild. Hence this is not usually attempted during fish-consumption surveys. Instead, post-survey adjustments are made to the estimated quantities of consumed fish using empirical models or production and trade statistics, and by applying the appropriate estimators in the case of Eq. 3-5 or Eq. 3-6.
- Catch estimates derived from fish-consumption estimates can be subject to significant bias and can even have negative values. This has been reported by Fluet-Chouinard, Funge-Smith and McIntyre (2018) for some of the largest producers of freshwater fish (including China, India and Viet Nam) where production from aquaculture is substantial and exceeds wild capture production. Over-reporting of aquaculture production or under-reporting of export of cultured fish were likely sources of bias, emphasizing the importance of accurate reporting of aquaculture production and trade statistics.
- Whilst "aquaculture production is likely to be more accurately documented than inland capture fisheries given its controlled production may facilitate record keeping" (Fluet-Chouinard, Funge-Smith and McIntyre, 2018, p.7625, aquaculture statistics are at risk of being inflated (biased) by erroneously including production from stocked natural water bodies as cultured production. This risk is highest for many Asian countries where paddy fields are often stocked with indigenous species and the harvest includes wild fish. In these cases, the production should be reported as capture (enhanced fisheries) and not aquaculture production in catch assessment surveys.
- Aquaculture and capture fisheries statistics are also at risk of bias when the production of introduced (exotic) species is assumed to come only from aquaculture, when there is also the probability of these species also being present in wild catches in neighbouring areas. Similarly, it is wrong to assume that all production of indigenous wild-caught species comes from capture fisheries, since many aquaculture operations involve the grow-out of indigenous species.
- International trade of aquatic products has grown significantly during recent decades (SOFIA, 2022) making it even more important to accurately account for imports and exports of inland fish in mass balance models. However, this can be challenging since official trade statistics do not include informal (unreported) cross-border trade, which can be substantial, for example in the case of dried freshwater fish in sub-Saharan Africa. Furthermore, trade statistics are normally reported by product type and hence conversion factors must be applied to convert the net product weights to live weight equivalents. This is not always straightforward when product descriptions lack important information necessary to apply to correct conversion factors or to determine the provenance of the species in question, potentially introducing further errors into estimates of inland water fish production.
- Other utilization of fish, such as for fish feed and farm fertilizer is not documented. This can be the case, particularly for low- and middle-income countries where the scale and prevalence of other utilization of wild caught fish remains poorly understood.
- Disaggregating consumption-derived catch by species is also very challenging. Survey respondents may either lack the necessary taxonomic expertise to reliably report the species

they consumed, or the consumed fish was in a processed or prepared form making species identification impossible.

Taking into consideration all the factors above, consumption-based models can provide an estimate of total catch when the following requirements are met:

- an accurate estimate of per capita fish consumption can be derived, taking into consideration of spatial and temporal (seasonal) variations in consumption;
- there exists good knowledge of pre-processing and preservation factors to convert edible quantities to live-weight equivalents; and
- quantities can be reliably estimated for aquaculture production, marine fish production, imports and exports of fish, and waste and other utilization of fish. Alternatively, if quantities for all or some of these elements are insignificant and therefore unlikely to bias the results of mass balancing.

3.2.4 Selecting complementary methods for estimating inland fisheries catches

As a general rule for catch estimates, direct observation remains the favoured means with which to estimate inland fisheries catches. Well-designed and well-resourced catch assessment surveys will provide estimates of catch comparable to, or at even higher levels of accuracy than, the alternative methods described in Section 3.2.3. Catch assessment surveys also have the added value that catch estimates are likely to be more easily collected at species level, while fishing effort and biological data, amongst other indicators, can be collected simultaneously with minimal extra effort or cost. Nevertheless, there are many cases where it is impractical to apply methods of direct observation due to resource or logistical constraints, and the alternative methods described in this chapter and elsewhere can be considered to provide complementary methods. The choice of which method or model to apply will include aspects that relate to the implementation of the different methods including:

- availability of model parameter estimates applicable to the country (or continent or geographical region to which the country belongs) and model category (economic classification, habitat, vessel, fleet),
- availability of data or predictors to apply the model,
- the likelihood that the model/method assumptions will be met,
- conditions or prerequisites for successful application of the method,
- acceptable level of likely error in the catch estimate, and
- necessary resources and capacity necessary to apply the method or model, such as current waterbody or hydrological mapping, fisher or population surveys or censuses, or health surveys.

Annex 3-2 summarizes the different models alongside assumptions, conditions or prerequisites for their successful application, including the likely magnitude of error margins in the derived catch estimates as well as additional data or data processing that will be necessary. This provides a means to identity which methods and models can be applied in the first instance. Judgements can then be made as to which might be most suitable based on the above criteria to achieve minimum standards of acceptable accuracy. This may result in a shortlist of model options, including non-linear sub models for fish habitat models. These options might then be ranked to identify the best option, or all options could be applied to provide a range of possible estimates from which the most likely value can then be judged and reported.

Where more than one estimate may be derived using different methods, or where estimates need to be evaluated, Weight of Evidence (WoE) methods (EFSA Scientific Committee *et al.*, 2017) can be applied to identify the most reliable estimate, in which evidence is integrated to determine the relative support for possible answers to a question. This usually comprises three basic steps: (i) assembling the evidence into lines of evidence of similar type, (ii) weighing the evidence, and (iii) integrating the evidence.

Three basic considerations in weighing evidence are identifying the reliability, relevance and consistency:

i. Reliability is the extent to which the information comprising a piece or line of evidence is correct.
ii. Relevance is the contribution a piece or line of evidence would answer a specified question, if the information comprising the line of evidence was fully reliable.
iii. Consistency is the extent to which the contributions of different pieces or lines of evidence to answering the specified question are compatible.

Weight of Evidence assessment and uncertainty are closely related and each of the three basic considerations in the WoE assessment may be expressed in terms of uncertainty and variability (EFSA Scientific Committee *et al.*, 2017). A range of methods exist to assess WoE, from qualitative methods such as listing evidence and best professional judgement to full quantification.

In our evaluation of the FAO catch statistics, we compared reported catch statistics with estimates using alternative methods. When area and fishing effort data are available a cross check was made by calculating implied CPUE from area-based estimates by dividing potential catch calculated with the aid of these methods by observed effort. Likewise, implied CPUA (kg/ha/year, or potential fishery productivity) can be calculated by dividing potential catch derived from effort (density) based methods by area. Uncertainty in estimates can be expressed in terms of variability; for most models used in this report standard errors or 95 percent confidence limits are given and can be used to calculate ranges of likely values. For instance, the Lymer *et al.* (2016) model confidence limits are around 20 percent of the mean value.

3.3 THE APPLICATION OF "ALTERNATIVE ESTIMATION METHODS" IN SOUTHEAST ASIA AND AFRICA

Some of the models described in the previous sections were applied to identify the most appropriate methods for estimating inland fisheries catches for selected case studies in Africa and Southeast Asia, based on the assessment of the quality of official data submitted to FAO outlined earlier. We consider how the most recent inland fisheries catches reported by these countries compare to the estimates derived where alternative methods were applied.

3.3.1 Southeast Asian case studies

For Southeast Asia, 24 alternative estimates of catches from inland capture fisheries were identified from the literature (FAO, 2023). These excluded speculative estimates made by Coates (2002). Most of the estimates available refer to the four major riparian countries of the Lower Mekong Basin and include estimates from consumption-based models or potential production derived from fish habitat models.

Below we discuss the reliability of these historic alternative estimates for five priority Southeast Asian countries where potential improvements in data quality were identified from the assessment of the official data reported to FAO. We also make recommendations for the future application of these alternative methods for these five countries and speculate how they might alter the most recent reports of inland fisheries catches for the five countries.

1. The Lao People's Democratic Republic

Fish-consumption models

- The Lao People's Democratic Republic is land-locked and had limited aquaculture until the late 1990s. Hence, the early fish-consumption-derived estimate of 166 000 tonnes for the year 2000 (Hortle, 2007) is likely to include a minimal aquaculture production component.
- This estimate is, however, significantly greater than the consumption-derived estimate of 88 000 tonnes for the year 2008 made by Fluet-Chouinard, Funge-Smith and McIntyre (2018).

- According to the official statistics reported by The Lao People's Democratic Republic, aquaculture production now greatly exceeds capture production so reliable aquaculture and trade statistics are essential if the consumption-based estimate is to be updated.

Fish-habitat models:

- The holistic fisheries habitat yield model of Hortle and Bamrungrach (2015) likely provides a more useful catch estimate compared to an atomistic model, owing to the hydromorphological characteristics of the fish habitat in the country. The model predicts a *potential* annual catches of between 112 000 tonnes and 246 000 tonnes.

In summary, the different models that have been applied suggest a potentially wide range of inland capture fisheries production in Lao People's Democratic Republic, highlighting the importance in quantifying the level of uncertainty when applying each of these methods and appropriate choice of model selection. This compares to the official estimates reported to FAO in recent years are of 60 000–70 000 tonnes per year.

2. Cambodia

Fish-consumption models:

- Hortle (2007) for 2000 and Fluet-Chouinard, Funge-Smith and McIntyre (2018) for 2009 inferred similar inland capture fisheries catch estimates for Cambodia (587 000 and 576 000 tonnes respectively) from fish-consumption survey data. Prior to 2010, aquaculture contributed less than 10 percent of total inland fish production in Cambodia, limiting the extent to which misreporting could occur between these sources. Since then, aquaculture production in Cambodia has increased significantly and – according to the latest official catches – almost equals that of capture fisheries.
- Catches from marine fisheries are also reported to have approximately doubled during the past twenty years. Exports are also now significant but accurate data are not available. The changes in fish production and trade could increase the sources of error for fish-consumption methods.

Fish-habitat models:

- The extensive flood zone in the country means that holistic models for fish habitat may be more appropriate as an indicator of *potential* production. Incorporating non-linear morphology-based yield prediction models would have marginal benefit because few large lakes and reservoirs exist outside the flood zone (approximately 2 percent of the total wetland area). Applying such a model, Hortle and Bamrungrach (2015) predicted a potential yield of 767 000 tonnes for the year 2000.

The official production estimates reported by Cambodia to FAO range between 383 000 and 478 000 tonnes in recent years.

3. Thailand

Fish-consumption models:

- The predominance of fish from marine capture fisheries and aquaculture in Thailand are likely to create difficulties separating the consumption of fish from these sources from inland capture fisheries, unless they are consumed in different ways. Limiting the geographic scope of consumption studies may also reduce the risk. For example, the consumption-based estimate of 911 000 tonnes reported by Hortle (2007) was based on surveys conducted in the part of Thailand within the Lower Mekong Basin containing only two coastal provinces.

Fish-habitat models:

- Holistic fisheries habitat yield models (Hortle and Bamrungrach, 2015) produced a similar estimate of potential yield (921 000 tonnes) for a similar area. Since this area forms only

37 percent of the total area of Thailand and does not represent an estimate for the whole country, catches from the Chao Phraya River basin and other rain-fed wetlands outside the Lower Mekong Basin were excluded.
- To ascertain a comparable estimate at the national level, it is recommended that a holistic habitat modelling method be applied to the entire area of the country using up-to-date habitat area estimates and existing or updated areal yield estimates for each habitat. Given the abundance of lakes and reservoirs in the country, there might also be merit in using non-linear areal yield models for these habitats.

Given that both the consumption surveys and fish-habitat models were conducted on a subset of provinces, it is possible that total inland fisheries catch for the whole of Thailand might be significantly higher than the official inland fisheries catch figures of less than 117 000 tonnes reported to FAO in recent years.

4. Viet Nam

Fish-consumption models:
- Inland capture fisheries production in Viet Nam is relatively insignificant compared to aquaculture and marine fisheries production. Inferring inland capture fish production from fish consumption is therefore potentially problematic, given the similar challenges as with Thailand and Cambodia. This is illustrated by the attempt by Fluet-Chouinard, Funge-Smith and McIntyre (2018) that resulted in a negative inland catch value.

Fish-habitat models:
- The holistic fisheries habitat yield model probably offers the most useful alternative method to estimate inland fish production in Viet Nam, building on the work of Hortle and Bamrungrach (2015) who estimated a potential yield of 369 000 tonnes for the area of the country lying in the Lower Mekong Basin – compared to official total catches of less than 150 000 tonnes reported by Viet Nam to FAO in recent years.
- Whilst containing highly productive fisheries, the study area of the habitat model amounts to just 21 percent of the total land area of Viet Nam, hence an estimate for the entire country that includes the Red River Basin in the northeast is likely to be significantly greater. To assess national fish production using habitat models would require compiling accurate estimates of the areas of each category of fisheries habitat across the remaining area of the country, while non-linear submodels will have little use as lake and reservoir habitats are sparse in the country.

5. Myanmar

Fish-consumption models:
- The estimation of fish production using consumption studies in Myanmar faces similar challenges to Cambodia, Thailand and Viet Nam, with production from aquaculture and marine fisheries both significantly higher than compared to inland capture fisheries. Exports of inland fish from Myanmar are also not insignificant, and so accurate trade statistics are also essential.
- Despite these concerns, Fluet-Chouinard, Funge-Smith and McIntyre (2018) inferred a catch estimate of 784 000 tonnes in 2006, which corresponds closely to current FAO estimates (786 000 tonnes in 2021).

Fish-habitat models:
- The holistic fisheries habitat model may be a more practical solution in terms of choosing an alternative method. Wetland maps and GIS already exist that could be provide the basis of these habitat area estimates (see NWCD, 2019), while seasonal flood extent would need to be added to these maps to re-categorize the habitats. Non-linear models could be applied to estimate catch from lakes and reservoirs outside the "flood zone". However, the choice of model would ultimately depend upon data availability and their relative prediction error.

In summary, the discrepancies between the alternative estimates (which often estimate potential rather than realized catch) and the official catch production are most pronounced for the Lao People's Democratic Republic, Thailand and Viet Nam. This assessment is complicated by the fact that comparisons between the FAO data and the alternative estimates in many cases refer to different years and therefore fail to take into consideration developments in Southeast Asia's inland capture fisheries between reference comparison years. Nevertheless, in most cases the indications from both the consumption-based estimates and fish habitat models point to higher potential production levels.

In conclusion, these alternative estimates would potentially raise the catch estimates for these five Southeast Asian countries by around 1.5 million tonnes, notwithstanding the uncertainties associated with these estimates and the difficulty of equating potential catches to realized catches.

3.3.2 African case studies

Catches from inland fisheries in Africa vary widely, with virtually no production in areas such as Northern Africa, compared to very high production in the major river basins and countries of the Congo Basin and Great Lakes subregions such as Chad, the Democratic Republic of the Congo, Nigeria and the countries bordering Lake Victoria. The catches for some of these are also considered to be highly uncertain.

The reported catches from 11 African countries[13], representing 66 percent of Africa's total inland fisheries catches in 2021 (FAO 2023), were evaluated using a range of alternative methods taken from the following sources:

1. Area-based estimation methods of potential production by Welcomme (2011), van Zwieten *et al.* (2011), Hoggarth *et al.* (2006) and Lymer *et al.* (2016).
2. Effort (density) based estimates of potential production by Halls *et al* (2006), Lorenzen *et al.* (2006), and Kolding and van Zwieten (2012).
3. Consumption-based estimates of inferred capture fisheries production provided by Fluet-Chouinard, Funge-Smith and McIntyre (2018).

The catch estimates disseminated by FAO for 2021 for the 11 selected countries differ in magnitude when compared with the consumption and area-based potential production estimates. In several cases estimates from the three methods are close to each other, while in other cases they differ widely with nonoverlapping ranges of uncertainty. Both consumption-based estimates and estimates based on habitat and effortdensity models may be both higher and lower than the FAO estimates.

1. Burkina Faso, Mali, Niger, Zambia

- For Burkina Faso, Mali, Niger and Zambia – all land-locked countries – estimates of national inland fisheries production derived from fish-consumption estimates were 20 percent (Mali), 163 percent (Burkina Faso) to 630 percent (Zambia) higher than officially reported or FAO estimated catches in 2021, while those of the Niger were 61 percent lower (Fluet-Chouinard *et al.* 2018). In these cases, no habitat or fishing effort-based model estimates could be provided, as insufficient reliable data on waterbody size or nominal fishing effort were available.
- However, additional information from other sources was available to assess the validity of the FAO data for selected years. Burkina Faso, Mali and Niger were included by the frame survey of the West African Economic and Monetary Union (UEMOA) program conducted between 2011 and 2013, which included an assessment of catches (Chavance and Morand, 2021) (see also Box 3-1). For Burkina Faso and the Niger, the data estimated from frame surveys appeared to be close to the data reported to (or estimated by) FAO for the same period – averaging around 40 000 and 22 000 tonnes respectively. For Mali, 2012 was characterized by exceptionally low catches, with

13 Burkina Faso, Chad, Democratic Republic of the Congo, Ghana, Kenya, Mali, Niger, Nigeria, Uganda, United Republic of Tanzania, Zambia.

an average estimate of 85 000 tonnes, compared with the estimate by FAO of around 71 200 tonnes for the same year (FAO, 2023).

- For each of these selected countries, consumption-based estimates were significantly higher (Burkina Faso, Mali) or lower (Niger) than reported catches. While it is unclear why these estimates were higher or lower, in some cases the higher estimates obtained through consumption studies may be the result of some fisheries not being fully included in FAO estimates. For instance, 2021 catches reported by Zambia to FAO of 105 100 tonnes may be too low, as small pelagic species caught in several fisheries are unreported (Kolding *et al.*, 2019). Nevertheless, the consumption-based estimates of production for Zambia of 769 200 tonnes by Fluet-Chouinard *et al.* (2018) seem too high, and which also do not take into consideration the small pelagic catches from several waterbodies. This consumption estimate would lead to a per capita consumption of 71 kg of fish annually (based on the population in Zambia in 2002–2003, the period the study was conducted), which seems excessive.

2. United Republic of Tanzania, Kenya

- In the case of the United Republic of Tanzania and Kenya, FAO estimates were reasonably close to the estimates from habitat models and effort-based models (i.e. where available), while consumption estimates showed higher deviations.
- The consumption estimate for the United Republic of Tanzania was 18 percent lower, while the habitat model estimate from Lymer *et al.* (2016) was 21 percent higher than reported catches of 414 200 tonnes in 2020, falling within the uncertainty ranges of these estimates. Effort density model estimates ranged from 4 percent lower (Halls *et al.* 2009) to 9 percent higher (Kolding and van Zwieten, 2012).
- For Kenya, estimates from habitat models (2 percent lower) and effort density model (6 percent higher) were very close the FAO reported catch of 103 000 tonnes, while consumption estimates were 23 percent lower.
- To arrive at national catch estimates, Tanzania, Kenya, as well as Uganda – discussed in more detail below – distinguish between major fisheries for which catch estimates are obtained through CAS and frame surveys, and minor fisheries for which catch estimates are obtained through other methods or are in some cases excluded entirely national catch estimates. The habitat and effort density-based models appeared to be particularly useful to estimate potential production from these smaller systems and consequently obtain a range of estimates that can aid in assessing the potential size of the error in the national catch estimates as reported to FAO when using other methods or non-reporting.

3. Nigeria, Ghana

- For Nigeria no consumption estimate was available, but habitat models suggest that the official inland water catches of 362 800 tonnes reported to FAO in 2021 are underestimated by around 35 percent, mostly due to a much higher estimated potential production of the Lake Chad floodplains and swamps compared to the national estimate.
- In Ghana consumption estimates were 47 percent higher than the FAO estimate of 81 000 tonnes in 2021, while habitat models suggested a 20 percent higher national catch – mainly due to Lake Volta, a highly productive reservoir. Inland fisheries in Ghana are driven by the catch of Lake Volta, over which there is limited consensus on estimates of production. Earlier reports have indicated that national statistics may underestimate the catch of Lake Volta as well (van Zwieten *et al.* 2011), while the consumption estimates appear to similarly point to higher domestic production from inland waters.

4. Uganda, Chad

- In 2021 Uganda reported a catch of 634 600 tonnes to FAO, an increase from 389 600 tonnes in 2017. Comparisons with consumption-based estimates (232 800 tonnes) and estimates of potential production from habitat models (282 300 tonnes) suggests that the reported catches may be overestimated.

- While the habitat models do not take into account the increase in production of small pelagics from Lake Victoria and other lakes in Uganda, accounting for part of the increase in recent years, the increase in reported catches to FAO appears to be mainly driven by catch estimates for the fisheries of Lake Albert and the Albert Nile. Reported catches from these systems imply a productivity of respectively 1 177 kg and 583 kg per hectare, which seems excessively high. The productivity estimate of the Ugandan part of Lake Victoria is 72 kg per hectare which is very close to the estimate used in the habitat models of 73 kg per hectare (Lymer *et al.* 2016).
- In the case of Chad, the FAO estimate in 2021 was 103 000 tonnes. Both consumption estimates (208 900 tonnes) and potential catch estimates from habitat models (286 416 tonnes) suggest a much higher production. Like Nigeria, the higher estimate is mainly driven by the estimated potential of Lake Chad, that depends on the highly variable size of its open waters, marshes, and floodplains.

5. Democratic Republic of the Congo

- In 2020 Democratic Republic of the Congo reported 210 000 tonnes of freshwater fish from inland capture fisheries to FAO. Ottaviani *et al.* (2017) provided estimates of freshwater area by habitat which, when combined with this level of production reported to FAO, implies a productivity of 7 kg per hectare, which is extremely low.
- The estimate of Lymer *et al.* (2016) for lakes and reservoirs only amount to a total of 288 280 tonnes and including the seasonally flooded areas leads to a potential total catch of over 1 million tonnes. This is more than four times the reported catch to FAO, but also close to the consumption estimate of 964 636 tonnes by Fluet-Chouinard *et al.* (2018). With a population in 2008 of 61.8 million people the consumption estimate is 15.6 kg per capita per year, which would be quite high compared to estimates for other African countries (see also Table 2-6).
- The Lymer *et al.* (2016) model leads to an average potential catch productivity of 32kg per hectare, which seems a conservative estimate. Ottaviani *et al.* (2017) provided estimates for the total number of fishers ranging from 363 827–500 000 people. This would imply a relatively low average fisher density of 1.1 to 1.5 fishers per km^2 over the estimated total inland water area. Effort density models (Kolding and van Zwieten, 2012; Halls *et al*. 2009) then lead to estimates of 1.1–2.1 million tonnes with an implied fisheries catch productivity 33–62 kg per hectare, values that are within the conservative ranges provided by Lymer *et al.* (2016). While these are all relatively crude estimates based on limited information, the converging productivity and per capita consumption estimates indicate that they may not be unreasonable, while the discrepancy with reported catches is very high. Nevertheless, the area currently covered by seasonally flooded areas in the country is still uncertain, also confirming the need to undertake habitat mapping with the aid of flood maps following the holistic method proposed here (Section 3.2.2) for more precise estimates.

In summary, the status of officially reported or estimated inland water capture production statistics for several countries in Africa is among the poorest in the FAO database, also compared to the other regions in the world. In several cases official data have not been received for many years, while FAO estimates are often repeated over a number of years or interpolated between the little official data that have been received from the countries concerned. Catches for many of these countries are relatively low, however in the case of Chad, Democratic Republic of the Congo, and also South Sudan, the presence of large inland water fisheries that may not be covered well by current FAO statistics may drive Africa's total inland water catches upwards.

Taking the consumption estimates and potential production estimates from the fish habitat-based models implies catch estimates as much as over 40 percent higher compared to current FAO data for the 11 selected African countries examined. If one assumes the same magnitude of differences applied to all countries in Africa, then total inland fisheries production would be increased by between 27–33 percent compared to current FAO estimates. The increase is predominantly driven by the estimates for the Democratic Republic of Congo and Lake Chad for the production estimates as well as Democratic

Republic of the Congo, Chad and Zambia for the consumption estimates. Reported catches in several West African countries with marine fisheries may be underestimated up to 20–40 percent (exemplified by Nigeria and Ghana). However, taking the current reports to FAO as a baseline such an increase would add only around 28 000 to 55 000 tonnes to the African total.

Although it is reasonable to assume that inland fisheries in Africa are fished to their full potential, given the overall population increases and the increase in small pelagic fish fisheries in many African lakes (Kolding *et al.*, 2019), the area and effort density-based models used essentially represent a potential production and not the actual catch. Uncertainties around the estimates used in these models were not reported here, but amount to plus or minus 20–25 percent of the estimates provided. Likewise, the reliability of consumption estimates is highly dependent on the reliability of estimates of the fraction of freshwater fish consumed, as opposed to marine fisheries, aquaculture and trade for each country, as discussed by Fluet-Chouinard *et al.* (2018). In this report, uncertainties were around 23 percent for the global estimates and higher for individual country estimates. These uncertainties give a range within which observed catch estimates may overlap to assist in concluding that observations are similar to estimates from these alternative methods. It is important to note that around half of the consumption and area-based potential production estimates are less than or close to equal to the FAO estimates and vice versa, highlighting issues such as the natural variability of the fisheries, random error, and issues with both the consumption estimates as well as the estimates of potential production of habitat models.

Thus, while FAO catch estimates for Africa appear in many cases to underestimate production levels compared to the alternative models available, there are some important caveats:

- Differences in Africa's total inland fisheries catches are driven by a small number of major producers of freshwater fish where large deviations are observed between FAO data and the alternative estimates available. However, the consumption estimates and estimates of areal extent of freshwater habitats for some of these producers that were examined in this study – notably Democratic Republic of the Congo, Chad and Nigeria – remain highly uncertain, which in turn raises questions on the suggested magnitude of underestimation compared to FAO data. The estimates derived from the habitat models are highly dependent on the area estimates of floodplains and rivers as well as the assumptions of their productivity or effort density. Consumption-based estimates are derived from studies that were mostly carried out between 10 and 20 years ago, and consumption patterns may have changed. Furthermore, consumption-based methods are dependent on estimates of exports and imports, reliable statistics of which are difficult to obtain for Africa.
- In our analysis of 11 African countries, we used estimates of areal extent of water bodies provided by countries (Uganda, United Republic of Tanzania), the Global Lakes and Wetlands Database, and summaries provided by Ottaviani, De Young and Tsuji (2017). The calculations using these data therefore in some cases focus only on the major fisheries as recognized by the countries in their catch statistics (Kenya, Uganda); use a wider range of estimates of waterbodies, many of which are not included in catch statistics but where these fished waterbodies are known (United Republic of Tanzania); or use all areal extent data available (Chad, Democratic Republic of the Congo, Ghana, Nigeria) while they are incomplete. A logical way forward would be to focus on obtaining better data on freshwater environment areas and flood duration by habitat, as well as ensuring accurate and up-to-date information on where major fisheries are taking place.
- Nevertheless, all models, including the Lymer *et al.* (2016) model which usually produces the highest values, appear to give conservative estimates of potential production. This may be the result of changes in waterbody productivity or of fisheries that are not captured in the current productivity estimates. An example is the boom in catches in small pelagic fish species that have taken place in many African lake systems over the last two to three decades (Kolding *et al.*, 2019) that are not captured by the habitat and effort density models used.

The case studies described above suggest that inland water fisheries production in some countries in Southeast Asia and Africa are underestimated by current FAO statistics. This is not a forgone conclusion. The true value of production is generally unknown and there is a risk that the estimates of production derived using the alternative methods are biased, or in many cases subject to considerable uncertainty. Hence, the application of these methods should not be regarded as superior or even an alternative for estimating national inland water capture fisheries production through direct observation. The methods can assist in examining the likelihood of, or in validating the estimate reported to FAO, while they may provide an aid to countries to cross examine methods used to obtain catch estimates of individual fisheries. If they appear to give the same results within the uncertainty ranges provided, then the likelihood that national estimates are reasonable is high. If values differ widely – i.e. falling outside the bounds of uncertainty ranges – then further examination of the values obtained by the various methods used is in order. Thus, the alternative methods can be applied in a complementary manner to certain fisheries or waterbodies that cannot be surveyed using conventional means, or to validate observation-based national production estimates. They cannot, however, replace estimates from observational methods.

3.3.3 FAO support: existing resources and guidance

The first step in addressing the challenges of monitoring catches from inland fisheries is that member states fully acknowledge the socio-economic importance and contribution to food and nutritional security of inland capture fisheries, including the commercial and informal subsistence fisheries. Also, that national agencies responsible for reporting inland fisheries statistics are adequately resourced to ensure their capacity to fulfil this role. This includes ensuring sufficient manpower to undertake data collection, that are properly trained and supported in the field alongside appropriate data management and analysis systems.

At the national level, determining how best to strengthen the capacity to compile inland fisheries statistics requires a thorough understanding of the current data collection and procedures used to generate their official statistics. Unfortunately, this information is often lacking when data are submitted to FAO. To help refine and target support, member countries are encouraged to provide FAO details of the survey and statistical methods used to generate their fishery statistics submissions. For example, providing information in the metadata section accompanying the FAO fisheries and aquaculture questionnaires, particularly as this information has been poorly reported in the past.

In many cases, in-country assessments led by FAO or other international organizations or agencies have helped improve the quality of statistics. This has included technical support and in-country training to design and implement new catch assessment surveys, or initiatives to strengthen existing data collection mechanisms. For example, between 2011 and 2013, the eight member countries of the West African Economic and Monetary Union (UEOMA) carried out a programme to build national capacity in fisheries statistics. FAO has also developed a range of tools and technical guidance to assist countries. For example, guidance on the design of catch assessment surveys is available in several FAO Fisheries Technical Papers and publications (Halls *et al.*, 2005; Stamatopoulos, 2004, 2002; Sparre, 2000; FAO, 1999; Caddy and Bazigos, 1985; Bazigos, 1974). FAO can also provide member countries with in-country support to advise the design of the survey and accompanying data management systems, such as Open ARTFISH[14] and Calipseo.[15] However, it is essential that the development and implementation of tools – particularly those that facilitate the data processing and estimates of total production – be accompanied by training of personnel and strengthening of expertise at the country level, in order that systems can be tailored accordingly to the needs of the country as well as the dynamics of the fisheries. Especially as there may be diverse fisheries within a country that may take place within different aquatic environments. As part of the review of FAO's inland fisheries statistics that began in 2023, new technical guidelines are in the process of being drafted to provide advice to countries on the range of alternative options for estimating inland capture fisheries production (scheduled for publication in 2024). In addition, the Coordinating Working Party on Fishery Statistics (CWP) Handbook[16] contains internationally agreed definitions, concepts, and standards for reporting fisheries statistics. Whilst it was initially prepared for marine fisheries, much of the content is applicable to inland fisheries.

14 Available at https://www.fao.org/fishery/en/statistics/software/open-artfish

15 Available at https://www.fao.org/fishery/en/statistics/software/calipseo

16 Available at https://www.fao.org/cwp-on-fishery-statistics/handbo

3.4 CONCLUSIONS

Despite improvements in the status of FAO's global estimates of inland fisheries catches, particularly in the last decade because of developments in national data collection and reporting systems, at the national level further efforts are needed to improve the level of reporting by countries, coverage of inland capture fisheries included in official data submissions, and granularity of catches available by species. Improvements are also needed to validate, and in some cases improve, FAO estimates for countries which have not reported data for many years. While the true catch is generally unknown, there are indications that the official inland fish catches declared by some member countries may underestimate production, at varying degrees of magnitude, when compared with estimates derived using alternative methods. However, these methods, such as production inferred from fish consumption surveys or predicted from fish habitat models and effort-based models, are also subject to significant uncertainties.

The complex nature of inland fisheries which are often in remote locations, highly dispersed, with catches consumed or processed shortly after capture or traded regionally over very large distances, indicates a need for flexibility in the methods that could potentially be employed. The dynamics of inland fisheries, including the diverse small-scale fisheries that operate both formally and informally, are generally well understood and well documented. However there remain significant challenges and often limited resources to adequately monitor these fisheries required to inform fisheries policy and management needs.

Changes in inland aquatic environments and livelihoods also create challenges for assessments. In recent decades, the significant growth in production from aquaculture and enhanced fisheries, combined with advances in related technology, has made the task of correctly identifying and reporting sources of fish production more important and demanding than ever when seeking to accurately estimate inland fisheries production. Careful attention to survey design and resourcing are necessary to ensure that existing or new surveys correctly discriminate inland capture production from aquaculture, particularly in countries where species of fish and other aquatic animals captured from the wild are also cultured, and where capture fisheries production remains important from a socio-economic perspective but dwarfed by production from aquaculture. Similarly, there can be important spatial and temporal differences in fishery productivity, fishing effort and fish consumption that need to be considered in the design of data collection programmes to reduce the risks of bias. These are issues that affect data collection regardless of the method used.

In terms of methods, direct observation remains the preferred option that will, if well-designed and adequately resourced, generate the most accurate estimates of catch and avoid some of the sources of error that can affect the alternative estimation methods. However, to minimize sources of error and reflect changes in fishing patterns, existing catch assessment surveys should be periodically reviewed and modified as required to ensure they are statistically robust and include all fisheries and inland aquatic environments that can be feasibly monitored at regular intervals. The surveys should be capable of generating accurate estimates of annual inland capture fisheries production, including enhancement fisheries and retained catches from recreational fisheries, disaggregated by species, genus or family in accordance with national and international reporting obligations.

As with other estimation methods, catch assessment surveys should in theory aim to include the full range of fish habitats within a country and observe the catch from fishing units operating over each habitat type. Direct measurement is most appropriate and cost-efficient for large lake and river fisheries that have well defined landing sites, or for fisheries where reporting (logbooks) can be made an obligation of a fishing license or an access agreement. For sites where there may be no formal landings sites and a large proportion of the catch is consumed for subsistence or traded informally (as in the case of most floodplain fisheries) then household surveys may be used to estimate production (FAO, 2017) – see also examples for countries in the Africa Western Coast subregion in Chapter 7. Pragmatic design and implementation of catch assessment surveys is therefore needed, potentially employing a mix of landings-based surveys, household surveys, and in some cases supplemented by other alternative methods of reporting or estimation of production.

If direct observation methods cannot be implemented, member countries should consider the options available for the alternative estimation methods outlined above, which can still be of considerable value from a fisheries management perspective despite their own uncertainties and biases as well as methodological complexities in some cases. These methods can be used to validate the production estimates derived from catch surveys. This might mean, for example, prioritizing certain fisheries while considering alternative methods for monitoring or estimating other fisheries that might still be important in terms of the contribution to total catches. Such mixed-method designs could be advocated to accommodate the complexities of collecting or estimating the catches from the diverse fisheries that operate in inland waters. However, this is highly dependent on the data availability and reliability of the parameters used in the models. As the comparison of alternative methods available for Africa and Southeast Asia have shown, the inferred production from consumption surveys and estimates from fish-habitat and effort-density models can provide similar estimates – despite being formulated on entirely different assumptions and data sources – while in other cases the estimates can strongly diverge. This suggests that the basis and practicalities of selecting alternative methods need to be more clearly established. We do not recommend that estimates derived from these methods are included in national catch estimates in place of observation-based methods, without considering other methods to estimate production from smaller or more dispersed fisheries.

Where there are opportunities to use habitat-based models to estimate production, the review undertaken in this chapter highlights the continued need for both up to date information on fisheries habitat types and extent and their productivity. Aquatic environments are some of the fastest-changing, for example through the building of dams and irrigation structures in some areas, removal of barriers in others and changes in land use. These changes all affect habitat types and their productivity. Furthermore, as discussed in Chapter 5 and Chapter 6, people are affected by how altered environments affect access and the role that fishing can play, affecting the production from these environments. To be able to estimate catches using predictive models it is therefore necessary to have information about habitat types, extent, and dynamics as well as on the effort or realized production for different habitats. Habitat models are highly dependent on the information available on waterbody type, extent and productivity which can give rise to potential errors, as in the case of African lakes where productivity has increased due to the development of small pelagic fisheries, or in cases where freshwater fish production comes from a combination of aquaculture and inland capture fisheries. Furthermore, many of the underlying datasets used in fish habitat models and effort density models are over 20 years old.

Similarly, the extent to which consumption models can be relied upon depends on the nature of the fisheries and the elements related to the mass balance model, notably identifying the provenance of inland fisheries catches and pre-processing and preservation factors. These inference models have the benefit of using observational data but can be computationally more demanding. Consumption-based catch estimates should therefore be robust and more applicable for those countries with minimal trade, aquaculture, marine fisheries, fish waste and other utilization, which in truth limits their applicability, or alternatively may be better suited to provide more localized estimates rather than providing indications of production trends at the national or regional level. Lastly, predictions of national catch derived from estimates of the mean per capita or per fisher catch rates will generally be highly imprecise, owing to multiplicative effect of large variations in both the catchability per person (or per fisher) and in fish biomass. However, estimates derived from these models might still be useful for providing envelopes of production, provide comparative estimates, or in cases where other estimates are not available.

The selection and combination methods offer the potential to improve the coverage and quality of inland fisheries statistics, particularly for habitats or fisheries that are diverse or complex to monitor using direct observation. However, there is a pressing need to consider the experiences with data collection and provide advice on the selection of methods to increase the accuracy and coverage of catch assessments. To support this, there is a need for advice on cross-cutting aspects, such as distinguishing wild capture and aquaculture production as well as to identify relevant data sources that can support the application of alternative methods. For example, it is important to evaluate and utilize the existing datasets and other resources, both within FAO and available externally.

The Illuminating Hidden Harvests project (FAO, Duke University and WorldFish Center, 2023) also illustrates the potential multidisciplinary designs for data collection and analysis that highlights the connectivity of inland fisheries across different domains. This recognizes fisheries as not concerned only with production, but also the contribution to livelihoods, nutrition, food security, and governance, and serves as an example of the way in which existing data can be utilized in different ways to inform fisheries management and planning.

In assessing the need for the collection of new datasets and priorities for the types of data to be collected, consideration should be made ways in which indicators can be collected across multiple domains more efficiently. Consumption and household surveys are the case in point, in which estimates on inland fisheries catches can be inferred (albeit under relatively strict conditions), in addition to indicators on employment in fisheries, consumption and nutrition, thereby maximizing cost efficiencies when there are limited resources available for data collection.

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4. INLAND FISHERIES, FOOD SECURITY AND NUTRITION

Molly Ahern

SUMMARY

Aquatic animal-source foods provide at least 20 percent of animal protein to over three billion people, while also being a unique source of essential long-chained polyunsaturated fatty acids and micronutrients. Two-fifths of aquatic food consumption consists of freshwater and diadromous species, highlighting the importance of inland fisheries to food security and nutrition. Lower-income countries, with higher rates of malnutrition and food insecurity, often depend more on inland capture fisheries than marine capture fisheries or aquaculture as a source of aquatic food. However, changes in food security and nutrition condition of poor or more vulnerable population groups often is not the focus of fisheries management, with less than half of fisheries policies globally including nutrition as a key objective.

This chapter will seek to address this imbalance, recognizing that the role of inland fisheries in food systems can be integral for achieving several Sustainable Development Goals (SDGs). The chapter explores the contribution of inland fisheries to food security through a food systems lens, exploring how inland fisheries supply chains contribute to food security and various drivers that shape what, when, where, how, why and to whom foods are available, accessible, affordable and acceptable.

4.1 FISHERIES AND NUTRITION

Although the percentage of children under five years of age who are stunted or wasted[17] has decreased between 2000–2022 (from 33 percent to 22.3 percent and 8.7 percent to 6.8 percent, respectively), the prevalence of overweight children has slightly grown, and there was no progress on reducing food insecurity (FAO *et al.,* 2023). While often not a focus of fisheries management, changes in the food security and nutritional condition of poorer or more vulnerable groups remain a key indicator of policy success (Arthur *et al.,* 2022). Despite this, less than half of fisheries policies (77 of 158 national fisheries policies) include improved nutrition as a key objective, and even fewer nutrition policies (68 out of 165) recognized the importance of aquatic foods (Koehn *et al.*, 2021).

Aquatic animal foods contributed at least 20 percent of the per capita protein supply from all animal sources to over 3.2 billion people (FAO, 2024). In per capita terms, global annual consumption of aquatic animal foods reached a record high of 20.6 kg in 2021 – ranging from 5.3 kg in low-income countries, 12.5 kg in lower-middle income countries, 26.7 kg in high-income countries, to 30.6 kg in upper-middle income countries (FAO, 2024). Nearly three-quarters of aquatic animal foods supplied are finfish, while the remainder is comprised of other species groups, including crustaceans, cephalopods, molluscs, and other aquatic animals (FAO, 2024). Freshwater and diadromous species account for a greater share of aquatic animal food consumption per capita at 41 percent compared to 33 percent for marine fish species, other molluscs (13 percent), crustaceans (11 percent), cephalopods (2 percent) and other aquatic animals (1 percent). While these figures from FAO (2024) serve to highlight the scale of the contribution of inland fish and other aquatic animals to consumption, it is also important to note that past publications have suggested that statistics on inland capture, and hence contribution, are likely underestimated (Fluet-Chouinard, Funge-Smith and McIntyre, 2018; Welcomme, 2010).

Globally, more people participate in inland and marine fisheries for subsistence than for commercial purposes (Virdin *et al.*, 2023). Many people take part in inland fisheries on a rolling basis, this

17 Stunting refers to low height-for-age, or poor linear growth often associated with chronic malnutrition, while wasting refers to low weight-for-height, which is often associated with acute malnutrition.

flexibility can increase household resiliency and prevent them from sliding into greater poverty (Béné and Friend, 2011). Virdin *et al.* (2023) found that, across seven countries studied, 40 percent of subsistence fishers were entirely outside of the formal labour force, demonstrating that small-scale fisheries absorb excess labour and fill livelihood gaps for agricultural workers during off seasons. This safety net role of fisheries was found to be particularly strong in inland fisheries, for example, in the Lao People's Democratic Republic, 97 percent of people working in small-scale fisheries (or 17 percent of the country's population) did so only for subsistence (Virdin, *et al.*, 2023). Beyond this economic safety net contribution, subsistence fisheries also make contributions as "nutrition safety nets" (Arthur, Friend and Béné, 2016). Virdin, *et al.* (2023) calculate that inland fisheries provide 112.5 million people with an average of 26 percent of daily recommended nutrient intake for six nutrients which are commonly deficient in diets (calcium, iron, omega-3 fatty acids, vitamin A, selenium and zinc). The welfare function of inland fisheries should be better recognized, using through implementation of tools such as the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (FAO, 2015) to support policy and practice.

In lower-income countries, where higher rates of malnutrition and food insecurity persist (FAO *et al.*, 2023), inland fisheries continue to play greater roles in addressing these challenges than either marine fisheries or aquaculture (McIntyre, Liermann and Revenga, 2016). The nature of what is produced from inland fisheries and how it is made available can also be important, with the potential accessibility of the foods produced playing important roles. Small indigenous fish species and aquatic foods from inland waters are often directed to consumption. These foods are typically sold for low prices, available in small quantities, and less often exported (Byrd *et al.*, 2021; Cooke *et al.*, 2016; McIntyre, Liermann and Revenga, 2016). Despite recognition that inland fisheries provide food for billions of people, and livelihoods for millions, global discourses on fisheries, food and nutrition policies continue to focus on marine fisheries (Lynch *et al.,* 2020).

This chapter will seek to address this imbalance, recognizing that the role of inland fisheries in food systems can be integral for achieving several of the Sustainable Development Goals (SDGs) despite inland fisheries being notably absent from the SDGs (Lynch *et al.*, 2020; Cooke *et al.*, 2016). The chapter explores the contribution of inland fisheries to food security through a food-systems lens, exploring how inland fisheries supply chains contribute to food security through food environments and individual factors and various drivers that shape what, when, where, how, why and to whom foods are available, accessible, affordable and acceptable.

4.2 INLAND FISHERIES VIEWED THROUGH A FOOD-SYSTEMS LENS

Definitions of food security have evolved over the last few decades, with recent discourses framing food insecurity as an outcome of hunger, poverty, conflict, climate change and other causal factors (such as Fanzo, 2023). Various food system frameworks have been developed to aid in understanding these complex interactions (Friend *et al.*, 2023; Fanzo *et al.*, 2022; Cojocaru *et al.*, 2022; HPLE, 2020, 2017; Eriksen, 2008). The World Food Summit in 1996 resulted in the still widely used definition of food security as meaning "that all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their food preferences and dietary needs for an active and healthy life" (FAO, 1996). This definition highlights the importance of key dimensions associated with foods including their availability, stability, utilization and access that can affect their contributions to food security. The articulation of these dimensions helped to bring clarity and enable measurement of food security but also created silos of thought and political action in some regards (Fanzo, 2023) as gaps appeared in relation to trade-offs for environmental sustainability, nutrition and livelihoods (Pingali, 2015, 2012). This chapter explores inland fisheries through a food system lens, using the framing from Fanzo *et al.* (2022). Adopting such a lens emphasizes the connections between production, provisioning, consumption and outcomes.

4.2.1 Inland fisheries production

Hundreds of millions of people around the world benefit from low-cost protein, recreation, commerce and employment provided by inland capture fisheries production. This includes activities associated with both wild and enhanced fisheries for commercial, subsistence and recreational purposes. Such benefits can be particularly important in regions where alternative sources of nutrition and employment are scarce. An estimated two-thirds of fish destined for direct human consumption are caught in small-scale fisheries (SSF), with that estimate rising to 90 percent for these fisheries operating in inland waters, supporting the food needs of billions (FAO, Duke University and WorldFish Center, 2023). Inland fisheries, encompassing pre- and post-harvest activities, employ an estimated 14.6 million people in fish harvesting with an additional 36 million participating in subsistence fishing, the majority of whom live in the Global South (FAO, Duke University and WorldFish Center, 2023).

Environmental factors such as temperature, water flows and nutrient availability driven by the seasonal variations in aquatic systems are primary drivers for the productivity and resilience of inland water ecosystems (FAO, 2022). Many countries experience high variability in fish yields, particularly in drylands and floodplains, relating to varying rainfall and climatic conditions (FAO, 2016). For example, in the United Republic of Tanzania fishing activity is driven by annual flooding, with subsequent changes in fish and labour availability (Moreau and Garaway, 2021). In Malawi, the high variability is perceived as a challenge by fishers related to policies, institutions and processes in terms of governance of fisheries and access, where closed fishing seasons and gear restrictions were perceived to negatively impact upon livelihoods (Simmance *et al.*, 2022a). Even in areas perceived to be biologically rich, food security has been shown to diminish with decreasing catch rates of wild fish and bushmeat (Tregido *et al.*, 2020). In the Brazilian Amazon, catch rates were recorded to be 73 percent lower in the high-water season, corresponding with decreased food security as one-third of households reported skipping meals and one-sixth reported not eating for an entire day (Tregido *et al.*, 2020). In Newfoundland, Canada, household fish consumption declined during non-fishing seasons as consumers preferred eating local over imported fish (Lowitt, 2013). The variability of fishing effort also highlights an important consideration: that productive inland waters do not necessarily result in high catches and consumption. People fish for a variety of reasons and may choose harvest efficiency over high catch volumes or vary the pattern of fishing and dependence on fish with the availability of other foods.

In terms of environmental sustainability, production of fish and other aquatic foods are often considered to have a lower environmental impact than terrestrial animal-source foods (Funge-Smith, 2018; Hilborn *et al.*, 2018). Crucially, many inland fish stocks are adapted to fluctuating aquatic environmental conditions, including water quantity and quality and habitat connectivity. As a result, they can often experience high levels of natural mortality but remain capable of recovering. Given the large numbers of people involved in fishing, fishing pressure can be high, but it often responds to fish abundance such that environmental factors can play a greater role than fishing pressure in the productivity and resilience of these fisheries. Despite this, concerns remain regarding the threat to sustainability posed by fishing activities (Naylor, 2021) but also in relation to high losses and waste in fish supply chains, estimated to be as high as 35 percent of all fish produced (FAO, 2022). Reductions in loss and waste and improvements in utilization may help to reduce pressure on fish stocks, furthering sustainability of inland fisheries (FAO, 2022).

4.2.2 Inland fisheries provisioning

Provisioning refers to the collective post-harvest activities associated with the food environment. This includes the processing, storage, distribution, marketing and sharing of fish as it moves and is variously transformed at stages between the producer and consumer. Fish processing is conducted widely for a multitude of reasons, including reducing losses of fish, extending the storage life, increasing availability (as with fish powders, stock, sauces, dried shrimp and fish as ingredients or additives) and changing sensory attributes such as flavour. Reducing the moisture content and related bacteria, mould and yeast growth of fish by sun-drying, smoking, salting, parboiling and drying, freezing, or powdering fish are effective ways of increasing storage life of fish products, offering an opportunity to extend consumption and reduce loss and waste (Fitri *et al.,* 2022; Nowsad, Shahriar and Hoque, 2021; Mahmud *et al.*, 2019). However, different processing and storage methods affect retention of specific nutrients. For example, Fitri *et al.* (2022) conclude that vitamin A degradation is more dependent on sunlight than high temperatures common in hot smoking, and Farid *et al.* (2014) highlight that the lipid content of dried fish is reduced after storage. Additionally, food loss and waste during processing can be high due to quality losses from contamination by flies and insects, use of insecticides, lack of cold chain or processing infrastructure, and seasonal gluts in fish availability coinciding with rainy seasons (Fitri *et al.,* 2022; UN Nutrition, 2021; Funge-Smith and Bennett, 2019).

While fish wastage (that is, from the retail point onwards) rates are estimated to be greater in North America and Oceania and mainly occurring due to consumption habits, fish loss (from harvest to retail) is estimated to be higher in developing countries where adequate infrastructure and services are often lacking (FAO, 2022). However, few studies have compared evidence on fish losses between marine fisheries, inland fisheries and aquaculture (Pushpalatha, 2023; Prodhan, *et al.*, 2022).

4.2.3 Food consumption and food environments

The food environment is defined as the consumer interface with the food system that includes wild, cultivated and built spaces (Downs *et al.,* 2020) and is the most proximal space to the consumer, thus a key space to promote healthy diets (Kennedy *et al.,* 2023). Amongst aspects of the food environment that can influence individual choices related to foods and food consumption are food availability and affordability).

Food Availability

Low–income and undernourished populations are especially reliant on inland fisheries compared with marine or aquaculture as a source of low-cost animal protein. McIntyre, Liermann and Revenga (2016) estimated that inland fisheries provide the equivalent of all dietary animal protein for 158 million people and Funge-Smith (2018) highlighted that the global distribution of inland fisheries production meant that low-income food-deficit countries (LIFDCs) account for 21 percent of the total global inland fish catch. Nations with gross domestic product (GDP) below the global median (at time of publication, less than USD 4 800 purchasing power per capita annually) also had higher nutritional dependence on inland fisheries, based on total animal protein consumption (McIntyre, Liermann and Revenga, 2016). These countries accounted for 81 percent of nutritional dependence on inland fisheries, and include countries such as Bangladesh, Cambodia, and Zambia, where alternative animal protein sources may be unaffordable (McIntyre, Liermann and Revenga, 2016).

From a nutrition perspective, animal-source foods such as small dried fish, liver, eggs and beef were found to be the most nutrient-dense nutritional sources often lacking from diets in Eastern and Southern Africa, however these regions have the second-lowest per capita daily supply of meat (29 g) and fish (16 g) based on food balance sheets (White *et al.*, 2021). However, it is noted that apparent supply data available in food balance sheets may underestimate fish supply, as small-scale and inland fisheries are often underrepresented (White *et al.*, 2021; Fluet-Chouinard, Funge-Smith and McIntyre, 2018).

Food Affordability

Fish from inland fisheries tend to be more affordable than other animal-sourced foods and provide an important source of nutrition and livelihoods to rural communities, as they are often available in remote areas (Funge-Smith and Bennett, 2019). A recent study examining affordability and supply of wild-caught fish in 39 low- and middle-income countries found that, relative to a low-cost diet based on local staple foods, freshwater fish such as carp, barbel and other cyprinids were the second least-cost group of aquatic foods (Robinson *et al.*, 2022). However, fish prices vary, often linked to seasonal availability but also due to factors such as quality of fish on the market, type of market, or, in the case of non-market transactions, social relationships (Baran, Jantunen and Chong, 2008). For example, where people are not able to participate directly in fishing activities, affordability of fish can depend on social relationships. It is also the case that primary and secondary users (such as fishers, fisher spouses or those who are involved in or financing fisheries operations) are often more able to obtain fish. Depending on seasonality of supply and culture, these users may have more say in the final price, whereas tertiary users (those who need to buy fish from fishers or traders) often have less say, particularly women who may have less bargaining power (Lentisco and Lee, 2014).

4.2.4 Properties of fish as food – quality and safety

Aquatic foods are recognized as a rich source of high-quality nutrients, although they are also highly perishable and affected by biological (bacteria, viruses, parasites), chemical (biotoxins) or environmental and anthropogenic food safety concerns (Ahern *et al.*, 2021a; Rasul, Yuan and Azad Shah, 2020). Freshwater fish are commonly associated with parasitic infections and special attention should be given to environmental sanitation issues in areas where insufficient regulatory measures exist (Vergis, Malik and Barbuddhe, 2021). Beyond food safety issues in production, the way in which fish is handled, processed, transported, distributed, and prepared can have an impact on the quality and safety of the final product. Although fish processing is beneficial in extending the storage life of fish, thus allowing it to be distributed greater distances and potentially smoothing consumption across non-fishing seasons, it can also impact aspects related to the safety and quality of fish products. Quality losses in the supply chain such as spoilage are often measured in monetary terms as a loss of income to the consumer (Kruijssen *et al.,* 2020), but also represent a nutrient loss to consumers and can present significant food safety risks. Additionally, quality and safety of the final product can be affected by various processing methods and poor storage. As mentioned in Section 4.2.2, fish smoking and sun-drying can negatively vitamin A content, and fish smoking using traditional methods can result in high levels of harmful polycyclic aromatic hydrocarbons (PAHs) (Asamoah *et al.*, 2021).

The nature of the processing and distribution can raise questions as to the extent to which the fish that passes through them is safe and hygienic, since fish can rapidly deteriorate in quality if not handled and preserved properly (e.g. Kruijssen *et al.*, 2020). In many cases fish are consumed shortly after capture and traditional processing techniques effectively reduce these risks, however with the growth of markets for inland fish there are concerns that new risks may arise. Rasul, Yuan and Azad Shah (2020) describe how in Bangladesh sale by weight can create incentives to not thoroughly dry fish as this can reduce profit, but the practice reduces the quality of the final product and accelerates insect infestation. Similarly, in the United Republic of Tanzania, despite evidence that using raised drying racks resulted in reduced post-harvest losses of dagaa (*Rastrineobola argentea*), artisanal fish processors reported preferring to dry fish on the ground, believing that heat from the sand aids in drying the fish faster as well as sand sticking to the dried product increasing the weight (and consequently the price) (Ibengwe and Kristófersson, 2010; Kabahenda and Hüsken, 2009). These practices raise concerns over fish quality and safety. Beyond traditional processing practices, concerns have also arisen about chemical adulteration linked to fish trade and the extension and expansion of national and cross-border market systems (Bavinck *et al.,* 2023). Examples of these practices include the use of organochlorine insecticides to protect the dried fish from insect infestation (Rasul, Yuan and Azad Shah, 2020; Mansur *et al.*, 2019). However, interventions and campaigns to eliminate adulteration practices are still rare (Bavinck *et al.,* 2023).

4.2.5 Properties of fish as food – nutrient content

While various food safety risks can arise in production systems and supply chains, they affect species differently (FDA, 2022), and species have diverse nutrient profiles to begin with. Marine fish species are generally recognized for their higher omega-3 fatty acid content (Strobel and Kuhnt, 2012; Imhoff-Kunsch *et al.*, 2012), which is often studied in relation to cardiovascular function and cognitive development, inland fish species also make important contributions to dietary docosahexaenoic acid (DHA),[18] particularly where they are frequently consumed (Byrd, Thilsted and Fiorella, 2021; Fiorella *et al.*, 2017; Yakes Jimenez *et al.*, 2015; Kwetegyeka, Mpango and Grahl-Nielsen 2008). In addition, freshwater species, particularly small freshwater fish that are consumed whole, are recognized as rich sources of micronutrients, concentrated in parts such as the bones or eyes (Byrd *et al.,* 2021).

18 DHA is a particularly important long-chained polyunsaturated fatty acid for brain and eye development and function. It is important to consume preformed DHA (found in aquatic foods, particularly fatty fish) at specific periods of life (during childbearing and for infants and young children) as synthesis from other polyunsaturated fatty acids, such as α-linolenic acid or eicosapentaenoic acid, is not efficient in the human body (Calder, 2016).

Box 4-1: Freshwater species in Global Food Composition Data – Representations and Completeness

To better understand available data on food composition of aquatic foods from marine and inland water bodies, two global databases on food composition of aquatic foods were analyzed for inclusion of food composition data on freshwater species:

- the Food and Agriculture Organization of the United Nations' International Network of Food Data Systems (FAO/INFOOD) Global food composition database for fish and shellfish, version 1.0 uFiSh1.0; and
- the Aquatic Foods Composition Database (AFCD) from Golden *et al.* (2021).

The FAO/INFOODs uFiSh1.0 database includes high-quality data with full nutrient profiles for 78 species in total, while the AFCD includes partial nutrient profiles (for example, analysis of specific components such as fatty acids or proximate values) for over 3 000 species. To facilitate the review of these two databases, only species for which data were available on ten select key nutrients were included, specifically eicosapentaenoic acid (fatty.acid.20.5.n3), docosahexaenoic acid (fatty.acid.22.6.n3), protein, calcium (Ca), iron (Fe), iodine (I), selenium (Se), zinc (Zn), vitamin A (retinol activity equivalent [RAE]), and cholecalciferol (D3).

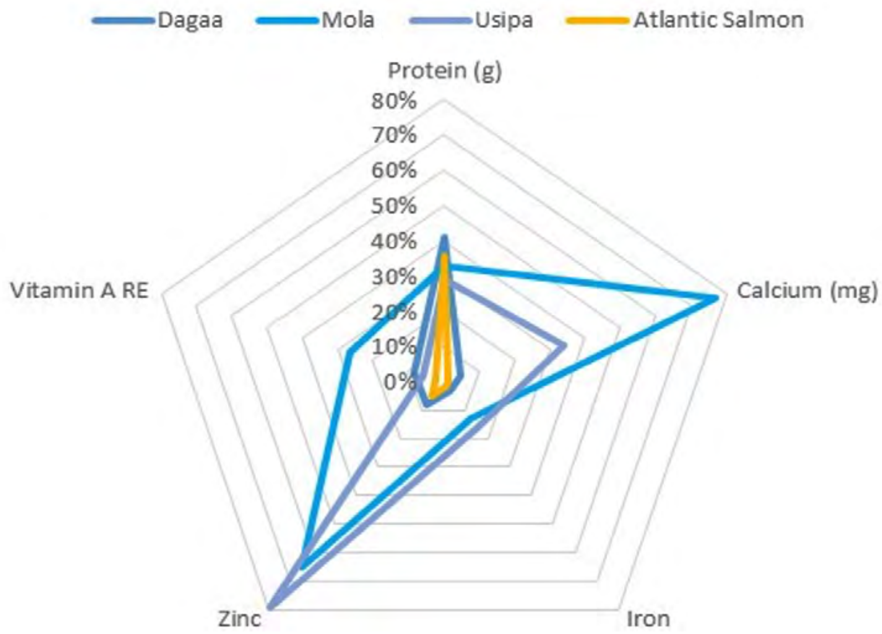
Species were further filtered to include only species in raw form to ensure comparability of nutrient content. Lastly, farmed species were removed, to only include species from wild capture fisheries, totalling 147 species. Of these species, duplicate records were removed, for a total of 116 species included. These species were classified as marine (n = 99) and freshwater (n = 16), demonstrating the greater availability of complete food composition data in global databases on aquatic foods from marine origin in relation to freshwater species.

Sources: Authors own elaboration of data from AFCD (Golden *et al.*, 2021) and uFiSh (FAO, 2016).

While global food composition databases on aquatic foods generally lack the full nutrient profiles of freshwater fish, a recent evidence scan of available food composition data found that of 515 unique aquatic food species published in various studies: 50 percent were freshwater, 45 percent were marine and the remainder were farmed species (Byrd, Thilsted and Fiorella, 2021). This demonstrates that although there are published food composition data on freshwater species available, there is still less representation of inland fish species in global databases. This lack of data on inland fish species within global food composition databases on aquatic foods may be due to some databases' stringent data validation steps, requiring specific laboratory analysis methods, or published data lacking complete nutrient profiles. Costs for high-quality nutrient analyses are often prohibitive, which may particularly affect availability of data on species of lower commercial value (Cohen *et al.*, 2022), such as small indigenous fish from freshwater lakes. This often results in a lack of data on select groups of nutrients (i.e. fatty acids), which likely did not appear in the search completed in Box 4-1 due to criteria set for completeness. The limitation of fish nutrient composition data is particularly problematic because the species consumed by those who are the most food insecure and nutritionally vulnerable are the most poorly accounted, such as species caught by small-scale fishers in inland water bodies (Byrd, Thilsted and Fiorella, 2021), and in particular small sized species (< 25 cm at maturity). The lack of data on these species, of importance in diets in many regions, can deter nutrition-sensitive fisheries management efforts, as global databases may not represent what is harvested nor consumed regionally or locally.

In recent years, there has been effort to build food composition tables in countries such as Bangladesh and Malawi (MAFOODS, 2019; Shaheen *et al.*, 2013) and include nutrient composition data on small indigenous species such as usipa (*Engraulicypris sardella*), utaka (*Copadichromis* sp.) and mola carplet (*Amblypharyngodon mola*). Additionally, efforts to estimate nutrient content of aquatic foods have been made where funds are not available for laboratory analysis (Froese and Pauly, 2024). To provide a snapshot of the nutrient content of regionally important freshwater species, a small

Figure 4-1: Contribution of selected marine and freshwater fish to RNI for adult women (per 100 g serving of raw edible parts).



Source: Author's own elaboration, based on data in Annex 4-1.

selection of freshwater and marine fish species was collated (see Annex 4-1 for nutrient content table). Three freshwater species known to be important in diets in the Africa Great Lakes region and Bangladesh were selected and compared to common marine species. Micronutrients were selected based on recognized global deficiencies, including iron, zinc, calcium, and vitamin A (Beal *et al.,* 2017; Ferguson *et al.*, 2015). Other nutrients of global importance, such as vitamin B12, folate and DHA, were not included due to limited data availability. Analytical data were prioritized where available, and gaps in nutrient content were filled by using modelled estimates from the FishNutrients dataset (Froese and Pauly, 2024).

Nutrient content data were then compared to recommended nutrient intakes (RNI) for adult women (see Annex 4-1), to calculate the percentage of the RNI that a 100 g serving of each selected species could fulfil (see Figure 4-2). In summary, freshwater fish species had greater content of calcium, iron, zinc, and vitamin A (retinol activity equivalent) in comparison to the Atlantic salmon (*Salmo salar*), which had slightly higher protein content in comparison.[19] Higher micronutrient content in the selected freshwater species may be due to edible parts considered to include the whole fish (including eyes and bones which are particularly rich in vitamin A and calcium), whereas protein content may be slightly higher for Atlantic salmon as edible parts included the muscle tissue only (in which protein is concentrated). Certain fish from inland capture fisheries are known to be rich in zinc and iron (Belton and Thilsted, 2014), including for example small fish harvested from paddy fields in Northern Thailand (Karapanagiotidis *et al.*, 2010). Nutrient composition can vary greatly across species, as seen in Figure 4-1, as well as in Byrd, Thilsted and Fiorella (2021) and Bogard *et al.* (2015).

4.2.6 Food messaging: information about freshwater fish in food-based dietary guidelines

While there has been growing recognition of aquatic foods as a source of micronutrients and essential long-chained polyunsaturated fatty acids, they are still often referred to as a protein-rich food in dietary guidelines and nutrition education efforts. Uyar *et al.* (2021) assessed 94 national food-based dietary

19 However, as noted previously, marine fish species are generally recognized for their higher n-3 fatty acid content (Strobel and Kuhnt, 2012; Imhoff-Kunsch *et al.*, 2012) however data were not included here due to limited availability.

guidelines (FBDGs) identified in FAO's repository[20] for the inclusion of aquatic foods, finding that 85 countries include messages on various aquatic foods. Only seven countries in Africa (Benin, Kenya, Namibia, Nigeria, Seychelles, Sierra Leone and South Africa) had food based dietary guidelines at the time of the assessment, and an additional four have adopted such guidelines since (Gabon, Ghana, Ethiopia and Zambia). While all these guidelines from African countries include messages on aquatic foods, they are often grouped with other animal-source foods (meat, poultry, dairy, eggs) or protein-rich foods (animal-source foods plus legumes) and do not explicitly mention freshwater fish, despite its importance in diets in many of these countries.

Although aquatic foods are often grouped with other protein-rich foods in FBDGs, dietary recommendations for fish and other aquatic foods include specific recommendations for fatty fish to increase omega-3 fatty acid and vitamin D consumption (often understood to be marine coldwater species but including freshwater species such as trout in some recommendations). Various recommendations from FBDGs are included in Table 4-1. Some guidelines mention consumption of whole small fish with bones (Bangladesh, Benin, Greece, Honduras, Japan, Philippines, Spain and Thailand), with few focusing on *freshwater* small fish species such as kapenta or omena (in the case of Zambia and Kenya respectively) for calcium.

Table 4-1. Inclusion of freshwater fish in food based dietary guideline recommendations.

Country	Message about freshwater fish / inland fisheries in food based dietary guidelines
Estonia	The amount of dioxins in fish in the sea and **inland water**s has been studied in Estonia since 2002 and the results show that eating fish twice a week (once low-fat fish, once high-fat) does not have undesirable side effects on human health, and that the health benefits of fish outweigh the risks of contaminants.
Italy	The guidelines mention that the amount of lipids, and thereby omega-3 fatty acids, in fish products varies enormously according to the species, the habitat of origin (marine or freshwater) and the type of production (wild or farmed). With this in mind, they suggest classifying fish products in three ways, based on the percentage of their lipid content: lean (less than 3 percent), semi-fat (3 percent to 8 percent) and fat (more than 8 percent). Regarding sources with the highest concentrations of omega-3 fatty acids, Italy's FBDGs list fattier and coldwater species such as salmon, mackerel and herring as examples and that there are significant quantities of omega-3 fatty acids in typical Mediterranean species, especially blue fish, as well as sea bream or sea bass, and also in **freshwater species such as trout**.
Oman	Some fish (such as salmon, **trout**, and herring) are high in a type of polyunsaturated fatty acid called "omega-3 fatty acids".
Guatemala	Fish such as sea bass, **tilapia**, mojarra, dorado, sardines and tuna contain omega-3 fatty acids.
Costa Rica	Tuna, sardines, **trout** and salmon are good sources of omega-3.
Canada	Includes coastal fish such as salmon, cod and arctic char, **and lake fish such as trout, walleye, whitefish and northern pike)**, and shellfish along the country's coastlines: "Traditional food varies across the country because Indigenous Peoples historically consumed what was available locally."
United States of America	Salmon and **trout** are given as more specific examples of vitamin D.
Denmark	Include for example herring, mackerel, salmon and **trout**. It is important to eat different types of fish.
Norway	Two meals a week equals 300–450 g of fish during a week, of which at least 200 g should be fatty fish such as salmon, **trout**, mackerel or herring.

20 FAO's repository of Food Based Dietary Guidelines can be found at: https://www.fao.org/nutrition/education/food-based-dietary-guidelines.

Country	Message about freshwater fish / inland fisheries in food based dietary guidelines
Austria	Eat at least one or two servings of fish (150 g) a week. Prefer high-fat fish such as mackerel, salmon, tuna and herring or local cold-water fish such as **river trout**.
Cyprus	Fish, and especially fatty fish (sea bream, salmon, sea bass, swordfish, **brook trout**), are recommended to be consumed at least 1–2 times per week.
Sri Lanka	Name mackerel, tuna, herring, sardinella, kumbalawa, **trou**t and salmon as examples of oily fish**.**
Zambia	Make **small fish such as kapenta** eaten with bones a major part of the fish options chosen per week.
Philippines	Describe **freshwater fish** and seafood, including seaweed, clams, lobster, oysters, shrimps, sardines and other saltwater fish as rich sources of iodine.

Source: Adapted and updated from Uyar *et al.*, 2021.

4.3 INDIVIDUAL FACTORS AFFECTING CONSUMER BEHAVIOUR TOWARDS FRESHWATER FISH

Aggregated national consumption figures can mask demographic, societal and geographic inequities in diets, including uneven access to animal-source foods (O'Meara *et al.*, 2021). Physical accessibility of aquatic foods can differ, based on level of economic development (Temsah *et al.*, 2018), as well as proximity to a water body and access to markets (see Box 4-2). Household proximity to water bodies

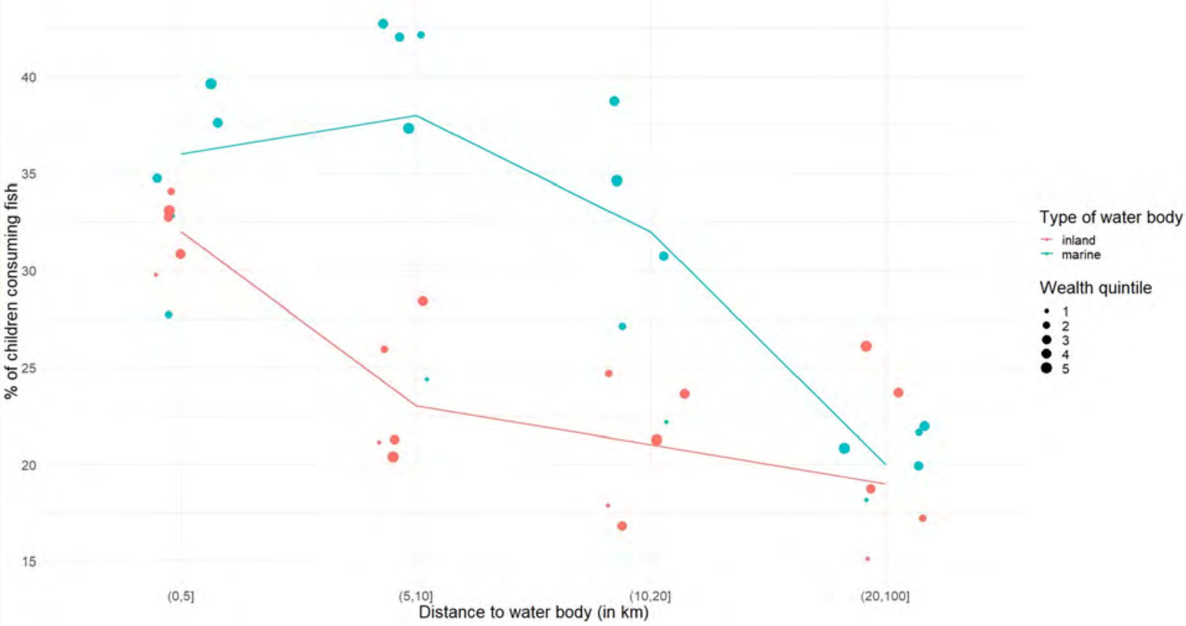
Box 4-2: Economic and situational factors affecting fish consumption for children in Cambodia, Ghana, Kenya, Myanmar and United Republic of Tanzania

The association between children's fish consumption and proximity to inland versus marine water bodies was further explored using ten existing geo-referenced datasets available through the Demographic and Health Surveys (DHS) analysed using spatial analysis and logistic regression models. Nationally-representative child nutrition and socio-economic data from DHS were merged for Cambodia, Ghana, Kenya, Myanmar, and United Republic of Tanzania. Child nutrition and socio-economic data for more than 48 000 children aged 0–59 months across the five countries were used, however dietary recall data were only available for a subset of these children. As 24-hour dietary recall data were focused on children aged 6–23 months given the validity of the Minimum Dietary Diversity (MDD) indicator and other infant and young child feeding indicators for this age group, the analysis was limited to children less than 24 months of age (n = 10 317).

Results suggest that children who consume fish are more likely to consume an adequate diet, based on positive correlation between children consuming fish and children meeting MDD. In addition, there is a positive relationship between higher attainment of maternal education (in years) and greater fish consumption by children fewer than 24 months of age. Of the children who consumed fish, a greater percentage lived in urban areas (24 percent in comparison to 22 percent in rural areas), however distance to water bodies was a better predictor of children's fish consumption when multiple variables were included. Across all countries, a greater percentage of children living near marine water bodies consumed fish in relation to children living within close proximity to inland water bodies (see Figure 4.2 below). For example, in Kenya 17.3 percent of children living within 5 km of the ocean shore consumed fish, compared to 7.8 percent of children living within the same distance of inland water bodies.

There is a sharp drop in percentage of children consuming fish beyond 5 km from inland water bodies, while an increase in percentage of children consuming fish is seen when the distance from the shore increases to 5–10 km, and then decreases when the distance is greater than 10 km. This may suggest that marine fisheries contribute more to the diets of children living close to marine coastlines and further afield, as supply chains for marine fisheries, including transport and distribution, may be more developed. Of note, household wealth (measured in quintiles by the DHS survey) plays a role in access, particularly for households living close to marine water bodies – as seen in Figure 4-2 which shows that a greater percentage of children from households in higher-wealth quintiles that live within 20 km of marine water bodies consume fish in comparison to children in lower-wealth quintiles living close to marine water bodies. The relationship is less significant for those living close to inland water bodies, as the percentage of children consuming fish from households in various wealth quintiles does not vary as much.

Figure 4-2: percentage of children (< 24 months of age) consuming fish by distance from marine and inland water bodies (1 = lower wealth; 5 = higher wealth).



Source: Ahern, unpublished data.

*Source***:** Author's own elaboration of DHS survey data.

has been associated with increased consumption of fish by children (O'Meara *et al.*, 2021; Choudhury, Headey and Masters, 2019) and improved income and food security (Simmance *et al.*, 2022b; Fiorella *et al.*, 2014). However these studies either focused on areas where only inland water bodies are present (O'Meara *et al.*, 2021; Fiorella *et al.*, 2014), or did not include any comparison of findings on proximity to different (marine, inland) fish types (Simmance *et al.*, 2022; Choudhury, Headey and Masters, 2019), thus making it difficult to delineate the specific role of inland fisheries for food security and nutrition.

Different inland fish species may be available to different people and this could have nutritional implications. A spatial analysis of flow of inland fisheries products in Malawi demonstrated that chambo (*Oreochromis karongae*) is sold primarily fresh or smoked in urban centres, while usipa (*Engraulicypris sardella*) is more available to rural populations in sun-dried form – linked to a higher number of markets, lower retail prices, and sale in smaller volumes (Bennett, 2022). Wealth can be a determinant of animal-source foods consumption and diet diversity, however other factors such as maternal education, nutritional knowledge, and food preferences mediate the translation of wealth into improved diet quality (O'Meara *et al.*, 2021; Choudhury, Headey and Masters, 2019). Choudhury, Headey and Masters (2019) found that while children's meat and egg consumption increased with household wealth gradients, fish consumption did not rise with household wealth and was common amongst those in even the lowest wealth groups.

4.4 DRIVERS

Although many food systems frameworks have referred to various drivers of food systems, a clear and consistent definition is still lacking (Béné, *et al.*, 2019). Food system drivers are defined in this publication to include "processes, factors, or conditions that shape what, when, where, how, why and to whom foods are available, accessible, affordable and acceptable" (World Obesity Federation, 2023), highlighting the importance of access, in terms of the *ability to benefit* (after Ribot and Peluso, 2003). While food supply chains, food environments and individual factors play a role in the availability of fish for consumption, they do not ensure the ability to benefit from this availability (Ribot and Peluso, 2003). Although someone may be within short geographic proximity to a water body, it does not ensure their physical or legal ability to engage in fishing to obtain aquatic foods. There may be important political or sociocultural factors that mediate access. For instance, even in situations where women can fish they may be required to use smaller or less advanced technologies than men, or fish in more marginal or less productive areas (Lentisco and Lee, 2014; Kusakabe, 2002), restricting their efficiency and, ultimately, access. Furthermore, evidence suggests that men (or specific groups with more influence) may take over production and marketing of commodities traditionally considered women's once it becomes financially lucrative to do so (Fröcklin *et al.*, 2013; World Bank, FAO and IFAD, 2009), with some consequences for conservation and management of fisheries (Fröcklin *et al.,* 2014). Thus, while fish may be physically present people may be constrained by gender, age, or social status to catch, process, consume or otherwise benefit from the fish, due to policies or social norms (Friend *et al.,* 2023; Arthur *et al.*, 2023; Moreau and Garaway, 2021; Ribot and Peluso, 2003). For example, men or elders may consume first, leaving less-nutritious or less-desired foods for women and children (Ahern *et al.*, 2020). Alternatively, fish may be withheld from children (Gibson *et al.*, 2020; Thorne-Lyman *et al.*, 2017) or pregnant women due to cultural beliefs or taboos (Meyer-Rochow, 2009). These aspects are important in the global context in which over 800 million people suffer from hunger and three billion cannot afford a healthy diet, leading to calls to transform our food systems to ensure food security, nutrition and affordable healthy diets for a growing population while also safeguarding environments and livelihoods (FAO, 2022). While there are factors that can restrict access, there are also many ways in which access can be enabled, including through management measures (see Chapter 5) and the ways in which fish supply and distribution is organized in ways that enable poorer or otherwise more vulnerable groups to potentially benefit (see Box 4-3).

Aggregated statistics can credit aquaculture for observed growth in global consumption of aquatic foods, which is increasing at an annual rate nearly twice that of population growth. However, the uneven distribution of aquaculture development and production leaves capture fisheries as the major contributor of aquatic foods in many low-income countries (FAO, 2022). Regionally, consumption of aquatic foods is generally low across Africa in comparison to global averages due to high population growth outpacing growth in capture fisheries production (FAO, 2022). At more disaggregated levels, the links between population and consumption are affected by other changes, including urbanization, changes in diets and food sourcing strategies (e.g. Zhao *et al.*, 2019; Arthur and Friend, 2011). In addition, market drivers such as income growth and distribution, new production technologies, or globalization and trade may affect production or redirect fish to other consumers domestically or internationally (Arthur *et al.*, 2023). While global national income growth led to an increase in global fish consumption, it is difficult to generalize as consumers have different perceptions about different aquatic foods in terms of safety and health awareness, which results in different consumption patterns along with income growth (Han *et al.,* 2022). Based on a mapping of nutrient yields from global marine fisheries, Hicks *et al.* (2019) found that current production has potential to meet global nutrient needs, however international fishing fleets, trade deals, waste and reduction to fish oil or animal feed, as well as other drivers such as food preferences and culture can all act as barriers to fisheries meeting these nutritional needs (Hicks *et al.*, 2019). Although this analysis focused on marine fisheries, there is ongoing research into the potential nutrient yields of global inland fisheries, which are expected to make a significant contribution to food security and nutrition, particularly in low-income food-deficit countries and rural communities as previously noted in this chapter.

Box 4-3: The diversity, persistence, and relevance of nonmarket arrangements in inland fisheries

Most consumers in the Global South obtain fish not through fishing, but commercial trade (Beveridge, 2013). While this highlights the importance of markets in enabling people to benefit from fishing, there are also other important ways in which inland fisheries are organized as local economies that have important implications for access. These other forms of economic organization have been described as the "informal" or "diverse economies" (Gibson-Graham and Dombrowski, 2021) that relate to heterogeneous forms of enterprises, transactions, labour remuneration, property and financing. Examples respectively include social enterprises and cooperatives, gift-giving and barter, in-kind payments, commons and financial or in-kind donations.

Diverse economies in inland fisheries can play important roles in mediating access in terms of the ability of people to benefit from fish, fishing and associated activities. For example, community-based management of fisheries can depend on voluntary labour contributions and in-kind payments. Management systems can also involve different access arrangements. Waterbody leasing in Southern and Southeast Asia can generate important community income for social development. At the same time, the arrangements may also include opportunities for subsistence fishing using a limited set of gears or the sharing of some of the harvested fish with poorer households.

Even where rights to fish are held, it may not be the rights holder that benefits materially from the fish that is harvested. For example, women may have the right to fish within close proximity to the household, but household norms related to food preparation and consumption may also affect the ability to benefit. Similarly, not holding rights does not preclude benefitting. Gifting and reciprocity represent important forms of exchange that enable a wider set of people to benefit materially but also highlight that there are important relational benefits that can be derived from fish and fishing.

These non-market exchanges can be important. Garaway (1999) found that in southern Lao People's Democratic Republic, around 10 percent of household fish supply resulted from interactions with others including payment for labour, gifts and reciprocal exchange (Garaway, 1999). Diverse economies are not just functions of developing country fisheries. For poorer groups in middle- and high-income countries, retained catches from recreational fisheries can reduce reliance on markets and contribute to nutritional security, including through the sharing of catches (Nyboer *et al.*, 2022; Cooke *et al.*, 2018).

Crucially, considering diverse economies shifts the focus beyond rights and market values of fish and rights to these other factors that determine who benefits from fisheries and how. Doing so requires increased attention to the relationships and social norms that mediate behaviours and the changing contexts within which these diverse economies are embedded. A focus on the relationships and cultural norms also highlights the critical role of power in relation to access. While non-market exchange can be enabling, they can also serve to reinforce exploitative arrangements and behaviours. Because of the critical roles that they can play and the hidden nature of diverse economies, as well as their role in relation to food security and nutrition, it is important to begin to look beyond markets and rights in order to better understand the diverse and informal mechanisms that regulate access.

Sources: Nyboer *et al.*, 2022; Gibson-Graham and Dombrowski, 2021; Cooke *et al.*, 2018; Beveridge, 2013; Garaway, 1999.

4.5 OUTCOMES AND IMPLICATIONS FOR FISHERIES MANAGEMENT

Aspects of fish production, food environments and consumption contribute to the outcomes of food systems and the connections between these aspects, and the institutions and relationships that mediate them represent important entry points for food system transformations.

4.5.1 Food security and diets

Food stability – the need for people to have adequate food at all times – was considered to be the least-studied dimension of food security (prior to the addition of agency and sustainability as dimensions of food security) (Tregido *et al.*, 2020; Ashley, 2016). Equally important as food stability can be food instability: Food instability is often associated with conflicts and natural disasters, however it can also be associated with change and hence most commonly occurs on a seasonal basis (Vaitla, Devereux and Hauenstein-Swan, 2009). Even mild food insecurity can be harmful to the health of vulnerable population groups such as pregnant women and children under five years of age (Gernand, 2016; Bailey, 2015), while other studies have shown health complications extend up to seven or eight years of age (Schmeer and Piperata, 2017). Although the focus is often on aggregate food quantity, seasonal variation in food availability has been shown to affect dietary diversity (a proxy for micronutrient adequacy in the diet) for women of reproductive age (Ahern, *et al.*, 2021) and pregnant women (Hanley-Cook *et al.*, 2022). Furthermore, micronutrient deficiencies in early pregnancy were found to be seasonal in rural Nepal (Jiang *et al.*, 2005), and child wasting and stunting were shown to increase in certain times of the year in Bangladesh (Hillbruner and Egan, 2008) and Ethiopia (Kabalo and Lindtjørn, 2022).

Wild aquatic foods are no exception to seasonal fluctuations which affect food security, diets and nutrition, as shown in previous paragraphs. Studies in Malawi found that, when top-down fisheries management strategies such as closed seasons and gear restrictions were put in place, fishers at times engaged in illegal strategies to catch fish since they had little alternative livelihood and food options (Makwinja *et al.,* 2021) (Simmance *et al.*, 2022a). Adaptation strategies were noted, including joining cooperatives which provided support in low seasons, flood plain cultivation (Makwinja *et al.*, 2021), as well as food preservation and storage at times of high availability to extend temporal and geographic availability (Ahern *et al.,* 2021). Studies in the Lao People's Democratic Republic have shown that access to wild animal-source foods, such as fish, differentiated households between those that had acceptable food consumption and those that had poor food consumption (Foppes, 2008). Although this and other findings have shown that wild foods such as fish from inland capture fisheries are important to the poor, there was a heavy promotion of aquaculture in the country to increase household food security and income (Bush, 2008). This focus on aquaculture is a widespread strategy that tends to focus on production as the means to close the gap between supply and demand, but interventions such as community-based co-management and building the resilience of poor and marginalized groups by recognizing diverse forms of tenure and rights for these groups should also be considered (Foppes, 2008).

While fisheries management has typically focused on fishing, fishing effort and quantity of fish produced, less focus has been given to food supply chains and food environments, which ensure not only availability of fish but also access and stability through processing, packaging and distribution. Change and instability in these aspects of the food system also have the potential to impact livelihoods, food security and nutrition. Simple, improved equipment such as raised drying racks, solar tents and improved fish-smoking kilns, have been evidenced for reducing losses in fish supply chains (Ibengwe and Kristófersson, 2010), as well as development of fish products based on underutilized species, bycatch, or byproducts (FAO, 2022; Glover-Amengor *et al.*, 2012). Fish powders, often produced from underutilized small freshwater fish or byproducts of larger species, have been highly accepted when added to meals served in infant and young child feeding programs as well as school feeding programs (Chadag, 2022; Ahern, *et al.*, 2021; Byrd, *et al.*, 2021; Borg, *et al.*, 2020, 2019; Bogard, *et al.*, 2015; Glover-Amengor *et al.*, 2012).

While the cost of including fish products in young child and school feeding programs and economic sustainability continues to be a challenge (Ahern *et al.*, 2021), reduction of losses in fish supply chains has been evidenced for providing as much as twice the amount of fish to children when compared to using the fillet only (Toppe *et al.*, 2021). Additionally, fish powders have a long shelf-life, offering an opportunity to stabilize supply by producing fish powder during high production seasons and storing it for times of low availability (Nowsad, Shahriar and Hoque, 2021; Mahmud *et al.,* 2019). Recognition of broader food system dynamics can inform household strategies to ensure availability, accessibility and stability of fish. This includes social strategies such as joining cooperatives, which provide support and opportunities for collective bargaining and protecting rights associated with tenure and access, and employing technologies, such as preservation techniques to extend storage life of fish.

4.5.2 Nutrition and health outcomes from freshwater fish consumption

Aquatic foods have been evidenced for improved public health nutrition outcomes in populations suffering from overnutrition and undernutrition (UN Nutrition, 2021). These include improved outcomes in relation to obesity and non-communicable diseases such as reduced energy intake (in comparison with other animal-source foods), reduced blood pressure, lower cholesterol levels, reduced risk of death from coronary heart disease, improved cardiovascular function, and reduced all-cause mortality (UN Nutrition, 2021). Additionally, consumption of aquatic foods is linked to improved dietary diversity and micronutrient intake for women of reproductive age, improved fatty acid composition of breastmilk for breastfeeding women, reduced stunting and severe acute malnutrition, as well as improved cognitive development and positive behavioural health outcomes (UN Nutrition, 2021).

Maternal consumption of freshwater fish and child growth and nutrition outcomes have been included in several studies. In rural China, maternal fish consumption was associated with decreased risk of low birthweight, mainly driven by freshwater fish and shellfish consumption (Wei *et al.*, 2023). Similarly, another study found that moderate freshwater fish intake during pregnancy is associated with lower risk of small gestational age of babies in the Chinese population (Zhang *et al.*, 2023). However, in the Amazon region of Brazil, habitual freshwater fish consumption by pregnant mothers did not affect anthropometric indices of children from birth to five years of age (Cunha, Marques and Dórea, 2018).

Further studies have investigated growth and nutrition outcomes from the inclusion of freshwater fish in children's diets (e.g. Konyole *et al.,* 2019). Marinda *et al.* (2018) found that children between the ages of 6–59 months consuming fish from Zambian lakes had greater dietary diversity and reduced risk of stunting (Marinda *et al.*, 2018). Similarly, Chipili *et al.* (2022) found improved linear growth outcomes for 6–12-month-old children in Malawi following a daily treatment including fish powder produced from dried small freshwater fish (Chipili *et al.*, 2022). In the Amazon, fish was the most common animal-source food available for children and was positively associated with haemoglobin concentration (Carignano Torres *et al.*, 2022). In Nigeria, children with rickets were treated with ground catfish to improve vitamin D and calcium status, proving to be a viable solution to replace expensive supplements (Thacher *et al.,* 2015). Other studies investigating growth outcomes and nutritional status of Cambodian children consuming freshwater fish-based complementary foods have found no significant difference between control and treatment groups (Nurhasan *et al.*, 2018; Sigh *et al.*, 2018; Skau *et al.*, 2015), suggesting that complimentary foods including freshwater fish are a viable alternative to corn soya blend (a fortified food distributed by organizations such as World Food Programme) or milk-powder-based complementary foods. For example, Nurhasan *et al.*, (2018) found that n-3 fatty acid content of the blood did not differ between children fed complementary food with small freshwater fish versus corn soya blend, suggesting that locally fortified complementary foods can provide needed nutrients in combination with breastfeeding.

Understanding the dynamics of food systems and how they relate to consumption patterns in different contexts and for different social groups is at least as important as knowledge of nutrient composition of foods such as inland fish for nutrition-sensitive fisheries management and policy. Varying nutrient content of species is more than a curiosity of composition, as it is apparent that the nutrient potential of fisheries yield is driven by species composition and not simply by total volumes landed (Hicks *et al.*, 2019). Based on nutrient variability amongst species, different production scenarios as well as losses throughout the supply chain, different fisheries management strategies may be more or less able to address the extensive health burden and costs associated with nutrient deficiencies. However, the focus of this analysis to date is predominantly fish production, and the food systems perspective highlights the critical need to also understand the broader diets, fish consumption patterns and preferences. Also of importance is the need to understand the nutritional needs of women, men and children in various contexts to develop different fisheries management strategies, so as to optimize individual and social health outcomes. For example, a recent household consumption and preference survey in Sri Lanka found that rural communities preferred fish from inland capture fisheries over farmed fish due to perceptions of freshness and cultural attitudes associated with religion, contributing to policy discussions on poverty-focused aquaculture development (Murray and Little, 2022). Consumption surveys often lack this level of detail unless, as in this example, it is a specific objective (see also Chapter 3 on issues associated with consumption survey methods).

Food consumption surveys also often use indicators such as the food consumption score or dietary diversity score, which aggregate fish consumption along with other animal flesh foods (meat poultry, fish, etc.) and record whether or not the respondent consumed at least one food in that food group (often with no detail of which food or species). The FAO-WHO Global Individual Food Consumption Data Tool (GIFT)[21] has compiled over 50 quantitative food consumption surveys globally, with survey data disaggregated into various food groups including fish, shellfish and their products. While some of this data are further disaggregated into different species or product types (including freshwater fish in some cases), these intra-food group categories differ across surveys and no standard methodology seems to be applied. Thus, collaborations between food anthropologists and nutritionists are encouraged to better understand broader food consumption as well as fish processing and preparation practices and the impact on nutrient content and nutrient availability from fish.

4.6 CHANGES IN FOOD SYSTEMS AND IMPLICATIONS FOR FISHERIES MANAGEMENT

Changes in the environment, in markets, shifts in fisheries practices and new management regimes can all alter the species composition of catches. By extension, these changes could affect the net nutrient composition of landings and thus, nutrients available for consumption. For example, the introduction of Nile perch (*Lates niloticus*) in Lake Victoria contributed to declines in the haplochromine population, ecological instability and stark changes in water quality, while the small pelagic cyprinid dagaa (*Rastrineobola argentea*, also called mukene or omena) proliferated (FAO, Duke University and WorldFish Center, 2023). Changes in ecology were accompanied by changes in production and provisioning. Fillet of Nile perch has become the focus of an export market while Nile perch carcasses and dagaa are consumed widely, with the latter appreciated as nutrient-rich – particularly since it is consumed whole (Bavinck *et al.*, 2023; FAO, Duke University and WorldFish Center, 2023). However, as demand for fish oil and fishmeal increased, a substantial part of the dagaa catch in Lake Victoria has been diverted to the reduction industry (Muyodi, Bugenyi and Hecky, 2010) reducing the percentage of dagaa production destined for human consumption (CAS Regional Working Group, 2015). Similarly, Bogard *et al.* (2017) found that although aquaculture production in Bangladesh over the past three decades had increased the total amount of fish produced, the nutrient quality of fish on the market had declined.

These examples illustrate how shifts in ecology and management can have a marked impact on nutrient availability and accordingly, highlight where nutrition-sensitive fisheries management can help improve nutrition outcomes. In multi-species fisheries contexts, such as many inland fisheries, sustaining species diversity may offer the opportunity to meet objectives such as biodiversity conservation while also maintaining a more nutrient resilient and nutritious fishery. When only overall fish production figures are used without considering compositional differences, nutritional contribution of catch is likely over- or under-estimated. It is necessary to raise awareness amongst fisheries as well as food security, health and nutrition policymakers of the variation in nutrient potential of catch under different scenarios of fisheries management or based on environmental impacts, and the subsequent impact of changes in these on the availability of certain species in landings and therefore for consumption.

Changes in the food security and nutritional condition of poorer or more vulnerable groups remain a key indicator of policy success, although these changes are often not considered in fisheries management or fisheries policies (Arthur *et al.,* 2022). Fisheries policies, which often focus on production, can help to fill nutrient gaps if they support sustainable increases in production of fish rich in particular nutrients (Robinson *et al.*, 2022). Adopting a comprehensive food systems perspective broadens the focus from what is produced to also include important considerations such as who participates in the food system, in what ways they participate, drivers of livelihood choices, dynamics between different actors in the food

21 See the FAO-WHO GIFT tool here: https://www.fao.org/gift-individual-food-consumption/data/en

system, and power differentials and social relations between them. Taking a food systems perspective in fisheries management can also help to identify entry points for change (such as drivers and patterns of processing, distribution and mediating factors in food environments) that are often overlooked relative to investments in production (Simmance *et al.*, 2022), as well as nutritional, environmental, social, and economic outcomes. Considering nutrient outcomes as part of fisheries management can also make important contributions to attaining food security and nutrition goals (Robinson *et al.*, 2022; Farmery *et al.*, 2021).

4.7 CONCLUSIONS

While often overlooked, inland fisheries have important roles to play in addressing the global challenges related to malnutrition and food insecurity and commitments to eradicating poverty worldwide. The food system perspective applied here reveals the importance of considering not just the production of fish but also the activities beyond the catching of fish, which can have important consequences for the quality, availability and affordability of fish and fish products. Explicitly recognizing, through a food systems perspective, the connectivity between production and consumption reveals some important considerations for the assessment and management of inland fisheries.

In the first instance, it is important in post-harvest studies that "fish" is disaggregated in relation to its production. It can often be challenging to identify whether fish is from inland capture, marine or aquaculture sources (see also Chapter 3, this volume) yet this can be important where availability and accessibility differ, and these fish play different roles in household nutrition strategies. Viewing this through a food systems lens draws attention to the importance and value of relationships and informal mechanisms in addition to, or instead of, markets as mechanisms for access. This is important in two respects. First, it highlights another, less visible, mechanism that can be important for poorer people and can also play a role in relation to recreational fisheries. Without recognition of these informal access mechanisms, there is a risk that fisheries management measures, including gear restrictions, closed areas and bag limits, and could have unforeseen and unintended consequences for food security and nutrition of vulnerable populations. Second, it suggests that there is a pressing need to find ways in which to recognize and value informal access mechanisms. Current estimates of the value of inland fisheries are based on the landed value of fish (that is, the quantity of catch multiplied by a local market value) and considerations of formal fish trade and value chains. As Chapter 5 emphasizes, this needs to be addressed as it both downplays the often-crucial role of informal mechanisms and alternatives to markets for the distribution of fish (particularly for poorer groups) and overlooks the value and importance of the relationships that support these mechanisms.

A better understanding of how production systems and supply chains work to supply food and income to communities is required for refocusing fisheries policies on equity and welfare issues (Moreau and Garaway, 2021). This requires understanding who participates and in what ways, including informal mechanisms and the role of diverse economies (Gibson-Graham and Dombrowski, 2021), as well as dynamics between different actors and food supply chain nodes. These aspects highlight the critical roles of power differentials and social relations that have been shown to affect fish availability and access, thus affecting food security, nutrition and poverty alleviation (Moreau and Garaway, 2021).

Gender and social dynamics play a role throughout supply chains as well. In the example of the Rufiji floodplain of the United Republic of Tanzania (Box 4-3), young men controlled the more profitable but riskier fresh fish trade, older men were more involved in smoked fish trade which provided more steady income, and women were constrained to selling cooked fish products such as fried fish (Moreau and Garaway, 2021). These dynamics may affect the activities that different genders or age groups are allowed to participate in or have influence over or may limit their access to productive assets that affect their efficiency and thus their access to fish. Global statistics such as those showing that women dominate the post-harvest activities associated with fisheries (FAO, 2023, 2022) can mask these important distinctions. There continues to be insufficient recognition of gender and social dynamics, resulting in gender-blind policies and the absence of enabling environments for women to engage equitably in safe and fair work in fisheries (e.g. Rajaratnam, Ahern and McDougall, 2021).

Issues of social equity and inclusion extend beyond supply chains and food production systems, as they can also affect intra-household distribution of foods. As noted previously, cultural drivers such as those dictating that men or elders eat first, or that pregnant women or children should not eat fish, can negatively impact the diets and thus nutrition status of those most nutritionally vulnerable (Ahern *et al.*, 2020; Gibson *et al.*, 2020; Thorne-Lyman *et al.*, 2017; Meyer-Rochow 2009). As seen in Section 4.2.3, nutrient composition of different freshwater and marine species varies, with further variations based on what parts of the fish are consumed. The head or fillet of fish may be prioritized for men or elders, leaving less-desired parts such as bones, often difficult to consume without further processing, or less nutrient-dense fish broth for children (Ahern *et al.*, 2020). Fisheries managers often are concerned with whole raw fish, expressed in live weight equivalent (FAO, 2022), while nutritionists look at raw, edible parts (which can vary depending on consumption patterns) and are concerned with who consumes which parts of what species (UN Nutrition, 2021). Many nutrient composition comparisons are limited to muscle tissue as this is what is commonly consumed in high-income countries, missing substantial edible portions of fish which contribute a rich variety of micronutrients (Byrd *et al.*, 2021) and representing a likely undervaluation of nutrient contributions, particularly from inland fisheries.

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5. INLAND FISHERIES MANAGEMENT

Robert Arthur and Philippe Tous

SUMMARY

A key challenge in advancing an ecosystem approach to fisheries management is the inclusion of social and institutional dimensions, particularly where the fisheries are inherently small-scale and are often geographically dispersed, and subject to environmental variability and externally-driven processes of environmental and social change. Given this reality for many fisheries, a promising alternative to management in the form of external control potentially lies in the practices of stewardship and care that are often associated with traditional management arrangements, many of which are informal. Fishing communities have a demonstrated environmental stewardship that is evident in their traditional management practices. Beyond this, many management arrangements also serve to enable access and provide opportunities of people to meet their livelihood needs and support social relationships and cultures.

Such practices of stewardship and care that promote social and environmental responsibility are based on accumulated knowledge and creative capacities. A focus on existing knowledge and management and the practices of care that are evident in traditional management can help inclusion to a greater extent of the social and institutional dimensions of the ecosystem approach to fisheries management. Doing so provides opportunities to better recognize the nature and role of inland fisheries, their contributions to livelihoods and value to households and communities. From a practical perspective, a focus on practices of stewardship and care also represents a means to support practices that support adaptive capacity, and both enable access and foster environmentally and socially responsible conduct. Furthermore, by recognizing care and stewardship as a viable alternative to control, embedded in fishing cultures, it is possible to move beyond narratives that portray small-scale inland fisheries as problematic or unsustainable.

5.1 INTRODUCTION

Inland fisheries continue to have the potential to make important contributions to livelihoods and diets across large parts of the world, including in many countries facing endemic food security and nutrition deficits (Chapter 2 and Chapter 4, this volume; FAO, Duke University and WorldFish Center, 2023). Inland fisheries take place in diverse aquatic environments, from large lacustrine and river basin-floodplain systems to the diverse and diffuse fisheries taking place in ponds, upland streams, and marshes (Welcomme *et al.*, 2010; Gregory, Guttman and Kekputhearith, 1996). Artificial waterbodies can also be important locations for fishing, including reservoirs, canals, paddy fields and even small ditches. People engage in fishing for many reasons and fishing can often be one of several livelihood activities. Fishing can occur at discrete times of the year or, alternatively, alongside other livelihood activities or as a collective pursuit. Food and income are important benefits, but also the contributions to local economies and cultures. Far from anachronistic or backward, inland capture fisheries continue to play important roles in people's livelihood strategies in many parts of the world.

How these opportunities can be created and realized is a focus of fisheries management. How fisheries can be managed well and how opportunities for inland fisheries management can be enabled and supported are key aspects of fisheries management and integrated water resources management respectively. In this chapter we therefore consider how and ecosystem approach to fisheries can be advanced, particularly in diverse and dynamic inland fisheries to support these two aims. In particular, the focus will be on how the social and institutional dimensions of the ecosystem approach to fisheries. To date, due to the historical development of fisheries management, there has typically been a greater emphasis on environmental aspects and the ecological dimension. This is evident in the attention to assessing stock status, production and productivity and the focus on ecological dimensions of local knowledge (e.g. Fischer *et al.*, 2015).

Fisheries management is frequently presented as a process of information gathering, analysis, planning, decision-making and the formulation and enforcement of fishery regulations (e.g. FAO, 1997). The resulting emphasis in conventional forms of fisheries management has primarily been on technocratic challenges of bioeconomic diagnosis and the control, in particular, of fishing effort. When applied across diverse fisheries, the process is typically affected by uncertainty and assumptions about the dynamics and responses of both fish stocks and fishers (Caddy and Gulland, 1983).

Given that over 99 percent of inland fisheries are small-scale (FAO, Duke University and WorldFish Center, 2023) and dispersed, the nature of these fisheries can present considerable practical challenges for advancing the ecosystem approach to management. Experiences and outcomes with approaches such as co-management have been mixed (e.g. Cohen *et al.*, 2021; Evans, Cherrett and Pemsl, 2011). Control through management can remain elusive and unintended consequences often arise when this is pursued (e.g. Arora *et al.*, 2020). The nature of the fisheries as small-scale and dispersed contributes to the challenge. Fishing in inland waters can often be considered as "irregular fishing" in that, as an activity, it is not unregulated but is instead largely governed by informal arrangements and measures that may be informed by social as well as ecological priorities. This is not always recognized and can result in assumptions about fishing being unregulated. Where this is the case, the perception may be at odds with the reality and there is a risk that introduced institutional arrangements may undermine existing institutions and may reinforce or enable socially exploitative and environmentally deleterious practices.

This chapter seeks to use the diversity of inland fisheries and traditional practices to suggest the need for pluralism in the forms of management, in which management as control, a form more common in marine capture fisheries, can coexist with alternative forms of management that are more suited to the inherently complex, uncertain and contested reality of many inland fisheries. This chapter identifies these alternatives by taking the practices, knowledge and lived experiences of inland fishers as a starting point. Enduring and productive inland capture fisheries can therefore provide important opportunities for understanding how sustainability can be achieved, particularly in the context of dispersed and dynamic small-scale fisheries for which formal support and resources may be limited.

5.2 THE CHALLENGE OF MANAGING INLAND FISHERIES

The bioeconomic foundations of fisheries management, have led to the widely accepted notion that "managing fisheries is managing people" and therefore about controlling activities (e.g. Hilborn, 2007; Holm, 1996; Merchant, 1980). Fisheries management generally reflects this focus on control with an emphasis is on the application of science through a process of rational planning involving assessment and diagnosis allied to technical solutions, regulations and institutional models that are introduced to modify fishers' behaviour. Critically, it is common that these regulations are typically in the form of restrictions that address issues of who can fish, where they can fish, how much fishing activity should be allowed, and how much catch participants should be allowed to take (e.g. Barclay *et al.*, 2023; Mansfield, 2004). This represents the conventional form of fisheries management. Management, and the effectiveness of the institutions and regulations at achieving control, are themselves dependent upon a sound fisheries governance framework that provides the enabling environment for successful management (Barclay *et al.*, 2023). The role of governance in this sense is largely instrumental (e.g. Hara, 2004), focusing on making fisheries manageable in the sense that the rational planning approaches can be implemented.

Because of the predominantly small-scale nature of inland fisheries, they are highly diverse (FAO, Duke University and WorldFish Center, 2023). Furthermore, many are situated in fluctuating and fast-changing aquatic environments and consequently they too can be highly dynamic, with fishers and fishery managers responding to changing conditions and needs. The diversity, variability, change and different ways fishers respond increases the uncertainty associated with, *inter alia*, the status of fisheries and predictability of management outcomes (Fulton *et al.*, 2011; Lorenzen and Garaway, 1998). These realities have implications for how conventional fisheries management responds, which includes: a focus on fishing effort, the practical challenge of shifting towards a more comprehensive ecosystem approach to fisheries, and the challenge of reconciling different interests and values in decision making.

5.2.1 A focus on fishing effort

Firstly, conventional forms of management are often focused on the impact of fishing on fish stocks and hence the control of fishing effort. It is accepted that fishing affects fish stocks and fish communities, potentially altering fish life history traits, community structure and relative abundances (e.g. Hall, 1999; Jennings and Kaiser, 1998). However, defining "natural" structure and function in dynamic systems, providing measurable indicators and reference points have proven problematic (e.g. Hall, 1999; Murawski, 2000; Rochet and Trenkel, 2003; Rogers *et al.*, 1999). Yet fishing is not the only driver of change. Fish stocks and fish communities in inland waters are also affected by changes in environmental factors that can affect the fisheries and that can lead to large changes in productivity within and between years even in the absence of fishing (e.g. Welcomme and Halls, 2004). Some of these changes can be driven by human activity that affects the nature of water flows and water quality (see Chapter 6). This is also accepted, but crucially, interpretation of the relative influence of these drivers can differ (e.g. Friend and Arthur, 2011; Lamberts, 2006; Rogers *et al.,* 1999). Determining the relative influence of different drivers, especially in fluctuating environments, can be challenging. Many inland fisheries lack monitoring frameworks that allow the effects of these drivers to be distinguished and their relative importance can be very much contested given the different interests associated with water resources development (see Chapter 6).

The concern when considering fisheries management is that conventional management focus on fishing effort, combined with a lack of information on the other drivers, can result in a focus on the risks associated with fishing effort. Dependence on fishing, particularly irregular forms of subsistence fishing, can lead to assumptions about its impacts and consequences, reflected in common concerns about "overfishing" and "too many people chasing too few fish" (e.g. Friend and Arthur, 2011). Adopted uncritically, such assumptions risk overemphasizing the design and enforcement of management measures to restrict access, including promoting "alternative livelihoods" (Finkbeiner *et al.*, 2017). This is not to negate concerns about the effect of fishing on fish stocks or the need to address the environmental sustainability of fisheries, but to highlight that the consequence of an overemphasis on restricting fishing and access can be significant where it reduces the opportunities and ability of poorer people to benefit.

5.2.2 The challenge of integrated assessment and management

In contrast to this first challenge, when wider issues *are* recognized, and wider environmental and social aspects are included within conventional forms of management, different risks arise. Where the emphasis is on management as a process of information gathering, analysis and planning, the tendency can be to look for technical responses, including in the form of comprehensive frameworks and sophisticated analytical tools. For example, the potential of quantitative and qualitative modelling of population dynamics to incorporate both fisheries and environmental drivers (e.g. Winemiller *et al.*, 2016; Arthington *et al.*, 2004). These tools and methods can be broadened to include social and economic factors to strengthen predictive responses (Fulton *et al.*, 2011). Barclay *et al.*, (2023) highlight social indicators relevant to harvest control rules, including employment, work satisfaction, social connectivity, food security and fisheries-related cultural and spiritual practices. The potential of such methods is however limited by the practical realities of inland fisheries. The diversity of inland fisheries and the limited resources available for fisheries assessment represent obstacles to more holistic assessments that typically require more data and information (Winemiller *et al.*, 2016; Halls *et al.*, 2005; Chapter 3, this volume). The risk, not unique to inland fisheries, is that the challenge of implementing these tools contributes to a sense that it is the fisheries themselves that are inherently problematic

Interest in co-management and the sharing of responsibility and authority for decision making (e.g. Borrini-Feyerabend *et al.*, 2007; Berkes *et al.,* 2001; Sen and Nielsen, 1996; Pinkerton, 1992; McCay and Acheson, 1987) served to highlight the knowledge and skills local people exhibited in managing their own local environments and the benefits that could be derived from them. This recognition has provided new opportunities to overcome the obstacles to more holistic assessments, increasing interest in the utility of participatory methods and fisher knowledge to generate additional information that could be incorporated into assessments (e.g. Bentley *et al.*, 2019; Fischer *et al.*, 2015; Kodio *et al.*, 2002). Examples include information on key fish habitats (Chan *et al.*, 2006), connectivity of habitats and fish migrations (Berkström *et al.*, 2019), technical aspects of harvesting and managing fisheries (Baird, 2007), and estimation of historical fishing effort (Bentley *et al.*, 2019). Other benefits of information provided by fishers include the potential legitimacy and quality assurance that it can provide to scientific outputs, as well as opportunities for cost-effective and efficient data collection (Stephenson *et al.*, 2016).

However, perhaps reflecting the association with conventional management, such interest in fisher knowledge tends to focus on ecological rather than other aspects of knowledge (e.g. Fischer *et al.*, 2015), tending to treat information and perspectives on fisheries as separate from the interests, opinions and values of fishers themselves. The risks here are firstly that the way that the fishery is understood is different to that of the fishers. When applied to selecting management measures, there is an implicit assumption that the gathering of information will, almost by itself generate the appropriate solution. The likelihood of unexpected outcomes is not necessarily reduced, particularly where resulting measures fail to reflect the values, interests and needs associated with the fisheries. Approaches to knowledge that separate information about the fisheries from values lend themselves to the expertizing of decision-making, potentially restrict or alter rights and opportunities for participation in decision-making and even undermining existing management capabilities (Arthur and Friend, 2022; Arthur *et al.*, 2022, Nunan, Hara and Onyango, 2015; Kolding and van Zwieten, 2011).

5.2.3 Consensus in fisheries management

A third challenge with conventional forms of fisheries management is that they are frequently based on consensus around management objectives. For example, Barclay *et al.* (2023) state:

> The foundation of good fisheries governance means (co-)management systems that engage both representation and multi-disciplinary expertise to set well-accepted social, cultural, economic and biological fishery objectives (Barclay *et al.*, 2023, p. 3).

Presented in this manner, minimizing disagreement and creating consensus through institutional interventions, including co-management, provides the enabling conditions for control. More inclusive processes incorporating stakeholder values create the risk of disagreement and conflict arising from tissues of agency and power, conflicting interests and objectives (Nunan, Hara and Onyango, 2015). For small-scale fisheries – over 99 percent of inland fisheries are small-scale (FAO, Duke University and WorldFish Center, 2023) – meeting the challenge has often focused on designing and strengthening institutions that can reduce conflict, facilitate consensus, and ensure that objectives are "well accepted" (Nunan, Hara and Onyango, 2015; Arthur, Friend and Marshke, 2011). Yet in many cases there appears to be little analysis of the historical context or of how new or reformed institutional arrangements alter power, influence, and access.

Elements of control are again present in these institutional design processes. This includes the nature of representation (Mikalsen and Jentoft, 2003) and the role of strong leadership and social cohesion (Gutierriéz, Hilborn and Defeo, 2011). The focus is on enabling these aspects through capacity building, learning, and formal tenure rights. Capacity building and strengthening tenure are frequently presented as apolitical processes in which different stakeholders with different interests come together. Yet engagement, learning and co-design to achieve consensus and establishing well-accepted objectives is frequently not straightforward (Smith, 1995). It is certainly less easily applied in contexts of conflict, amongst stakeholders of different degrees of influence and power (Arthur, Friend and Marshke, 2011). "Secure tenure" may also not intrinsically be a good thing: the wrong kind may well be harmful to the well-being of small-scale fishers and their communities (Charles, 2011), particularly where the focus is limited to individual rights and the material benefits. The emphasis on control, consensus and cooperation, allied to a largely instrumental representation of the role of institutions has been challenged in various ways (Mosse, 1997; Stacey, 2001; Verweij and Thompson, 2006). From these perspectives, the role of institutions is not limited to delivering management outcomes (an instrumental role), but about mediating human relationships and relationships with the natural world. While instrumental processes have their place, they make less sense in the sorts of complex, messy and highly politicized contexts that characterize many inland fisheries. In practice, they can risk overlooking the nature of relationships that exist within the fisheries, and local communities more broadly, and the full range of benefits derived from inland fisheries and the various ways in which they are continually negotiated and contested.

5.2.4 Uncertainty, the illusion of control and management pluralism

The emphasis on many of the tools and methods that are applied are on reducing uncertainty and increasing predictability. Yet uncertainty frequently remains a pervasive feature in the management of fisheries, including inland fisheries (Fulton *et al.*, 2011; Sethi, 2010; Allison *et al.*, 2001; Charles, 1998; Hilborn, 1987) and few fisheries behave according to theoretical models. Control is likely to remain elusive and the challenges of trying to achieve control can generate new risks (Charles, 1998). For fisheries managers, attempting to pursue control where there is uncertainty and a resulting lack of consensus can result in constant reassessment and readjustments, as attempts at control do not proceed as planned (Arthur, Friend and Marshke, 2011; Smith, 1995). Yet it is also the case that in reality many inland fisheries remain productive and capable of delivering crucial social and environmental benefits, even in the context of rapidly changing environments and societies (See Chapter 6, this volume). We are interested in what this reality can reveal and adopt the lived experiences of fishing households and communities as the starting point for considering the possibility of alternative forms of fisheries management that can also advance an ecosystem approach to fisheries. Such alternatives can be assessed in the extent that are appropriate to diverse, dynamic and contested contexts; maintaining and creating livelihood opportunities; and responsible practices that can support social, economic and environmental goals. Given the nature of inland fisheries, we accept that such alternatives are likely to be opportunistic and "unstable" in the conventional sense. However, reflecting calls in fisheries for alternatives (e.g. Allison *et al.*, 2001; Caddy and Gulland, 1983), as in the case in other disciplines, the intent is to identify alternatives relevant to different contexts and reflect different values and interests (e.g. Söderbaum, 2008; Clément, 1991). Inland fisheries provide a wealth of experiences and accumulated knowledge of living with change that can be drawn upon for evidence and inspiration. It is to this that we look.

5.3 FISHERIES MANAGEMENT: LESSONS FROM TRADITIONAL MANAGEMENT AND GOVERNANCE

The remainder of this chapter presents examples of forms of management that are rooted in fishers' own understandings and practices. In doing so, we draw on some of the literature on traditional and local management practices in inland fisheries that reveal alternative entry points and forms of fisheries management that are not primarily about control but that address issues of uncertainty and disagreement in different ways: ways in which they can even represent strengths and opportunities, aspects intrinsic to the fisheries and fundamental to the relationships, and experiences that enable fishing communities to respond to and successfully navigate change. Environmental, social and economic variability are an intrinsic feature of fluctuating fisheries. Environmental and social change and uncertainty are a frequent reality of aquatic environments. Despite this, people for whom fisheries are important livelihoods have often created adaptive strategies that allow them to cope with change and take advantage of changing and fluctuating conditions. These lived realities and experiences from diverse inland fisheries provide a rich set of evidence related to enduring arrangements that have enabled people to live with and adapt to change, in addition to making reliably productive use of dynamic and contested environments. Learning from these lived realities can reveal possibilities for alternative forms of fisheries management that are complementary to conventional forms and applicable to more complex contexts.

The framing that we adopt is based on the ecosystem approach to fisheries, considering the ecological, social and institutional dimensions of fisheries management (Staples and Funge-Smith, 2009; FAO, 2003). Institutions (that is, the formal and informal rules that influence behaviours) represent an important aspect of an ecosystem approach to fisheries because of the way that they mediate access – in this case the ability to benefit (Ribot and Peluso, 2003). We therefore also draw on political ecology theories and frameworks that recognize the economic structures and power relations associated with inland capture fisheries and that drive environmental and social change more generally (Blaikie and Brookfield, 1987).

5.3.1 Lived experiences in inland fisheries

The lived experience in inland fisheries is frequently one of diverse, dynamic and often uncertain livelihoods, within which relationships and the social institutions that regulate them play important roles. Large lakes, reservoirs and canals can be relatively stable environments (within and between years), and may provide increased full-time, permanent and predictable fishing opportunities. Fisheries in these types of environments can be more predictable and amenable to control forms of management (see Section 5.2, this volume). However, most inland fishery environments are much more dynamic and are typically subject to wide variations driven by seasonal, local and regional weather patterns. These affect the nature and extent of the habitat and therefore the productivity of the fisheries and influence how people interact with them. There are limits to the predictability of such fisheries and across large areas of the world this has shaped the contributions fisheries make to livelihoods, as well as the ways people associated with inland fisheries have learned to live with change and the uncertainty that it creates (Mosepele *et al.*, 2022). Foremost amongst these is that fishing may not be the only or even main livelihood activity, but instead contributes to portfolios of household activities and provides opportunities to support and enable relationships within communities.

Responding to change: adaptive and diversified livelihood strategies

In more dynamic fisheries environments fishing can be a seasonal or occasional activity and may involve the use of different gears in different environments at different times of the year to target different species or life stages (Kelkar and Arthur, 2022; Deap, Degan and van Zalinge, 2003). Fishing is often conducted alongside or in combination with other activities including agriculture, livestock rearing, and collection of wild plants and animals. Individuals combine and shift between activities and livelihood strategies depending on aspects including the relative productivity, conflict and access associated with different options. Fishing may also be occasional, for example when flooding or drought affect crops, or when the fisheries are particularly productive (e.g. Hamerlynck *et al.*, 2019; Arthur, Friend and Béné, 2016; Friend, Arthur and Keskinen, 2009; Jul-Larsen *et al.*, 2003; Begossi, 2002; Claridge, 1996; Thomas, 1996).

These livelihoods are also changing. The increasing roles for markets can be an important driver of change, with the potential to fundamentally alter food systems, livelihood opportunities, institutional frameworks, and relationships (Biswal and Johnson, 2023; Arthur *et al.*, 2021). Responding to changing livelihood opportunities mean that households associated with inland fisheries have adopted different strategies. These include diversified or stretched livelihoods (e.g. Winkels, 2011; Smith, Nguyen-Khoa and Lorenzen, 2005), often engaging in non-fishing activities or forms of transhumance akin to the regular movements of pastoralists from one pasture to another. Fishing and non-fishing activities are closely interrelated (Hamerlynck *et al.*, 2019; Arthur, Friend and Béné, 2016), such that the variability that characterizes the fisheries itself becomes a resource, creating opportunities as floods bring fish and sediments.

How these changes and opportunities are perceived by different individuals and groups can have an important effect on how they behave and respond (e.g. Ensminger, 1992). In this respect, it is often useful to consider fisheries from a household perspective (Salmi, 2005; Allison and Ellis 2001). Fishing is often an activity that different household members, including women and children, contribute to in different ways: participating in fishing, often using different gears or fishing in different locations; processing, trading and preparing fish; or even engaging in economic or care activities that more broadly underpin participation (e.g. Bauhardt, 2019; Gallois and Duda, 2016). Furthermore, such activities may not be identified as the primary household activity but can nevertheless play crucial roles within household livelihood strategies such that fishing contributes to making the livelihood viable. Inland fisheries are therefore often only one focal point for decision-making within households and communities. Consistent with an ecosystem approach, inland fisheries management also needs to recognize this reality.

For example, Gallois and Duda (2016) describes how within Baka societies in the Congo Basin fishing activities are primarily carried out by women, often assisted by their children. While fishing is not as significant in daily life as other subsistence activities, fishing expeditions are critical for children’s education and women's empowerment, essential roles for maintaining the social cohesion amongst the Baka. This reality can be the basis of misunderstandings about the actual practice of fishing (including recreational fishing) and nature of access, with the place and economic roles of women and children in particular being obscured. Dynamic and changing fisheries can therefore create both challenges and opportunities for different household members and give rise to changes in access and livelihood opportunities that may affect them differently. The reasons for people to engage in fishing can be enormously varied and the relationship with poverty is also not straightforward (Béné, 2003).

5.4 STEWARDSHIP AND CARE AS A FEATURE OF FISHERIES AND FISHERIES MANAGEMENT

Change and uncertainty frequently represent the context within which fishing, and fisheries, need to be seen and management responses crafted. Attempting to do so through attempts at control articulated through often state-led and formal rational planning, regulation and institutional designs is often associated with conventional fisheries management. However, this downplays the potential beneficial role that variability and change can play and the opportunities that may be associated with, or emerge from, them (Arthur, Friend and Marshke, 2011; Sarch, 2001; Caddy and Gulland, 1983). Accepting uncertainty as a fact of life where there are multiple livelihood opportunities and decision making is both uncertain and contested, and attempting to navigate rather than control uncertain and changing worlds has emerged as an important challenge for fisheries management and governance (Chuenpagdee and Jentoft, 2019; Bavinck, Jentoft and Scholtens, 2018; Charles, 2001; McCay, 1998). This has a distributional dimension, concerned with the nature of the process and the implications of change for different people (e.g. Jentoft *et al.*, 2022; Arthur *et al.*, 2022). This is also the basis for interest in practices of environmental stewardship (e.g. Charles, Macnaughton and Hicks, 2024) and, more broadly, care (Mol, Moser and Pols, 2010. These practices represent ways of engaging with the world that are inclusive of, and are motivated by, values, relationships, culture and spiritual aspects. As locally situated practices, they can potentially provide more flexible, responsive and context specific responses to uncertainty and change that effectively create possibilities and provide grounds for hope. Critically, practices of stewardship and care are explicitly inclusive of social and human relationships and the institutions associated with these, extending beyond the environmental stewardship to encompass care for the environment, for one another (social care practices) and for the institutions, traditions and cultures associated with them and the knowledge that underpins them. The focus on practices is important, linking knowledge and intent with agency and action (e.g. McConney *et al.*, 2019). In this regard, what we will refer to as "stewardship and care" provides an alternative to the control and restrictions often associated with conventional forms of management and a useful means of more explicitly addressing and including social and institutional dimensions of the ecosystem approach to fisheries. Experiences of living with fisheries and practices of stewardship and care often have their basis in traditional practices but are not synonymous. Local traditions may incorporate new knowledge from elsewhere and adapted to incorporate new technologies, needs and interests. This is what keeps these practices alive and relevant to changing contexts and conditions.

Central to the different experiences of stewardship and care as an alternative to control is the maintenance and reproduction not just of environments but of people, communities, knowledge and cultures (Mol, Moser and Pols, 2010). A key feature of these experiences is that stewardship and care are often rooted in the informal and irregular, in relationships and tacit understandings. This can be a strength but also means that they can be more at risk of being overlooked, downplayed or perceived in different ways. If the actions of fishers are not considered in the context of histories, cultures and livelihoods, there is a risk that they will be misunderstood or misrepresented and consequently subject to rules and regulations that undermine their effectiveness and contributions. However, it is the opportunities for fisheries management and governance that are of interest. As Tronto (1993, p. 101) identifies: "The world will look different if we move care from its current peripheral location to a place near the centre of human life." Stewardship and care have been identified across a range of human activities and as a significant aspect of life itself in different contexts (e.g. de la Bellacasa, 2017; Mol, Moser and Pols, 2010). It is therefore to the fishing communities continuing to depend upon and benefit from viable fisheries that we can look for experiences and evidence of these practices of stewardship and care.

Consistent with an alternative to control, Tronto (1993) points to how starting with existing practices shifts the focus towards the relationships that support livelihoods. Connectivity is a theme in this edition of the circular and recognizing these relationships highlights the interdependencies and connectivity that exists between people and people and the environments and their relevance to management and policy. Processes of commoning (e.g. Partelow and Manlosa, 2023; Bollier and Helfrich, 2015) and commonization (Nayak and Berkes, 2011) as well as practices of care (Bauhardt and Harcourt, 2020; Arora *et al.*, 2020) emphasize these notions of connection and interdependence, both with the environment and between people. The emphasis on practices is again important, focusing on examples of interventions that maintain and enhance ecological processes while providing and creating opportunities for people to benefit. Critically, using practices as a starting point provides the opportunity to look beyond formal interventions to include informal and dynamic tenure arrangements and diverse economic practices (Gibson-Graham and Dombrowski, 2021; Nightingale, 2019; Gibson-Graham *et al.*, 2016).

5.4.1 Care for people, environment and institutions

Practices of stewardship and care encompass all three dimensions of the ecosystem approach to fisheries inclusive of ecological processes, social care and maintenance of relationships as well as investments in knowledge, institutions, traditions and customs (Bauhardt and Harcourt, 2020). Individual and collective stewardship and care therefore draws on situated knowledge in the form of experience and expertise, as well as skills and technologies that may be developed and adapted through everyday practices. Such practices differ from conventional management and its emphasis on planning and control in the way that they are embodied not in targets but in actions to sustain the reproductive potential of environments and societies. As such, stewardship and care can assist in reestablishing practices and norms that may have been marginalized by technologies and policies of control and in articulating these in terms of social justice and equity (Arora *et al.*, 2020).

These aspects of stewardship and care are evident in the practices and traditions of fishers and fisher communities around the world. Where these are supporting effective and equitable forms of management and access, they can make important contributions to sustainable and responsible management. Furthermore, the enduring nature of many traditional management and tenure arrangements is due to their evolving nature. Far from anachronistic, evolving forms of traditional arrangements are highly relevant to ongoing processes of change and adaptation and can be the basis for new and creative forms of management capable of ensuring sustainable fisheries and deliver equitable transformations. In the following sections we describe some examples of existing practices of stewardship and care using the three pillars of the ecosystem approach to fisheries – environmental, social and institutional – and also describe how these are underpinned by traditional knowledge and values. In doing so we highlight how these practices have continued relevance for, and could contribute to, both inland fisheries and integrated resources management in ways that can support an ecosystem approach to fisheries.

5.4.2 Maintaining and enhancing environmenal well-being and fisheries productivity

Charles, Macnaughton and Hicks (2024) identify small-scale fishers and fishing communities as among the most effective contributors to the conservation of aquatic environments. This is based on their knowledge and close interaction with aquatic species and environments in addition to their underlying values, ethics, relationships, and cultural and spiritual aspects that can include a sense of responsibility towards natural systems on behalf of future generations. These contributions reflect practices of stewardship and care with regard to aquatic environments. These practices serve to maintain and enhance the productivity of aquatic environments, sustaining and creating livelihood opportunities. Examples include management measures to avoid overexploitation as well as investments of time and other resources in environmental maintenance.

An example of measures introduced to reduce the risk of overexploitation is the use of spatial restrictions that are a feature of rivers, ponds and perennial waterbodies (e.g. Ulluwishewa, 1995). Critically the focus is on enabling access but with the condition that within agreed areas, fishing may be partially or completely restricted, often through traditional regulations and rituals such as prayers and sacrifices conducted to seek the favour of river deities and spirits. These restrictions can help to maintain stocks, particularly during the dry season, while guaranteeing access to fish to meet vital household needs. Such spatial restrictions are often associated with important habitats, including deep pools, submerged caves, ponds, and perennial waterbodies (e.g. Ruddle and Satria, 2010; Baird, 2006; Baird and Flaherty, 2005; Shoemaker *et al.*, 2001). Examples in riparian environments include near today's Lake Bagré in Burkina Faso, along the Logone River (Béné *et al.*, 2003) and on the Niger River (Quensière, 1994). Spatial restrictions can be seasonal or permanent and the importance of these areas means that there may also be rules regulating their modification. For example, in floodplains in the Caprivi, Namibia, waterbodies that form in depressions (*mulapos*) require permission to be ploughed (when the pond dries out to reveal rich soil) to avoid compromising their role as fisheries at other times (Abbott, 2002).

Protection may be combined with environmental maintenance and modifications. An example are the fish refuges that are a common management measure in floodplain, river and paddy field environments. These refuges may be created by individual farmers or by collective user groups and communities. Fisheries productivity can also be maintained and enhanced in other ways, including protecting riparian vegetation, selection of less water-intensive crops, habitat restoration, and stocking of native or exotic fish species (e.g. Thompson, Sultana and Arthur, 2010). Another form of enhancement and habitat modification found in inland waters, but also common in coastal lagoons and brackish waters in many areas of the world, are brush parks (e.g. Kelkar and Arthur, 2022; Welcomme and Kapetsky, 1981). These are constructed within waterbodies to attract and concentrate fish, shrimps and crabs from the surrounding waters and increase the efficiency of capture fishing. Acadjas are one form of brush park that is associated with lakes and lagoons in West Africa, where there may be high levels of acadja ownership. The productivity of these acadjas means that there can be restrictions on how and where they are constructed and on how ownership is transferred (Sonneveld *et al.*, 2019).

Changing aquatic environments can affect these practices in different ways. Where the fisheries play important roles in livelihoods and cultures there may be efforts to increase the effectiveness of existing practices, for example extending the area or depth of refuges and their connection to other habitats through the creation of dykes, channels and artificial ponds as well as managing flows in irrigation systems (Gregory, Funge-Smith and Baumgartner, 2018). The creation of new habitats, including reservoirs and irrigation schemes, can provide new fishing opportunities. For example, Tilapia, Indian and Chinese carps have been introduced into many Asian reservoirs (De Silva and Funge-Smith, 2005). Stocking can however lead to wider social and institutional changes (Lorenzen and Garaway, 1998) that may have implications for different groups and be resisted. For example, Amarasinghe and Nguyen (2009) report that for a time under agrarian laws in Sri Lanka stocking was not permitted because of the implications for access.

Changes in environmental productivity can affect fisheries in other ways. Management may become less restrictive, including restricted open access arrangements or tolerance of subsistence fishing even where formally prohibited can occur (Mosepele *et al.*, 2014). Patterns of fishing may also change, for example Laë and Weigel (1994) describe how following the intensification of droughts and declines in productivity, gear use in the Inner Niger Delta in Mali shifted from collective techniques in favour of individual gear use. In particular, there was a decline in the use of large seines (*djoba*), and the development of smaller, cheaper seines (*xibiseu*) together with the widespread use of small traps that could be used by a single fisher. These changes are indicative of lower investment in the fishery.

5.4.3 Enabling access and reducing conflict

Inland fisheries (including fishing, processing, trading and ancillary activities) not only provide food, employment and income but can also be an important route to participation in social networks, developing and maintaining individual and collective relationships. This enables the benefits from inland fisheries to extend beyond those harvesting the fish. For example, Garaway (1999) studying rural areas of the Lao People's Democratic Republic found that around 10 percent of household fish supply resulted from interactions with others, including payment for labour, gifts and reciprocal exchange. From the perspective of food security and poverty reduction, access to inland fisheries is also acknowledged to be of particular importance for poor people and can be a safety net and coping strategy for local populations (Béné, Hersoug and Allison, 2010).

Inland fisheries can therefore be the sites of investment by people in fishing and fisheries management, exemplified by sophisticated varieties of fishing gears and skilled forms of management and benefit sharing (e.g. Dounias *et al.*, 2016: Arthur, Friend and Béné, 2016). For some, opportunities to maximize the volume or value of production can be important, for example during productive seasons where fish can be preserved and contribute to food security or where markets provide opportunities for income generation. Examples include the *dai* fisheries in Cambodia and fishing spots in the Rio Grande in Brazil (McKenny and Tola, 2004; Begossi, 1998). Alternatively, for fishers engaged in other activities or where subsistence is the reason for fishing, harvesting efficiency and productive fisheries may be valued because of the opportunity cost that fishing represents. Importantly, these different objectives may be associated with different user groups and, where environments are fluctuating or changing, their interests may also change in response – not necessarily in the same way. For example, Siriwardena and Lidzba (2008) describe activities associated with irrigation tanks in Sri Lanka. These tanks are used by farmers, livestock owners and fishers, with the latter often being from the lowest socio-economic strata. Following aquaculture and stocking initiatives, fishers are at risk of exclusion as farmers and farmer groups claim rights and jurisdiction over the fish in irrigation tanks.

Access, and the ability to benefit from inland fisheries is in many cases a fundamental and indivisible part of cultures, playing critical roles in survival and well-being in addition to being a way to create and reinforce a collective identity (Song and Soliman, 2019). The concerns of users reflect this, often less about too many people chasing too few fish and instead relate to issues of equitable access, tenure, and the encroachment of commercial interests (Arthur, 2020; Friend, Arthur and Keskinen, 2009). This creates a perhaps subtle but important distinction between measures that restrict access (i.e. where access is limited to a particular user group) and measures that make access conditional (i.e. based on use of certain gears, locations or types of fish that may be consumed). This is particularly relevant where there may be limited fishing opportunities and where exclusion may be impoverishing.

Links to food, and traditional foods in particular, can be an important part of practices around access and the conditions associated with it, recognizing that loss of access and the opportunities it provides represents a form of impoverishment. This is reflected in traditional local practices (see Box 5-1) where fisheries management measures are typically designed to enable rather than restrict access and to ensure that there are critical safety nets for households. Accommodating different interests and enabling access can result in strategies that do not optimize production but instead seek to enable all to benefit (Bavinck and Franz, 2023).

Box 5-1: Enabling access: creating equitable opportunities through stewardship and care

In parts of India and Sri Lanka, the *padu* system enables eligible members of communities to fish using specific methods within designated fishing grounds or fishing spots within the lagoon during specified seasons (Amarasinghe, Chandrasekara and Kithsiri, 1997; Mathew, 1991). Where there are multiple waterbodies, as within floodplains, different waterbodies may be managed in different ways: as commercial operations, as subsistence fisheries, and even open access (Garaway *et al.*, 2006). The level of regulation can reflect the perceived importance of the particular fishery, with greater management investment in the more productive fisheries, or those that have a particularly important role in livelihoods.

Temporal strategies are also used. Where there are limited numbers of fishing spots and different levels of productivity, community-based management can use mechanisms including lotteries and rotating access to the more productive locations to ensure equitable opportunities (Nayak and Berkes, 2011; Amarasinghe, Chandrasekara and Kithsiri, 1997; Mathew, 1991). Fisheries associated with paddy fields may be open to community members for subsistence fishing until the water recedes and field boundaries become clear. Similarly, on the Khone Falls on the Mekong River two types of traps used at fishing spots: one in the wet season and one in the dry. Rights to fish can be transferred between different households with the change in gear (Baird, 2010). Thus, the same area or waterbody may operate as a commercial and subsistence fishery at different times of the year.

In fluctuating fisheries such as floodplains, changing abundance and distribution of fish and other elements can result in mosaics of different and often overlapping management measures, rights and responsibilities for the use of water, land, and the plants and animals associated with them. This can include roles for open access, private, state, and collective rights (e.g. Haller, 2010; Khumsri *et al.*, 2009). These mosaics can be dynamic with elements changing, for example with changes in water level when boundaries become more or less definable and enforceable (Chiaravalloti, 2019; Fregene, 2016; Haller, 2010; Abbott *et al.*, 2007; Begossi, 2002; Thomas, 1996; Moorehead, 1991; Netting, 1982). Within these mosaics, mobile fishers will often arrive at informal tenure arrangements through social bonds and local networks with other fishing groups (Kelkar, 2014).

Sources: Chiaravalloti, 2019; Fregene, 2016; Kelkar, 2014; Nayak and Berkes, 2011; Baird, 2010; Haller, 2010; Khumsri *et al.*, 2009; Abbott *et al.*, 2007; Garaway *et al.*, 2006; Begossi, 2002; Amarasinghe, Chandrasekara and Kithsiri, 1997; Thomas, 1996; Mathew, 1991; Moorehead, 1991; Netting, 1982.

The importance of being able to maintain access opportunities informs social practices and the relationships within and between groups. This includes groups outside individual communities. For example, Donda (1996) describes how in Lake Chiuta (Malawi), local chiefs and fishers' committees regulated access, allowing people from outside to fish once they had been granted permission by the chief and committees. Many inland fisheries are dynamic, and the changing nature of many inland fisheries means that movement of fishers is a common feature, particularly in lakes and large river systems. Moving in and out of fishing as an activity, between different types of fishing as well as transhumance – that is, the regular and traditional movement of people between fishing grounds – can be features of inland fisheries for example in the Inner Niger Delta, Barotse, Logone and Tonle Sap (e.g. Hamerlynck *et al.*, 2019; Sithirith, 2016). Strategies related to transhumance can differ: People may move between productive locations and seasons or may follow migrating fish as a strategy to maintain catches. Such movement may include crossing boundaries, a feature of some fisheries in western and southern Africa (Entsua-Mensah, 2002).

Fishers moving and wishing to fish, process or trade fish are often able to secure rights to fish through agreements with the local traditional chiefs or community leaders. For example, in the Upper Zambezi River floodplain fisheries and Yaéré floodplain in Chad, people wishing to fish are generally allowed to, provided they abide by local rules (Abbott *et al.*, 2007; Béné *et al.* 2003; Thomas, 1996). However, it is also the case that these actions and groups may also be viewed negatively by resident fishers, particularly where fisheries become degraded and consequently less productive. For example, such fishers have been marginalized in Indian small-scale fisheries and blamed for real or perceived malpractices (Bower *et al.*, 2017).

People can organize themselves by investing time and other resources in both fisheries management (such as through local decision-making and enforcement activities) and fishing activities. For example, Tapela, Britz and Rouhani (2015) and Britz *et al.* (2015) provides an example from the Pongola floodplain in South Africa where the fishers coordinate their fishing activities, fishing with baskets within floodplain depressions. This organized form of fishing provides a way to fish in waterbodies that could not be fished effectively by just one or two individuals and allows fishers to regularly share experiences and strengthen social cohesion.

While fisheries management often focuses on the individual benefits costs, collective benefits can also be important. This also serves to highlight that while inland fisheries are important components of food systems, they also provide other benefits. Generating collective benefits, through coordinated fishing or generating income for community investments can also be critical. Hirsch (2000) describes how villagers in southern Lao People's Democratic Republic would use barrier traps to hold fish in deeper floodplain pools that become isolated from one another as the water recedes. Pools are held in common by a group of households and specific rules govern when fish are caught, how they are to be divided, and who can be invited to fish in the pool. Also in the Lao People's Democratic Republic, but at a higher level, village administrations can organize the collective harvesting and sale of fish to generate income for village development (e.g. Garaway *et al.*, 2006). Collective harvesting can be combined with opportunities for subsistence fishing or be suspended in times of hardship, demonstrating how management can respond to changing collective and individual priorities (Comptour, Caillon and McKey, 2016; Arthur and Friend, 2011).

The "fishing day" systems in African and Asian countries (e.g. Garaway *et al.*, 2006; Shoemaker, Baird and Baird, 2001; Thomas, 1996) often extend access to neighbouring villages under reciprocal arrangements. Participation is recognized as both providing material benefits in the form of fish but also plays a major part in maintaining community solidarity (see Box 6-2). Customs of giving and sharing fish can also support strong social norms, encouraging wealthier households to help the poorer (Garaway, 2005). For the less powerful participants in this process, ensuring that access is maintained can be critical.

Box 5-2: Fish and fishing as mechanisms to create solidarity: fishing days and fishing festivals

The practice of "fishing days" or "fishing festivals" is common to floodplain environments across South and Southeast Asia and in parts of Africa (e.g. Ferry *et al.*, 2015; Shyllon, 2007; Garaway *et al.*, 2006). These practices are based on management rights held by local authorities, which include village administrations and user groups (including women's groups), and which may also extend to include water and land management rights. The fishing events themselves attract large numbers of participants, sometimes numbering in the thousands, and usually take place as waters recede, coinciding with times of low agricultural labour demand. Fish living in these environments at these times experience extremely high mortality, and virtually all the fish are condemned to die of anoxia and starvation. The biomass then present in these pools constitutes a unique opportunity that is enables the systematic catching practices, known as "depletion fishing". These practices in no way compromise the sustainability of the fishery, as other adjacent ponds that do not dry up completely may be completely closed to fishing (Martin *et al.*, 2011). Fishing on the day is usually restricted to a limited set of traditional small-scale gears. This includes types used by men, women and children to promote participation and has the added benefit of providing opportunities to share and pass on skills and knowledge.

It can be important that these events are not just about fishing, sometimes taking place in combination with other festivals. As such, they are also about coming together in ways that are facilitated by fishing and that support and reinforce reciprocal relationships, including between villages and social groups. This aspect can make important contributions to cultural heritage and social cohesion and even to maintaining peaceful relations. Participation may require the purchase of a ticket, the price of which is determined by gear type, and this can also provide opportunities for communities to generate income that can be used for community development.

What these examples illustrate is that tenure is not just about fish and fishers, and that responsibilities can extend beyond fish and fishing to support and enhance the collective and individual lives as lived within communities. These lives are also changing and, where people may be finding employment opportunities elsewhere, these events can play important roles in maintaining connections to fishing, communities and traditional ways of life. It is also important to consider how these events relate to the wider fisheries management context and the role tenure plays in these. Thus, fishing days can be combined with gear restrictions and closed areas as well as commercial fishing, regulated open access and provisions for mobile or migrant fishers. For example, fishing may be restricted in areas such as riverine deep pools, floodplain channels and paddy field water bodies in the dry season to protect large spawning fish. Collectively, these arrangements can ensure fisheries provide opportunities to meet livelihoods needs, including food and nutrition as well as playing important roles in conserving stocks and protecting habitats.

Sources: Ferry *et al.*, 2015; Martin *et al.*, 2011; Shyllon, 2007; Garaway *et al.*, 2006.

5.4.4 Investing in institutions to improve outcomes

As the ecosystem approach to fisheries emphasizes, access and environmental productivity are enabled through the social relationships, institutions and processes that regulate them. One important aspect to consider is how these relationships and institutions function and operate to accommodate diverse interests, securing benefits while avoiding conflict. There is evidence of how people have developed and established enduring institutional arrangements across different aquatic environments. Individual, household and user group, or community rights are a common feature in inland fisheries (Laë and Weigel, 1994), with use and management rights in inland fisheries are often based on water and riparian land tenure. This can include rights associated with the fisheries adjacent to areas of land, particular waterbodies, or with specific fishing spots (e.g. Oviedo and Bursztyn, 2017; Baird, 2010; Begossi, 1998; Thomas, 1996). Examples include the use of stationary gear such as set bag nets, traps and fyke nets or with fish aggregating structures such as the *acadjas* in Lake Nokoue (Atti-Mama, 1996). In many cases, rights to fishing spots are held by households who belong to a particular lineage, providing them with the recognized right, and these may be inherited, leased and even sold (Sugunan, 2010; Kassibo, 1994). These arrangements may also be recognized between different communities (Kassibo, 1994; Castro and McGrath, 2001). Permission to fish within designated fishing areas can be preferably granted according to the way in which the user is associated with the rights holder. In more open waters such as lakes, river deltas and lagoons, territories may be restricted to the edges, whereas in the central areas rights may be less clear and more contested.

The institutions mediating access and relationships can be formal, informal or a combination of the two. As an example of informal institutions and relationships, reliance on gifting and reciprocal exchange can also be particularly important as a mechanism for access for poorer groups (Garaway, 2005). Formal and informal rules and norms may also interact in different ways. For example, formal regulatory frameworks may include in practice accommodation by authorities of "illegal" fishing activities that may be justified by participants based on need (particularly where this is for subsistence) and recognized and tolerated as such (e.g. Ballesteros and Rodríguez-Rodríguez, 2018; Béné, Bandi and Durville, 2008). For poorer and marginalized groups, mechanisms for access can therefore include a range of strategies in relation to institutions and authorities that can variously include compliance, non-compliance (e.g. poaching) and patron–client relationships (Sithirith, 2016; Kolding and van Zwieten, 2014). Such strategies can include forms of "everyday resistance" to regulations or initiatives that are perceived as unjust or inequitable (Scott, 1976). For example, Utete *et al.* (2022) describe how people limited their participation in streambank conservation programmes that were perceived to negatively affect fishing rights.

It is also important to recognize that institutions and rights relate not only to fishing. Inland fisheries can generate a wide range of benefits for different people and the institutional arrangements play a critical role in determining what these are and who benefits and how (e.g. Garaway *et al.*, 2006). This includes in relation to fishing, trade and exchange, fish consumption and the role that fisheries play in reducing conflict. There can be a wider range of actors associated with inland fisheries who are able to benefit in different ways, with benefits (and costs) for groups and individuals shaped by institutions and how people respond to them. The social setting in which the actors are situated are therefore an important element, including aspects beyond fisheries regulations that include the role of gender, caste and wealth that may be less directly, or not at all, concerned with the fisheries or fishing. Institutions and relationships related to the mechanisms that affect their ability to benefit or shape the types of benefits that they are ultimately able to derive. For example, societal norms and customs may have the effect of preventing the person from engaging in fishing or handling fish. Being able to determine what is done with the fish that is harvested may also require negotiation, for example with other fishers or household members.

The management strategies and tenure arrangements that people have developed to mediate access reflect this complex and contested reality and are generally dynamic. In floodplains, streams and paddy fields, user rights and access reflect the changing nature of the environment and will typically change with the flood cycle. The importance of access and the roles that fisheries can play means that exclusion, even in the form of loss of the option or opportunity to benefit, can represent a form of impoverishment.

Many traditional arrangements therefore include an aspect of active creation or maintenance of fisheries as commons ("commoning"), even if this is within complex mosaics of overlapping, sometimes changing, and often contested tenure arrangements (e.g. Tubtim and Hirsch, 2005; Leach, Mearns and Scoones, 1997; McGrath *et al.*, 1993). These "commoning" strategies are active processes that can play an important role in securing access and navigating uncertainty and disagreement (e.g. Ruddle and Satria, 2010). Included in these strategies are a combination of formal and informal institutions and diverse economic practices (Gibson-Graham and Dombrowski, 2021).

However, it is important to recognize that effective institutional arrangements are not necessarily the result of design but may be the result of social and environmental change and the contested rights that can result. Contestation and disagreement can also play positive roles, for example where it fosters creativity or collective action and investments to restore degraded environments, communities and livelihoods. (see Box 5-3). Change in environments and the introduction of formal regulations or markets can alter the balance of power and undermine existing access in ways that create the conditions for resistance (Kelkar and Arthur, 2022). Examples of enclosure and exclusion are common across inland fisheries and take many forms. One example is construction of artificial channels in the Yaéré floodplain in Cameroon to concentrate fish. Once linked to community activities and shared benefits, formal regulation of these channels has effectively enabled enclosure, resulting in the other fishing practices becoming less profitable and the owners of fishing channels becoming the main beneficiaries (Ziébé, 2015).

Box 5-3: Establishing and defending rights: the role of resistance

Resistance has played an important role in establishing and defending rights, particularly for the poor, and an enduring basis for collective action. For example, Arora *et al.* (2020) describe how Dalit women in South India organized themselves to defend their rights to benefit from irrigation tanks and to reassert the value of these waterbodies as multi-use village commons, rather than as irrigation instruments controlled by landowning farmers. This is one of many examples of resistance to the enclosure of the fisheries and aquatic environments (see also Sharma, 2006). In some cases, these acts of resistance can lead to changes in policy and the formal recognition of rights. An example is the fishing lot system that was historically used to manage fisheries in the Tonle Sap in Cambodia.

The fishing lot system was initially established with the French colonization of Cambodia, when the lake was divided into privatized fishing concessions or "lots" that were auctioned off to the highest bidder (Evans, Marschke and Paudyal, 2004; van Zalinge *et al.*, 2000). This gave rise to quite complex arrangements, whereby the winning bidder would then often sublease management and access rights to subsections of the fishing lot area, which might then again be further subleased (e.g. Degen and Nao, 2000). The lot system provided opportunities for leaseholders and to generate government revenue from the auction process but involved excluding local communities. The result was tensions with local communities unable to harvest fish. By 2000 the escalating conflicts resulted in negotiations that led to the reduction in size of many of the fishing lots, the release of 56 percent of the fishing lot area and eventually, in 2012, the cancelling of the fishing lot system and a new focus on promoting co-management of these areas through "community fisheries" (Ratner, 2006; Evans, Marschke and Paudyal, 2004). The pursuit of particular interests by managers, for example maximizing production, can have complex and sometimes unexpected consequences for different social groups. Therefore, it is important that they should also be seen as actors with interests in the management arrangements and outcomes.

Resistance and collective action can be about recognizing rights but also promoting accountability and the responsibilities among users and managers that can undermine these rights. These point to critical issues of power that are often less well addressed in the fisheries management literature (e.g. Nunan *et al.*, 2018). Importantly, the examples also highlight that resistance and struggles over access and rights are often articulated in terms of social justice and the ability to pursue their livelihoods, not in terms of allocations or overall value of natural resources (Ratner, 2006, Arora *et al.*, 2020).

Sources: Arora *et al.,* 2020; Nunan *et al.*, 2018; Ratner, 2006; Sharma, 2006; Evans, Marschke and Paudyal, 2004; Degen and Nao, 2000; van Zalinge *et al.*, 2000.

5.5 STEWARDSHIP, CARE, KNOWLEDGE AND CULTURE

Local traditional practices and management institutions provide a rich and diverse set of examples of effective and evolving practices that address the environmental, social and institutional aspects of inland fisheries and are consistent with an ecosystem approach to fisheries. Critically, these arrangements and practices are embedded within the cultures and livelihoods of the groups concerned and based on their knowledge and experiences of the fisheries and their associated aquatic environments (Legrand, Boranin and Young, 2020; Quensière, Tounkara and Kane, 2018; Fischer *et al.*, 2015). Knowledge is therefore fundamental to practice and often involves detailed time and place understanding of local environments and their dynamics (see Box 5-4). This knowledge, of landscapes, water bodies and practices can be integrated into a specific vocabulary or artistic forms, some of which may be specific to certain groups or castes (Taïbi *et al.*, 2023, Lorin, 2015). However, it is also essential to acknowledge that knowledge extends beyond ecological and includes knowledge of social realities, food systems, needs and priorities. These aspects also central to the ecosystem approach to fisheries and play critical roles in shaping interests, institutions and management decisions, and the individual and collective investments in environments, knowledge and social relationships.

Box 5-4: Ecological knowledge and livelihood responses in the Barotse floodplain

The first signal of the arrival of a flood is the ballooning (production of silk threads in the air) of a spider known locally as *mendayi*. The abundance of silk threads indicates the greater extent of the expected flood. The second notable signal of the level of flooding is a beetle known locally as *tumbombo*. When this beetle is observed on the grass pointing its head upwards, it is a sign that the flooding is continuing to progress and that areas at risk of flooding should be evacuated. In cases where people do not evacuate, the dykes around houses must be reinforced to prevent damage caused by rising water. When the water begins to recede, the *tumbombo* beetle turns down to face the ground. It then signals to the community that the maximum water level has been reached.

Observation of the behaviour of these insects allows households and communities to start planning for the receding water and the resumption of cultivation. The third signal is linked to the behaviour of birds, particularly swallows and gulls, whose presence earlier or later is an indicator of the intensity of the flooding. The behaviour of certain ducks is also thought to indicate the imminence of a storm. These wildlife observations are corroborated by meteorological observations, in particular the initial direction of the winds during the first rains. This knowledge informs farmers about the timing and type of crops that can be planted.

Sources: Mapedza *et al*., 2022.

It is important to return to the point that knowledge is not simply a stock of information but is embedded within the relationships and the actions of people (Stacey, 2001). Knowledge is dynamic and relational. Being related to action and practice, knowledge and ways of knowing also inform and can support creative capacities and collective action that can enable adaptation and transformative processes (Chapman, 2016). While there is a risk that when presented as traditional knowledge and practices, stewardship and care may be perceived as anachronistic or less relevant in the context of development and modernization. However, the innovation evident in local practices and adaptation and integration of new technologies, illustrates how knowledge and tradition can be constantly updated. This keeps such knowledge and practices contemporary and therefore of ongoing relevance to fisheries management. Investments in knowledge and the relational nature of knowledge are particularly evident where fishing and processing activities are concentrated, providing opportunities to develop and reinforce relationships and to pass on and exchange knowledge related to fishing and fish processing (e.g. Legrand, Boranin and Young, 2020; Box 5-2).

This way of understanding knowledge and its relation to practice is important since decoupling knowledge and meaning from people and relationships acts to depoliticize and dehumanize knowledge. in which issues of accountability and social justice, of whose agenda, objectives and interests count need to be considered (Arthur and Friend, 2022). The significance is to shift from the acceptance of the importance of fisher knowledge and the emphasis on integrating their information and data in management planning. Recognizing that knowledge is embedded in practice shifts the focus instead towards inclusion of practitioners in decision-making and issues of rights and social justice that are associated with the VGSSF (Arthur and Friend, 2022).

Cultural traditions and practices can help reinforce management measures and adherence to them. For example, in the Inner Niger Delta in Mali, myths relate that the water and the fish that live in it are the property of the genies. The right to use the water (in this case to cross the river) and the right to fish involve offering tributes to these genies. The religious alliance between the first person to provide a tribute and the water genie guarantees fishing for him and his male descendants (patrilineage) on specific sites that have been recorded, named and passed on from generation to generation (Kassibo, 1994). The Ganga River in Uttar Pradesh is another example where temple authorities have historically banned fishing in the vicinity of important religious worshipping sites (Doron, 2012). These traditions can help enforce rules and can also be a way of managing the conflict and tensions around conflicting interests.

When disagreement becomes conflict represents both a failure of governance and a cost to individuals and societies. In many cases therefore there are important benefits in strategies to avoid or accommodate disagreements so that they do not escalate. For example, in many large lakes in Africa (such as Lake Malawi, Lake Mweru, Lake Tanganyika and Lake Victoria), the emergence of markets and commercial interests has led to the differentiation within the capture fisheries between relatively large-scale commercial operations, small-scale commercial operations and local subsistence fishers.

5.6 STEWARDSHIP AND CARE AND THEIR RELATIONSHIP TO FISHERIES MANAGEMENT

Uncertainty and disagreement remain intrinsic and enduring features of many inland fisheries, especially in the context of rapidly changing aquatic environments. Conventional forms of fisheries management typically identify uncertainty and disagreement as problematic aspects, to be minimized through management and governance interventions. This is variously achieved through an emphasis on trust and consensus, data and information for planning and restriction and enforcement of fishing activities to achieve stability. Conventional forms of fisheries management have their place but, particularly in fluctuating or changing environments, often contrast with local practices derived from experience and tradition and where stewardship and care is instead evident through informal and irregular actions that reflect responsibilities towards other people and the environment and in investments in knowledge and institutions.

The values associated with care play important roles in relation to fisheries management in uncertain and contested contexts. This includes supporting environmental stewardship (Charles, Macnaughton and Hicks, 2024) but also extending to social and institutional roles and outcomes. Adapting to change and navigating uncertainty can also require flexible responses and openness to experimentation (Garaway *et al.*, 2006). Creative capacity, supported by traditional knowledge and experience, can play important roles in innovation and experimentation, helping to navigate change, identify new options and opportunities, and resolve differences (Chapman, 2016). New technologies, including stocking, novel fishing gears and market access among others, can be part of such processes in which values play a role in the ways that technologies and institutional arrangements are adapted and in the resulting roles of the waterbody and access (Garaway *et al.*, 2006; Brooks *et al.*, 2015). At a landscape scale, the result of innovation and experimentation can be forms of adaptive radiation as technologies and institutions are adapted in different ways to reflect the different contexts, interests and relationships across different groups (Arthur *et al.*, 2023; Thompson, Sultana and Arthur, 2010; Garaway *et al.*, 2006). Creative capacity and local innovation can also provide the basis for insights into how fisheries respond to changing productivity and management measures, coordinating experimentation and testing responses in forms of adaptive management (Garaway *et al.*, 2006; Walters 1986).

Successful adaptation and accommodation of different interests are features of stewardship and care, recognizing social and ecological responsibilities and linked to ideas of how things can be changed for the better, offering optimism and hope and an agenda for transformation (de la Bellacasa 2017; Tronto, 1993). Such transformation may not be reached through consensus but also arise from a desire for environmental and social justice, in which fish and fisheries may play important roles (see Box 5-5). In contrast to conventional management focused on control, by explicitly situating management within the complex relationships between humans and nature, stewardship and care also allows uncertainty and disagreement to be viewed more positively. For example, while environmental variability – as well as ambiguous, dynamic and overlapping tenure and polycentric governance arrangements – may lack certainty, it can also provide disincentives for capture and exclusion, thereby facilitating and even enabling access and participation in inland fisheries. When the wrong kind of secure tenure may be harmful, uncertainty can provide a bulwark against enclosure and exclusion. As Jul-Larsen and Mvula (2007, p. 13) note with respect to land tenure, "we find that the inherent ambiguities and contradictions in customary tenure tend to increase the land security among smallholders rather than to reduce it."

Box 5-5: Fisheries management, stewardship and care and the right to food

Management, when related to food security and nutrition, reinforces the importance of access. Indeed, regulated forms of open access are an enduring feature of many local and traditional tenure systems (Arthur, 2020). Such arrangements make sense where environments fluctuate, and patterns of fishing or livelihood activities change over the course of the year or between years. For example, where flooding reduces crop production or farming opportunities fishing may become more important and management regulations that enable access can provide insurance and social protection roles. The importance of these roles was highlighted in the Lao People's Democratic Republic by Meusch *et al.* (2003) who found that, while harvesting fish and other aquatic organisms (including frogs, snails and insects) represented the main household strategy for dealing with the fairly regular rice crop failures, there were no such coping strategies for fish production failures.

Food, livelihoods and access are often therefore linked in traditional management arrangements. Crucially, access is linked to food but not just any food but those forms of food that are important and integral to livelihoods and cultures (Arthur *et al.*, 2022). This has two important consequences: First, substitution or replacement of foods is not simply a question of calories or nutritional content but also cultural appropriateness. For example, Quaempts *et al.* (2018) explain how smallmouth bass (*Micropterus dolomieu*), a fish introduced to the Pacific Northwest of the United States of America that, despite being widespread, is not used in traditional ceremonies as a substitute for native fish. Similarly, fish from aquaculture is often not considered as a replacement for wild caught fish (Arthur *et al.*, 2022). Second, fish that are important components of food cultures can be the basis for fisheries and environmental management. For example, where there has been environmental and social change that have restricted access or reduced productivity, the importance of traditional foods can be a focus of management focus that emphasizes culture, restoration and development opportunities linked to rights not mitigation measures (Arthur and Friend, 2011).

Food, traditional foods, and relationships with the environment manifested through food are at the forefront of several of these initiatives. For example, Quaempts *et al.* (2018) describe how the inability of local landscapes to provide traditional foods adequate for ceremony and subsistence uses was the basis for food-based, community-led management responses. The first of these was the "River Vision" that articulated a management vision encompassing water, aquatic environments and rights associated with traditional foods from these environments such as salmon, trout and mussels. Consistent with an ecosystem approach, it recognized the dependence of functional rivers on the interconnected aspects of hydrology, geomorphology, riparian vegetation, and aquatic life as well as the connection of these to human livelihoods, cultures and well-being. This provides an example of how care for the environment, welfare, well-being, and traditional knowledge and practice combine around the right to food. The potential of such food-led initiatives also suggests the potential for a shift in the focus of assessment from the state of stocks in the water to the state of food on the plate.

Sources: Arthur *et al.,*2022; Arthur, 2020; Arthur and Friend, 2011; Quaempts *et al.*, 2018; Meusch *et al.*, 2003.

While local knowledge and traditional practices are recognized as having value in fisheries management, considering these in relation to stewardship and care, i.e. embedded in cultures, relationships and environments, can enhance management. Firstly, the embedded and relational nature of these practices requires more inclusive forms of management. Secondly, care requires greater attention to the equity of processes and outcomes, ensuring that actions are responsible, and that people are accountable for these actions. Finally, care needs to be recognized as an alternative to control, important as a complementary means to navigate uncertainty and change and valued for the knowledge, experience and capabilities on which it is based. Recognizing existing practices of stewardship and care as an entry point for accelerating transformations can help advance the ecosystem approach to fisheries. In turn this can help promote environmentally and socially responsible fisheries in dynamic and dispersed fisheries where there is a need for alternatives to control.

There is already some evidence of how this is recognized in relation to the environmental dimension of the ecosystem approach to fisheries in the form of environmental stewardship (e.g. Charles, Macnaughton and Hicks, 2024). Furthermore, some locals have gained formal recognition in ways that enable socially and environmentally responsible management without control. Examples include the "One Commune, One Community Fish Refuge" adopted by government of Cambodia to promote dry season fish refuges (Gregory, 1997), or community fisheries in the Lao People's Democratic Republic that are allowed to experiment with management measures (Garaway *et al.,* 2006). In these cases, positive outcomes are achieved where local managers are enabled and supported in adapting technologies and experimenting with management measures, allowing adaptive radiation and different forms to develop rather than single solutions.

5.7 CONCLUSIONS

While conventional forms of fisheries management that attempt to control and impose order can be effective, in situations where fisheries are fluctuating, changing and uncertain it is recognized that the conditions necessary for establishing control may be challenging to create or intrinsically counterproductive, and consequently that there is a need for alternatives (e.g. Caddy and Gulland, 1983). Engaging with how people live with, experience, and engage with inland fisheries and the creative capabilities they demonstrate can represent a starting point for such an alternative. People continue to invest in fisheries and fisheries management, although the resulting practices may be irregular and the institutions in many cases informal. However, in many cases these practices are underpinned by notions of care for both the environment and for people. Stewardship and care are therefore relevant to the management challenges evident in inland fisheries and associated also with wider aquatic landscapes management in that it is about addressing needs in practical ways that involve accommodating different interests. Critically it also provides a means to frame fisheries management in a more positive fashion, not limited to fixing problems and finding solutions but navigating change and creating opportunities. As Mol, Moser and Pol (2010, p. 15) articulate in a very relevant fashion "care is active, it seeks to improve life."

As an alternative to control, stewardship and care provides a means to successfully develop, adapt and maintain management arrangements capable of delivering equitable social benefits and maintaining productive environments. Knowledge, relationships, connections and practices are key elements reflected in stewardship and care. Advancing the ecosystem approach to fisheries by supporting and strengthening stewardship and care provide opportunities to improve management and governance of inland fisheries, especially in situations where control and the tools of rational planning are less relevant or practical. Critically, the focus shifts from external interventions to the processes of transformation and adaptation that occur more locally, as well as to the multiple resources, knowledges, interests and institutions (both formal and informal) that contribute to and mediate responses to uncertainty and change. This provides the basis for forms of management that recognize management as not limited to environmental stewardship but inclusive of social aspects such as relationships, equity and well-being as well as the institutions, knowledge and traditions that mediate them care and the values associated with caring. For management, there is a greater emphasis on the rights and responsibilities in particular to how rights – whether related to fishing, trade or consumption – can be exercised responsibly. This represents different forms of management and an alternative starting point, but does not suggest that conventional management does not also have its place. What is therefore argued is for managerial pluralism to support positive transformations in situations in which different forms of management are required for different conditions and contexts.

Within diverse local contexts, the ecosystem approach to fisheries, with its basis in the code of conduct for responsible fisheries, can usefully provide principles for negotiating and defining what constitutes environmentally and socially responsible conduct, including by managers, processors, traders and fishers (e.g. Cotula, 2021). In diverse and dynamic inland fisheries, practices of stewardship and care provide additional tools to engage with and navigate uncertainty and disagreement, aspects that are frequently a challenge for conventional forms of management. The enduring and adaptive nature of many inland fisheries, the important roles that they play, as well as the investments that people make in maintaining productive fisheries and fishing cultures (and in asserting their rights) represent a strength. The challenge is to recognize, value and support stewardship and care, enabling within formal policy frameworks the creative capacity and diverse practices evident and inherent within these fisheries. Beyond this, there is also a question of how local practices of care – embedded as they are within the traditional knowledge, values and practices of fishing communities – can provide evidence of the role inland fisheries can play within the wider context of integrated water resources and landscape management. This is an important aspect. Demonstrating the value of existing practices, the capabilities of those dependent on inland fisheries and the stewardship care that they are capable of, can help challenge prevailing views that inland fisheries have little to contribute to the development and sustainability challenges and societal aims. The connections between fisheries, knowledge and culture described in this chapter, also highlight what is at stake should these opportunities be missed.

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6. INLAND FISHERIES IN A BASIN MANAGEMENT CONTEXT

Rachel F. Ainsworth and Gretchen L. Stokes

SUMMARY

Inland fisheries, with recorded landings of 11.4 million tonnes in 2020 (12.5 percent of total global capture fishery production), deliver accessible, affordable, and high-quality food to some of the world's most vulnerable populations (FAO, 2022). However, unlike marine fisheries, there is currently no standardized assessment method to track and monitor the status of inland fisheries global sustainability indicators (FAO, 2021).

The highly dispersed nature of inland fisheries and their subsistence provisioning often results in disparate data records and poor reporting of fish catch metrics. Without assessments, it remains difficult to track trends in global inland fish production, monitor the effects of human pressures (for example climate change, land use, hydropower, or human development) on inland fish populations, and identify priority areas for restoration or conservation measures. Because the pressures on inland fish and fisheries are often externally driven, tracking and monitoring inland fisheries requires methods appropriate at a basin level that utilizes habitat and watershed metrics beyond fish catch or fishing pressure alone. Furthermore, the highly dispersed nature of inland fisheries requires means that such methods are applicable at scales that can extend beyond country boundaries.

This chapter contextualizes, describes and demonstrates the use of a newly developed unified and standardized methodology for assessing the status of inland fisheries and their habitats by nested hydrological basins. Assessing fisheries in the context of multiple uses also holds potential use as an indicator tool for monitoring inland fisheries by fishery managers for individual fisheries as part of "sentinel" fishery programmes and by global policy makers and decision-makers for the establishment of global sustainable targets.

6.1 ASSESSING INLAND FISHERIES AT A BASIN SCALE

Approximately 80 percent of inland fisheries catch comes from just 20 countries, or some 50 major basins, yet most of these are not routinely monitored and fish stocks remain to be defined (FAO, 2022). Currently, global inland fishery statistics compiled by FAO are reported at a national level and represent an aggregated amount from a range of fisheries based on different aquatic habitats (such as wetlands, lakes, reservoirs, rivers and in some cases estuaries) (Funge-Smith, 2018). This means evaluating the production and state of a particular river basin fishery typically requires the compilation of national data from multiple countries, which can be a resource-intensive, time-consuming endeavour and is impractical for regular, repeated evaluations (Ainsworth, Cowx and Funge-Smith, 2021). A basin assessment methodology was introduced in Funge-Smith (2018) as a means to apply the principles of the ecosystem approach to fisheries and provide a method to assess and monitor inland fisheries in the context of wider use of land and water resources within basins. The aim of this chapter is to expand upon the work in Funge-Smith (2018) to provide an indication of how basin scale assessments might be used in decision-making, including the potential for using indicator or "sentinel" fisheries and the application of basin threat mapping tools at different scales.

The assessment of inland fisheries is challenging owing to their unique characteristics, such as being highly seasonal, small-scale, dispersed, fragmented, multi-species, and multi-gear, often catering to subsistence or household consumption and forming part of diversified livelihood strategies (Ainsworth, 2020; Ainsworth, Cowx and Funge-Smith, 2021; Bartley *et al.*, 2015; FAO, Duke University and WorldFish Center, 2023; Lynch *et al.*, 2016). Most (up to 90 percent) global inland capture fisheries production is used for human consumption (Welcomme *et al.*, 2010), but not all fish that is caught and retained enters market systems and thus may go unreported entirely. The complex and widespread distribution of freshwater bodies, coupled with the transboundary nature of many inland fisheries, makes monitoring costly and time-consuming (FAO, Duke University and WorldFish Center, 2023), necessitating alternative methods to traditional sampling based on direct observation (see also Chapter 3), for accurate trend detection.

The freshwater environment is one of the most threatened on earth, as many as one-third of freshwater fish species are now threatened with extinction and some populations are at a higher risk of decline. This includes freshwater migratory fish species, which, of those monitored, have declined by 76 percent since 1970 (McRae, 2022). Yet not all inland fish stocks are in decline: Many fisheries are naturally fluctuating, and it is also possible that even when inland fish production is increasing or stable overall, this could be concealing a decline in one or multiple fisheries within a basin. Conversely, improved management and habitat restoration may also stabilize or increase fish biomass, and production and enhancement can also play a role, including in reservoirs and other man-made water bodies (e.g. Ainsworth, Cowx and Funge-Smith, 2021). What is clear, amidst diverse drivers, uncertainty and the apparent limited data, is the need for improved assessments that can document evidence concerning the status of inland fisheries.

6.1.1 The utility of basin assessments

Considering that the world's freshwater environments are amongst some of the most threatened ecosystems on the planet, and given the challenges with traditional assessment methods, there is a pressing need for more effective assessment methods that address the multiple pressures on fisheries and aquatic environments. Basin-level assessments provide a meaningful level of analysis consistent the ecology of basins and watersheds and the interconnected nature of inland fisheries and fisheries habitats within contiguous river and lake systems. This level can be meaningful from a management perspective, as basins often transcend national boundaries and are then associated with basin management organizations. It allows for major global reporting and lends itself to lower resolutions and sub-basin or catchment level thinking and assessment. Furthermore, basin scale assessments allows different productive aquatic environments to be considered in aggregate as well as separately, since natural and artificial habitats may capture varying degrees of increasing or decreasing production.

Utilizing "basin" (drainage basin, catchment or watershed) boundaries allows for the examination of fish catch and habitat pressures across hydrologically meaningful delineations of land drained by rivers and their tributaries (see Section 6.3.1). It also overcomes issues associated with highly dispersed or aggregated data and the potential loss of valuable fisheries information from national catch assessment programmes. Furthermore, assessments of activities occurring within basins allows for the identification of the key fisheries that occur within a productive basin (namely fisheries important for food security and nutrition, commercially important fisheries, biodiversity hotspots) and improves the understanding of how different components and habitats provide relative contributions to food security, livelihoods and biodiversity. For example, this could include areas where fish catches are particularly high around areas of high rural population density; where people are able to easily participate in the fishery; where there is a strong culture of fish consumption; or where the local climate, economy, or religion restrict the rearing of livestock and thus increases dependency on fish (Ainsworth, Cowx and Funge-Smith, 2023, 2021). Ultimately, assessing inland fisheries in the context of other activities occurring within basins not only overcomes the barrier of traditional monitoring and addresses current needs for inland fisheries but it also, given the nature of the threats, advances the understanding of inland fisheries at the water–energy–food nexus and their contributions to global sustainability goals (Coates, McInnes and Davidson, 2023).

Basin assessment and monitoring provides a means to contribute to holistic and transdisciplinary approaches, embracing the principles of an ecosystem approach to fisheries. The reality of basins is that there are often multiple and overlapping management units within them related to fisheries, agriculture, water management and other uses. Assessments at a basin scale can place fisheries within this context and inform these different, interrelated management processes. While the connection between inland fish stocks and fisheries with their associated watershed components (biotic, abiotic and human) makes an ecosystem approach particularly relevant, in the context of multiple uses and activities it is also a different challenge to fisheries management. Basin assessments that contribute to an ecosystem approach provide a framework for engagement and integrated management strategies that are inclusive of different land and water use and livelihood interests (such as forestry, crop production or livestock production). As such, they can begin to inform debates over integrated resources management that move beyond "trade-offs" towards accommodating different values, uses and benefits and in which inland fisheries can present opportunities to contribute to development goals (Friend, Arthur and Keskinen, 2009).

6.1.2 Opportunities for integrated resources management through basin assessments

Adopting assessment methods inclusive of different sectoral activities and interests can more explicitly recognize and assess the costs and benefits, winners, and losers to inform decision-making, responsibilities and mitigation measures, including in relation to the Sustainable Development Goals (SDGs). For example, inland fisheries and sustainable freshwater management are integrally linked to FAO's mandate to achieve food security, improve nutrition, and reduce poverty. As the custodians of 19 indicators within SDGs 2 (Zero Hunger), 6 (Clean Water and Sanitation), 14 (Life below Water), and 15 (Life on Land), FAO is positioned to holistically address the targets within these Goals, which fall at the water–energy–food nexus. For example, SDG 15 (Life on Land) emphasizes the protection, restoration, and sustainable use of terrestrial and freshwater ecosystems and biodiversity amidst accelerating anthropogenic pressures. Achieving SDG 15, and ultimately safeguarding the world's freshwater resources, requires cross-sector integrated planning (Target 15.9), benefit-sharing (Target 15.6), and resource mobilization (Target 15.a, Target 15.b) (UN, 2015).

6.2 BASIN-SCALE INLAND FISHERIES PRODUCTIVITY AND CATCHES

While fish are caught worldwide, river basins with the largest volume of catch are typically located in tropical and subtropical regions and developing countries, particularly Africa, Asia and South America (see also Chapter 2) but also basins outside these areas, including in the Russian Federation and Finland. In general, inland fisheries are concentrated around productive waters such as lakes, rivers, floodplains, wetlands, paddy fields and ponds – typically where there is a large rural population or where the local climate, economy, or culture generally prevents the cultivation of other foods (Ainsworth, Cowx and Funge-Smith, 2023; Funge-Smith, 2018). As such, while national catch figures provide a useful overview of global catches, they are seldom able to provide accurate detailed information on individual fisheries (see also Chapter 3). However, viewed from a basin perspective, a picture emerges of where the world's inland fisheries occur according to basin boundaries and the contribution of different habitats to global fish food supply.

The tables and figures in this chapter provide an overview of fish catches from river basins around the world as outlined in Ainsworth, Cowx and Funge-Smith (2021, 2023) and the methods can be found in their respective documents. Fishery data were collected from the literature for the most recent year available, however for some basins the most recent year was dated from the 1960s and 1970s. It is unlikely that fish catch has remained stable since this time and therefore some of the data should be treated with caution. Additionally, fisheries often fluctuate, driven by a range of environmental variables (Lorenzen *et al.*, 2016; Welcomme *et al.,* 2010) The resulting variability may not be captured in existing fisheries assessments available within many subregions (Funge-Smith, 2018; see also Chapter 7).

Basin-level overviews of fish catch were developed using the boundaries of hierarchically nested sub-basins (HydroBASINS) delineated by Lehner and Grill (2013). The HydroBASINS delineation is a series of polygons with global coverage that, because of the nested nature, allows for analysis of catchment characteristics with consideration to upstream and downstream connectivity (Lehner and Grill, 2013). For this work, we use the term "basin" to refer to the largest unit (HydroBASINS Level 3) of polygon delineations, and "sub-basin" to refer to the next-sized unit (HydroBASINS Level 4). Generally, examining fish catch and fishery characteristics at Level 3 and 4 provides meaningful comparisons across continents and regions, while smaller sized polygon units (HydroBASINS Levels 5–7) may be more meaningful units for local fishery managers. Generating an overview at the basin level is complicated by existing reporting. Fisheries can occur outside of major sub-basins, such as when countries report catches that are wholly located within the largest basin unit, in which case the catch cannot be associated with one particular sub-basin. This includes large archipelagic countries, which have many small basins and few large basins but still have considerable inland fisheries catches. Similarly, some island states with considerable freshwater resources (such as Republic of Fiji, the United Kingdom of Great Britain and Northern Ireland, and Sri Lanka) are not associated with sub-basins and instead each is considered as one basin (Ainsworth, Cowx and Funge-Smith, 2021).

6.2.1 Distribution of global inland catches by basin

From a basin perspective, the world's largest inland fisheries in terms of catch are the Mekong, Nile (including Lake Victoria), Irrawaddy, and Brahmaputra Rivers (Figure 6-1). Globally significant fisheries environments include the large rivers, lakes and reservoirs and floodplains (Figure 6-2 and Figure 6-3). It is however difficult to determine the contributions of these different environments due to differences in data availability, how data are reported in the literature, and the methods used for data collection. For example, the limited catches reported in the literature from floodplains could reflect a lack of comprehensive surveys and monitoring of these areas, rather than genuinely low catch rates. As identified in Chapter 3, more accessible and stable environments may be easier to monitor and therefore receive more attention, while more dynamic seasonal floodplains are more challenging to track and monitor consistently (Welcomme *et al.*, 2010; Lorenzen *et al.*, 2016). Similarly, for many smaller water bodies data remain inadequate or unavailable in sufficient detail to be able to incorporate them into basin summaries. Compounding the challenge of assessing fisheries, inland aquatic environments are undergoing rapid changes due to economic development. In some cases, fisheries management affects productivity, including the promotion of fisheries enhancement through stocking or resulting from fishing restrictions. For example, a ten-year fishing ban was recently introduced on the Yangtze River, which has resulted in the decline in reported inland fisheries catch from 2.2 million tonnes in 2017 to 1.4 million tonnes in 2020, and is expected to decline further (FAO, 2022).

Figure 6-1: Estimated basin-level inland fish catch (tonnes) (green scale). Major Lakes are incorporated into their corresponding river basins. For basins with catch ranges, the mean catch is presented (basin ranges and lakes catches are presented in Supplementary Table S1 and Supplementary Table S2).

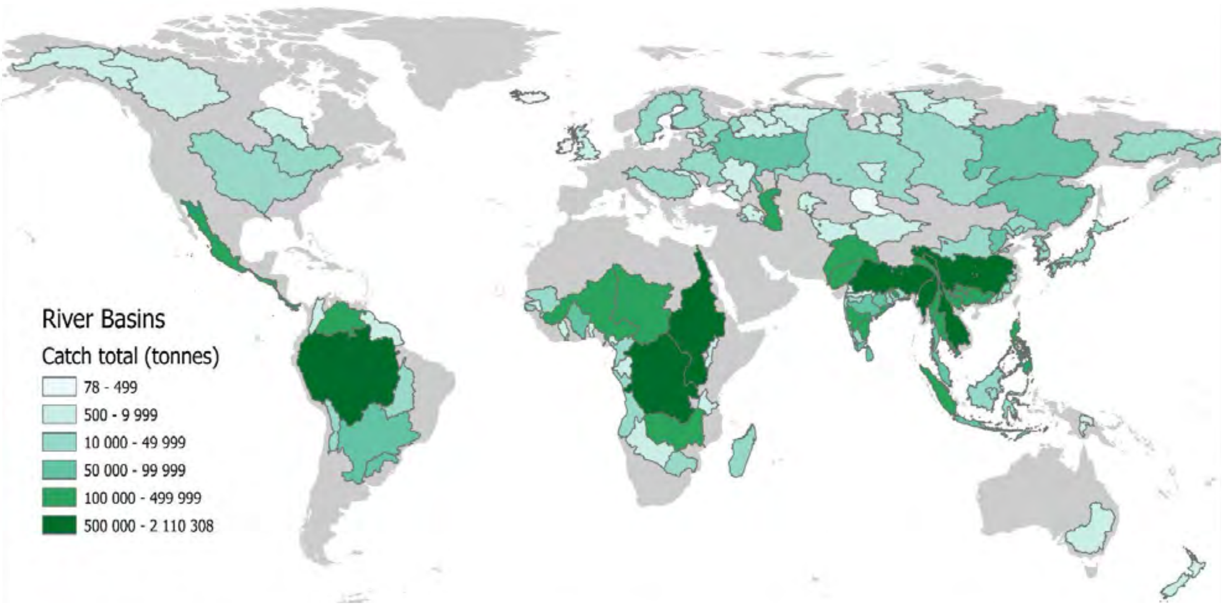


Figure 6-2: Estimated basin-level inland fish catch (tonnes) (green scale) and proportional amount of basin catch reported by country (yellow), lakes or reservoirs (purple), basin (blue), river (red) and floodplain or wetland (green) for North and South America, Africa, Europe, and the Russian Federation, including Siberia (basin ranges and lakes catches are presented in Supplementary Table S1 and Supplementary Table S2).

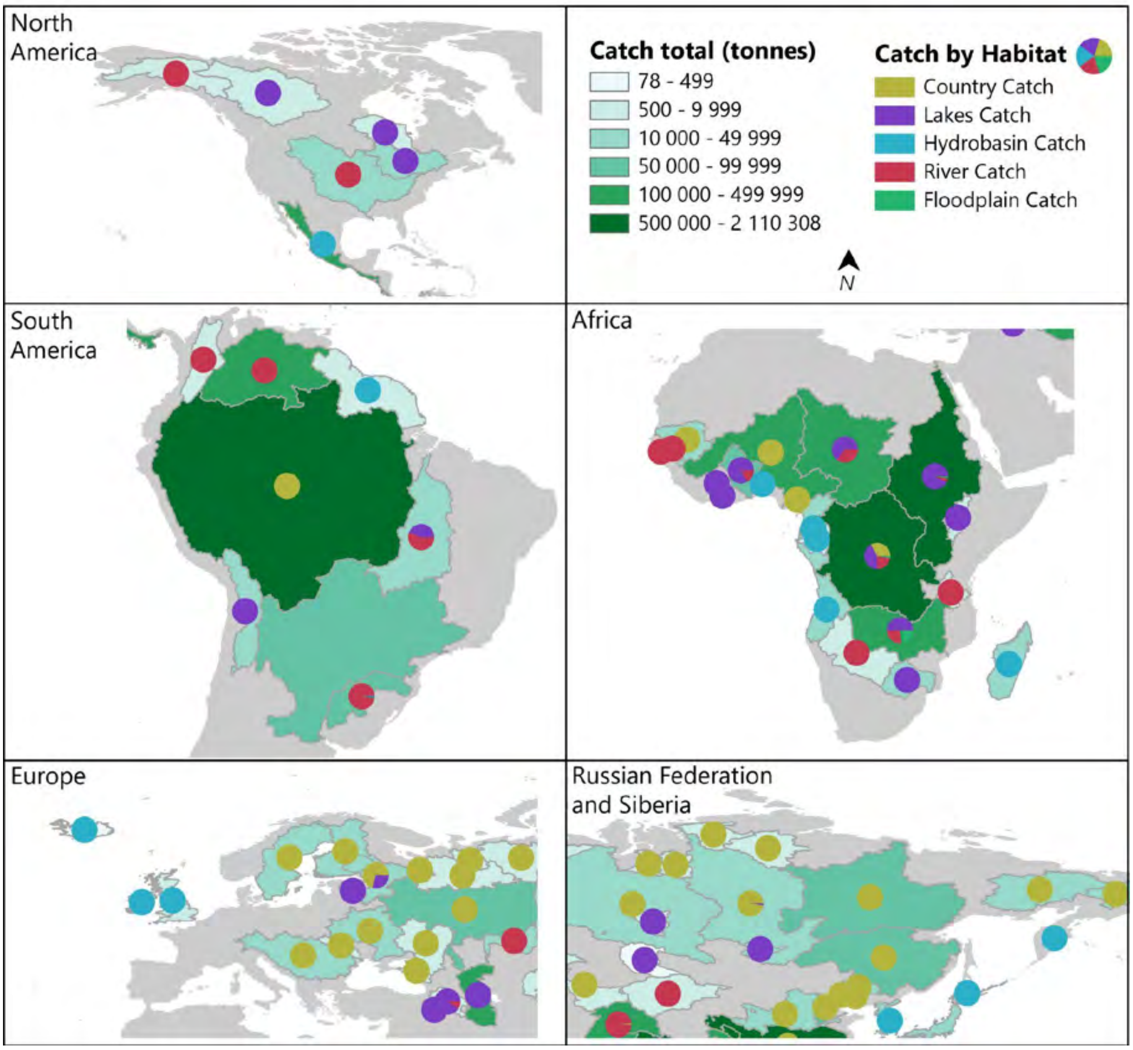
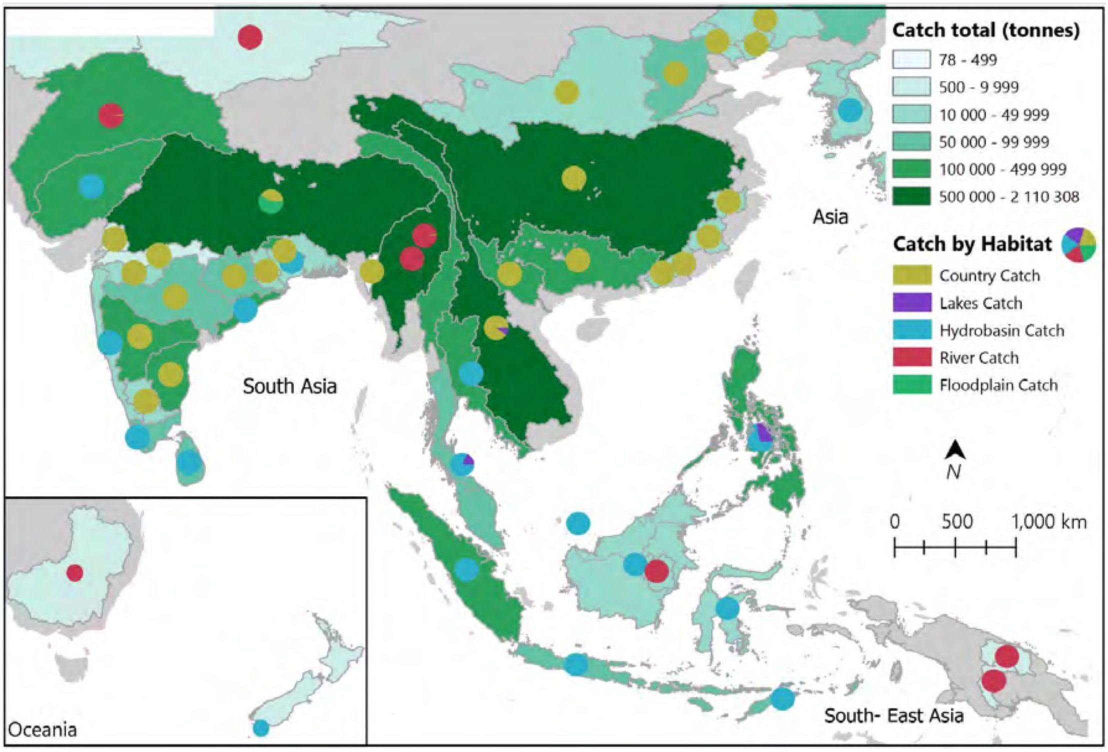


Figure 6-3: Estimated basin-level inland fish catch (tonnes) (green scale) and proportional amount of basin catch reported by country (yellow), lakes or reservoirs (purple), basin (blue), river (red) and floodplain or wetland (green) for Asia, Southeast Asia, and Oceania. (basin ranges and lakes catches are presented in Supplementary Table S1 and Supplementary Table S2).



BOX 6-1: Habitat production estimates versus fish catch estimates: A case study of the Zambezi River

The Zambezi River, the largest in Southern Africa, sustains one of the continent's most extensive fisheries. It comprises 13 sub-basins, including the Chobe, Kafue, Luangwa, and Shire rivers, with significant floodplains along the Barotse, Kafue, and Chobe rivers. Dam construction in the central basin has given rise to vital reservoir fisheries in Lake Kariba, Lake Itezhi-Tezhi, and Lake Cahora Bassa. Lake Malawi, the largest natural lake in the basin, connects to the Shire River. This diverse basin hosts a wide array of habitats and, consequently, a variety of fisheries.

Unlike some basins where fisheries data are only available from the countries that share the basin, Zambia reports its inland fish catches, including those for the Zambezi River basin, as fisheries catch from major rivers, floodplains, lakes, and reservoirs (DoF, 2016; Ainsworth, Cowx and Funge-Smith, 2021, 2023). It is therefore an ideal candidate with which to examine the potential fisheries production from different habitat types with the reported production from the literature.

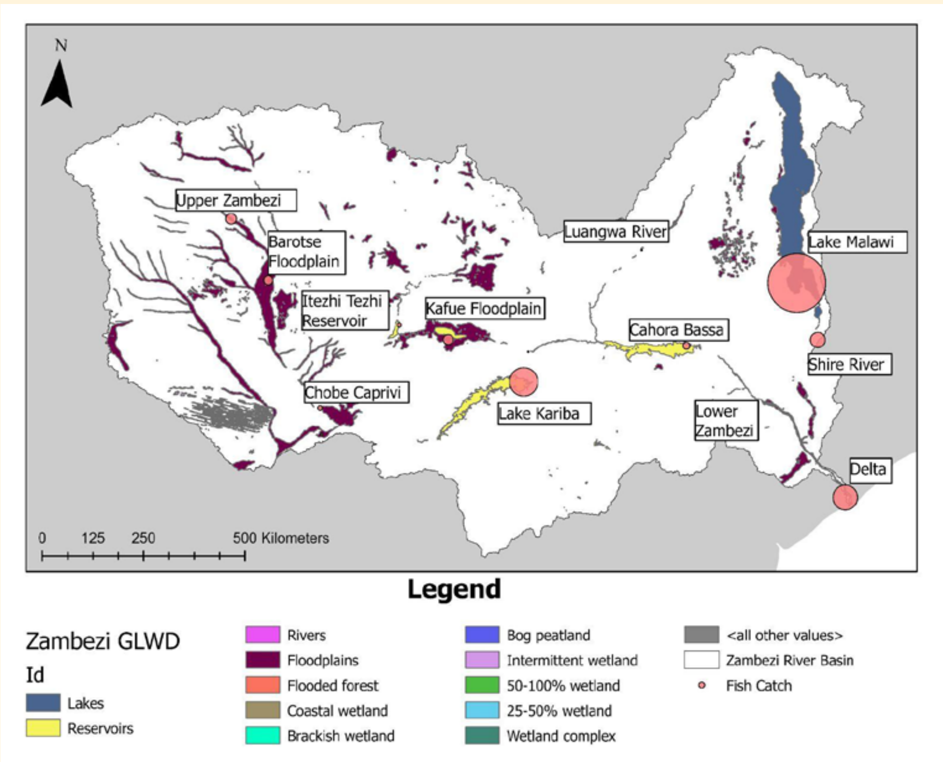
Applying a basin-scale assessment to estimate fisheries production that utilizes the characteristics of aquatic habitats is an important step in identifying the ecosystem services that inland fisheries provide (Beard *et al.*, 2011). The global theoretical harvest by habitat type, as outlined in Lymer *et al.*, (2016), provides an indication of potential harvest, and by extension the ecosystem services provided by continent, type of habitat, area of habitat and habitat–continent specific fisheries yield data. Using the estimates of continental fish yield by habitat type outlined in Lymer *et al.*, (2016) and habitat area calculated from the Global Lakes and Wetland Database (GLWD; Lehner and Döll, 2004), we can examine the potential contribution of inland fisheries at a basin scale (Table 6-1, Figure 6-4).

Table 6-1: Fish production by habitat type from the Zambezi Basin using Lymer *et al*., (2016) habitat production estimates and estimates derived from the literature from (Ainsworth, Cowx and Funge-Smith, 2021, 2023). Lake estimates inclusive of Lake Malawi. For range estimates an average value was used.

Habitat type	Habitat area (km²)	Potential fish harvest based by habitat type (tonnes)	Fish harvest estimates from the literature (tonnes)
Wetland	4 347	1 348	
Floodplain	61 229	308 594	23 323
Rivers	1 328	4 077	26 805
Lakes	30 192	220 406	57 007
Reservoirs	10 890	90 395	4 343
Total	**107 986**	**624 820**	**111 478**

The modelled potential fish harvest (624 820 tonnes) is nearly six times the actual fish catch estimates obtained from the literature (Table 6-1). The difference could be due to the lack of detailed fisheries information available in the literature, particularly for floodplains. It may also be related to the use of continental fish yields in the modelling rather than basin-specific fish yields. However, these metrics may not be readily available for each basin or habitat type. Conversely, this difference could indicate that sufficient fish is caught within the basin to sustain the market demand and populations; therefore, it is unlikely that actual fish catch would reach the modelled theoretical catch as that level of fish catch is not needed. For the Zambezi, the actual fish catch from the literature for rivers (26 805 tonnes) was higher than the modelled potential harvest estimate by area (4 077 tonnes). Fish yield estimates for rivers in Africa were not available for modelling in Lymer *et al.*, (2016), so an average of the estimate for rivers from Asia and South America was used. This may not be reflective of the yields from rivers in Africa. Additionally, the small area recorded for rivers in the Global Lakes and Wetland Database suggests that the area of rivers may be underestimated in this dataset, leading to an underestimation in the final estimates for potential fish catches.

Figure 6-4: The global lakes and wetland database (Lehner and Döll, 2004) indicating different habitat types for the Zambezi River Basin (polygons) and fishery estimates for specific waterbodies (circles, proportional to size).



This case study indicates that actual fish catches in the Zambezi are lower than the modelled potential harvest by habitat type, and that fish yields could be increased in future if it was a desired objective. The relationships examined here emphasize the importance of maintaining healthy river basins through appropriate land use, as well as that sustaining the quality and quantity of water flow through runoff mitigation and enhancement measures is imperative to the current and future provisions of the vital ecosystem services inland water provides (UNEP, 2010).

Sources: Ainsworth, Cowx and Funge-Smith, 2021, 2023; DoF, 2016; Lymer *et al.*, 2016 ; Beard *et al.*, 2011; UNEP, 2010; Lehner and Döll, 2004.

6.3 ASSESSING THREATS TO INLAND FISHERIES AND INLAND AQUATIC ENVIRONMENTS

Across basins and countries with inland fisheries, challenges are experienced in the collection and reporting of capture fisheries statistics (see Chapter 3 of this volume; IUCN, 2022, Pelayo-Villamil *et al.*, 2018; Funge-Smith, 2018). This limits opportunities to prioritize and realize the contribution of inland fisheries in relevant policies and management plans. At the same time, estimates of human-induced impacts on inland waters suggest that more than 65 percent of inland habitat is moderately or highly threatened by anthropogenic stressors (Vörösmarty *et al.*, 2010). Providing an assessment of these threats is essential to identify which inland habitats and fisheries are impacted and provide a basis for monitoring changes over time. However, unlike marine fisheries, there is no standardized method to monitor and assess the status of inland fisheries. While fishing impacts fish stocks, where there are multiple pressures, the greatest threats to inland fisheries come from outside inland fisheries (e.g. Welcomme *et al.*, 2010). As such, an ecosystem approach for inland fisheries requires not only fisheries management interventions but also methods and tools that are consistent with the approach that can identify and provide a basis for addressing these external pressures. Without broader scale and higher-level assessments that are inclusive of the diverse threats facing inland fisheries and associations of relative risk, it remains difficult to track the impacts of climate change, land use and human development on fisheries and prioritize conservation efforts.

6.3.1 Description of the basin assessment methodology

The basin assessment methodology is based on threat mapping, which is increasingly recognized as a useful tool for spatially evaluating the dimensions of threats at a regional and global scale (Das *et al.*, 2016). Such a tool is especially useful in providing robust analysis at a fine scale for expansive, heterogeneous ecosystems (such as freshwater) that vary widely across landscapes. Systematic weighted ranking of the effects of threats to each type and subclassification of ecosystems have been applied successfully to the creation of threat maps for marine and land vulnerability analyses (Halpern *et al.*, 2007). Spatial threat maps can be used as important instruments for policy formation and directing priorities for areas most susceptible to harm (Adger, 2006). The standardized, reproducible assessment of threats and pressures to inland fisheries presented here provides the framework for doing this.

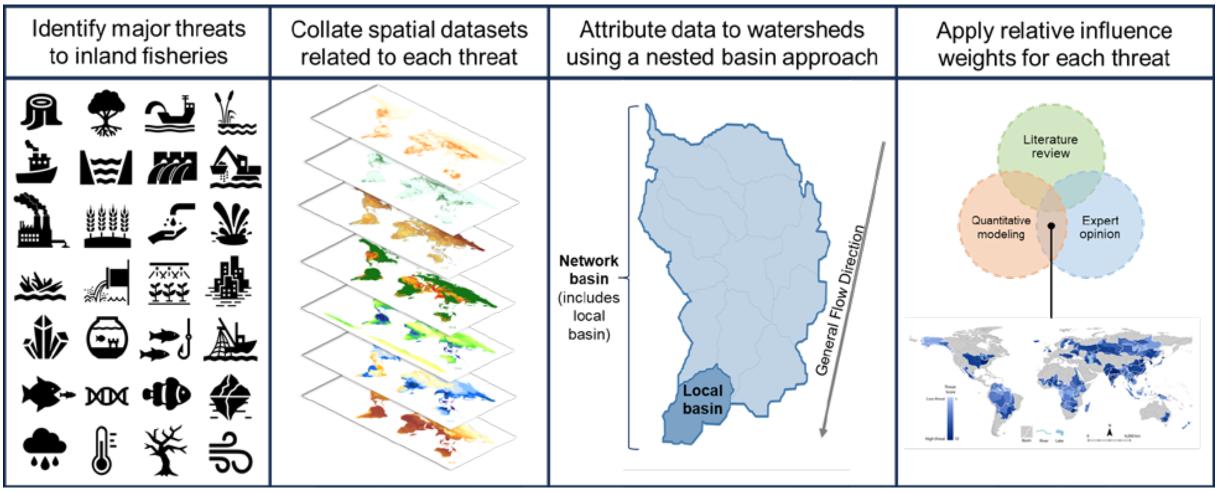
This basin assessment methodology adopts the standard lexicon framework from Salafsky *et al.* (2008) for threat-related terminology, where *contributing factors* are the underlying factors, drivers or root causes that contribute to the occurrence or persistence of threats and *direct threats* are proximate anthropogenic processes or activities that cause *stresses* – degraded ecological attributes (Salafsky *et al.*, 2008). For example, a change in market demands for fish (*contributing factor*) can lead to unsustainable fishing (*direct threat*), which can cause reduced population size or truncated size structure within fish populations (*stresses*). In this work, the focus for mapping threats at a basin level is on the most proximate threats (*direct threats*) and their possible impact on the potential production of inland fish and fisheries. Importantly, the resulting assessments evaluate threats in terms of the impact on inland fisheries habitats and stocks; however, the effect on a given fishery will depend on the nature of the fishery (such as where there are few fishers, the impact on fish may be large but on fisheries may not be as substantial).

This effort utilizes a geospatial and watershed attribution framework method to assess potential threats to inland fisheries and their habitats. This basin threat assessment is implemented using the following steps from Stokes (2022) and shown in Figure 6-5:

- identification of major threats to global inland fisheries;
- collation of open-source geospatial data representative of each type of threat;
- summarization of data into nested hydrological units (basins);
- derivation of relative influence weights of each threat using three discrete sources (literature, expert input and modelling); and
- application of weights to produce maps of individual and composite threats to basins and sub-basins.

Threat mapping allows for the evaluation of the relative threats to inland fishery production at multiple scales from the global level to individual basins or sub-basins (Stokes, 2022). The sub-basin disaggregation shows how different parts of a basin may contribute to its overall threat level, which can assist in identifying focal areas for conservation and ecosystem restoration efforts.

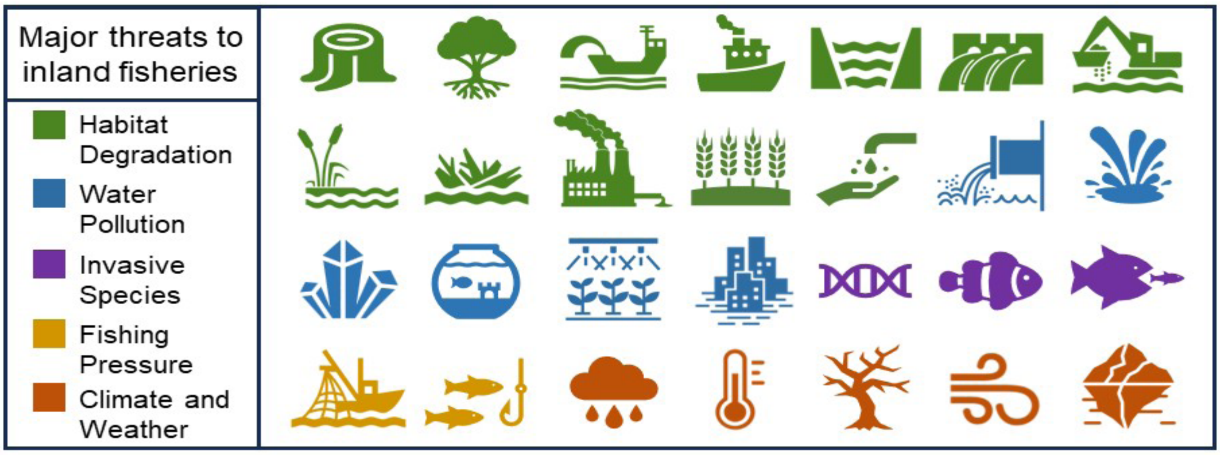
Figure 6-5: Conceptual figure showing the methods used to assess threats to inland fisheries within basins. *Source*: Adapted from Stokes, 2022.



6.3.2 Major threats to inland fisheries

Major external drivers of threats to inland fisheries include demand for energy production, competing demand for water resources, land transformation for agricultural expansion and urbanization, modification of riverways for flood control and navigation, and lack of governance and policy. The resulting threats to inland fish yield and sustainability include altered quantity and timing of water flow from abstraction, runoff and sedimentation from land-use practices, degraded water quality from pollution and eutrophication, altered habitat structure or function (e.g. dams, channelization, groundwater depletion), altered flows and temperatures from climate change, and resource competition or habitat impacts from invasive species (Grill *et al.,* 2019; Arthington *et al.,* 2016; Dudgeon *et al.*, 2006). The effects of these influences are often exacerbated by multiple complex interactions between stressors. For the purposes of basin assessments, threats are classified using five major categories: habitat degradation, water pollution, fishing pressure, invasive species, and climate change (Figure 6-6). The threat-mapping framework identifies 28 major threats to inland fisheries within these categories (Figure 6-6; Stokes *et al.*, 2021), which are described below by respective category; however, many fisheries experience other threats, which may be incorporated on an individual basin or case-by-case basis.

Figure 6-6: The major threats to inland fisheries by category, including threats related to habitat degradation and catchment disturbance (green), impacts to water quality from effluents and water pollution (blue), fishing pressure (yellow), introduced species and problematic native species (purple), and climate-related influences (orange). *Source*: Based on Stokes *et al.*, 2021.



Habitat degradation

Drivers and threats: The threat framework identifies a set of threats related to habitat degradation, catchment disturbance and hydrological connectivity, including deforestation and associated sediment runoff, riparian degradation, dams, channelization, wetland drainage, dredging, weirs and other flood protection, and water abstraction for industrial, agricultural, and urban uses. Primary contributing factors leading to habitat degradation and loss include energy production and mining, land use change for urban and agricultural development, transportation and navigation demands, and flood control – all of which impact habitat structure and function, including longitudinal and lateral connectivity of riverine habitat, water quality, and water quantity (such as the onset, duration and timing of natural flooding cycles).

Potential impacts on fish: Potential impacts on fish from the loss of forest cover and associated sediment runoff can reduce water quality, alter turbidity and change allochthonous inputs. Similarly, riparian loss and degradation from land use change and urbanization can impact the functioning of river or lake systems and biodiversity – from reduction of vegetation important for mitigating runoff and filtering sediment and nutrients, loss of bank stability, diminished energy subsidies (i.e. allochthonous inputs), and altered thermal regulation from decreased vegetative cover. Dams, weirs, and other flood protection can impact fish migration, reproduction and behaviour by altering flow patterns, fragmenting migration corridors, reducing longitudinal and lateral connectivity, reducing sediment inputs, and changing thermal gradients that are important for fish migration, spawning habitat and flood pulse spawning.

Opportunities for mitigation and adaptation: The impacts of deforestation and riparian degradation can be mitigated by improved protection of buffer zones, selective logging techniques that minimize disturbance, and sedimentation reduction measures where necessary. In addition, realization by policymakers of the direct impacts of riparian land use on aquatic environments is an important step towards elevating the importance of addressing catchment disturbance. The impacts of dams and flood protection structure may be mitigated by the construction of fish passages to enable fish movement, controlled and strategically timed flooding of agricultural land (especially at the onset of flood season), and installation of instream structure to create artificial breeding habitat. Further, cooperation with hydroelectric industries, reservoir management authorities and agriculture corporations is important to address issues related to catchment disturbance, drainage, habitat connectivity, and the duration and timing of seasonal flooding.

Water pollution

Drivers and threats: The threat framework identifies eight major threats related to water pollution: agricultural effluents, aquaculture effluents, industrial effluents, urban wastewater, plastics, mining, oil and gas exploration, and pharmaceuticals. While point source and nonpoint source runoff can be challenging to attribute by sector, each type of effluent is distinguished to allow for the potential to highlight cross-sector cooperation and, when possible, better identify the root causes and contributing factors related to degraded water quality. Primary contributing factors related to water pollution include economic development, urbanization, population growth, increased food production demands, expansion of aquaculture production, weak environmental policies or regulations, limited enforcement, and poverty.

Potential impacts on fish: Potential impacts on fish from degraded water quality and water pollution include reduced spawning success, changes in reproduction, changes in fish behaviour, compromised fitness, acute toxicity and, in extreme cases, fish kills. Direct point source discharges can have wider impacts, such as resulting in cumulative toxicity issues for fish. Discharge from industry or mining, as well as land-based runoff from agriculture and urban activities, can lead to eutrophication and excessive macronutrients (such as phosphorus) within catchment scales. Solid waste runoff can increase turbidity and sedimentation. Nutrients and solids from aquaculture runoff can cause anoxic conditions and food web changes from increased turbidity and sedimentation, and pathogens can cause immunosuppression or disease issues. The effects of emerging pressures such as microplastics and pharmaceuticals are less studied but pose substantial threats, including intersex and hormonal changes from endocrine-disrupting chemicals in prescription medications (Jobling and Tyler, 2003).

Opportunities for mitigation and adaptation: The impacts of water pollution can be reduced or mitigated through improved regulatory measures and industry standards, enhanced treatment protocols for aquaculture tank and pond systems, and proper disposal of harmful chemical and plastic waste. When reduction of waste production (including fertilizer and chemical applications) is not feasible, ensuring proper disposal and treatment through monitoring and regulations is essential. Investment in innovative methods of waste management such as recycling mining waste offer cross-sector benefits and cost-saving solutions. For example, advanced technologies for the removal of slurry, sludge and solids from mine tailings and settling tanks offer efficient and easy-to-use alternatives to traditionally complex, costprohibitive removal practices. Opportunities for reducing harmful agriculture effluents include integrated pest management, agroforestry practices, cover cropping, optimization of irrigation and fertiliser practices, and other best management practices for water quality.

Fishing pressure

Drivers and threats: The threat framework identifies two major threats related to fishing pressure: unsustainable levels of fish harvesting and destructive fishing practices. Drivers of unsustainable harvest can include changes in patterns of fishing and increased commercialization of fishing operations. Drivers of destructive fishing practices include the use of damaging fishing gears, which may occur in commercial, subsistence or recreational fishing.

Potential impacts on fish: Potential impacts on fish from unsustainable harvest and destructive fishing practices include population size being reduced below biologically safe levels, trophic shifts, changes to size structure, and changes to species composition. Explosives or poisons used for fishing may cause habitat destruction, have toxic effects on fish, or impact stock recruitment. Fish assemblage and size structure changes from fishing activities are well-documented across types of fisheries.

Opportunities for mitigation and adaptation: Drivers of fishing pressure vary and addressing these can involve complex governance, socio-economic, or enforcement issues related to trust, social capital, agency, fishing infrastructure, and alternative livelihood opportunities. Cooperative development of fishing regulations and community-based fisheries management have proven effective in some areas. Additionally, adoption of the ecosystem approach to fisheries provides the means to identify the drivers associated with fishing activities and begin to address them.

Invasive species

Drivers and threats: The threat framework identifies three major threats related to invasive species: introduced invasive, alien, or non-native species; problematic native species; and introduced genetic material. Contributing factors to introduced or problematic species include intentional stocking and release (such as aquaculture, enhancement, biological control), unintentional stocking and release (such as bait bucket releases, ballast water from shipping, escape from fish farms or ornamental trade), and invasive plants or macrophytes (examples include pasture grass and water hyacinth). It is important to note, however, that there are cases where invasive or non-native fish species pose a threat to biodiversity but positively contribute to food security or recreational fishing opportunities.

Potential impacts on fish: Potential impacts on fish from invasive or problematic species include competition for food or habitat resources, hybridization, reduced fitness, and reduced native populations. Invasive plants can outcompete native species and disrupt hydrology and habitat structure. Fish introductions can alter trophic web dynamics and reduce the abundance of native species through predation, competition for resources, hybridization, and parasitism. They can alter community structure and function including nutrient cycling, food web structure, and energy flow.

Opportunities for mitigation and adaptation: Possible mitigation measures for addressing invasive and problematic species include enhanced biosecurity practices, aquaculture zoning away from sensitive habitats, guidelines for responsible aquaculture and stocking practices, and targeted eradication when possible. Education and awareness campaigns can also play an important role in improving understanding of the potential or realized risks and mitigation strategies.

Climate and weather

Drivers and threats: The threat framework identifies five major threats related to climate and weather: change in water temperature, change in flooding, change in wind patterns, drought, and change in ice cover. Drivers of global climate change are primarily linked to anthropogenic activities and greenhouse gas emissions. Shifting climate regimes associated with alterations to global precipitation, runoff patterns, and evapotranspiration rates are predicted to cause: changes to the duration, onset and timing of the hydrological regimes of natural river–floodplain systems; changes to the onset and duration of ice cover in lakes; changes in the frequency and intensity of precipitation events; warming water temperatures; and changes in wind patterns leading to impacts on the timing and duration of lake stratification.

Potential impacts on fish: Potential impacts on fish from changes in climate and weather patterns include increased mortality, changes in movement patterns, changes in reproductive success, population decreases, and changes in growth. Hydrological intensification, including longer and more severe droughts and more intense and frequent storm events, may lead to restricted habitat availability, loss of connectivity, reduced recruitment, and altered migration patterns. Warming waters may impact fish range and distribution patterns, reproductive success, and metabolic function. Change in ice cover may increase the risk of egg mortality for overwintering eggs and may increase fishing pressure with earlier onset ice-off.

Opportunities for mitigation and adaptation: The Resist-Accept-Direct (RAD) framework offers a means to respond in the context of rapidly changing fisheries and aquatic environments, in which managers and those dependent on inland fisheries can *resist* changes through mitigation actions aimed at offsetting the impacts of changes, *accept* changes by managing systems as they change, or *direct* changes towards fostering ecosystem health under future conditions (Rahel and Lynch, 2022). This framework can serve as a useful tool to address uncertainty and risk associated with freshwater ecosystem transformations.

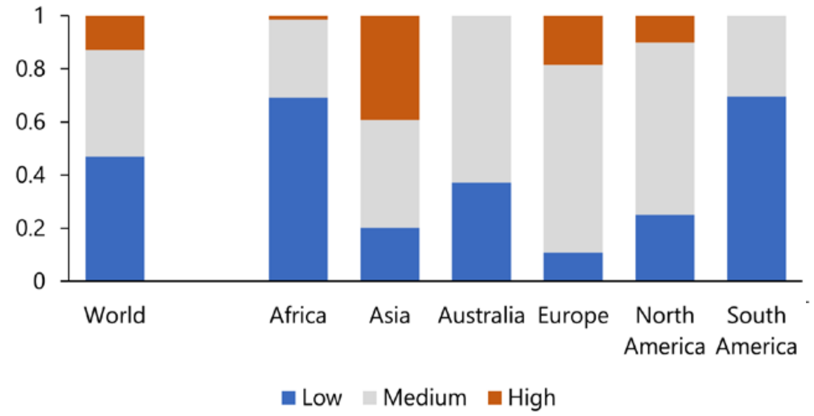
6.6.3 Basin-scale assessment of threats to inland fisheries

The basin assessment methodology can be an effective method to illuminate patterns of threats within a basin to prioritize responses as well as helping to provide a baseline from which changes can be monitored (Stokes, 2022). In the context of multiple and increasing threats, it allows for examination of individual threats, categories of threats (habitat degradation, pollution, fishing pressure, invasive species, climate change) and overall composite threat.

Global patterns of threat to inland fisheries

Results from the latest aggregate global assessment prepared for this circular show that, when binned using pressure bin sizes of 3–4 on a total threat scale of 1–10, approximately 47 percent of all global basins are under *low threat,* approximately 40 percent are under *moderate threat* and 13 percent are under *high threat* (Figure 6-7). However, it is important to note that while these numbers may be useful for understanding larger patterns, they are highly dependent on the way in which the distribution of data is categorized (binned). For example, if scores are binned in an alternate manner (i.e. *low* = 1–2, *moderate* = 3–7, *high* = 8–10), these results would suggest that 31 percent of major inland fisheries are under *low threat*, 56 percent under *moderate threat*, and 13 percent under *high threat*. Therefore, caution must be used when categorizing threats to summarize global threats.

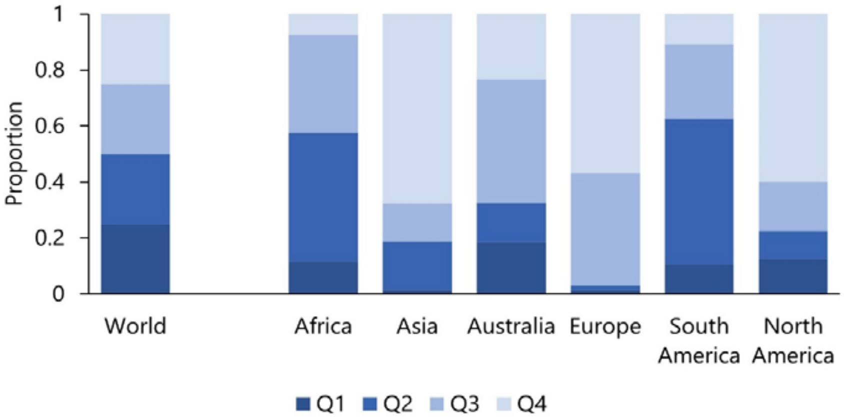
Figure 6-7: The proportion of major inland fisheries by pressure bins (*low* = 1–3, *moderate* = 4–7, *high* = 8–10) and summarized by continent using a scale of 1-10 where 1 indicates the lowest threat and 10 indicates the highest potential threat.



Source: Authors' own elaboration of threat data.

Instead, a useful way to understanding threats to inland fisheries is using quartiles, which provides a less biased and more objective interpretation of the distribution of threat scores globally. Using this method, major inland fisheries important to fish production (Ainsworth, Cowx and Funge-Smith, 2023) show higher than average threat, especially in Asia, Europe, and North America (Figure 6-8). In this method, all continental aggregations of major fisheries score below the average for quartile 1; Asia, Australia, Europe, and North America for Quartile 2; Africa, Australia, Europe, and South America for Quartile 3; and Asia, Europe, and North America for Quartile 4.

Figure 6-8: The proportion of major inland fisheries by pressure quartile (Q; shade of blue) and continent, in contrast to global distribution of threat scores for all basins ("World"). Q1 is the lowest threat quartile and Q4 the highest.

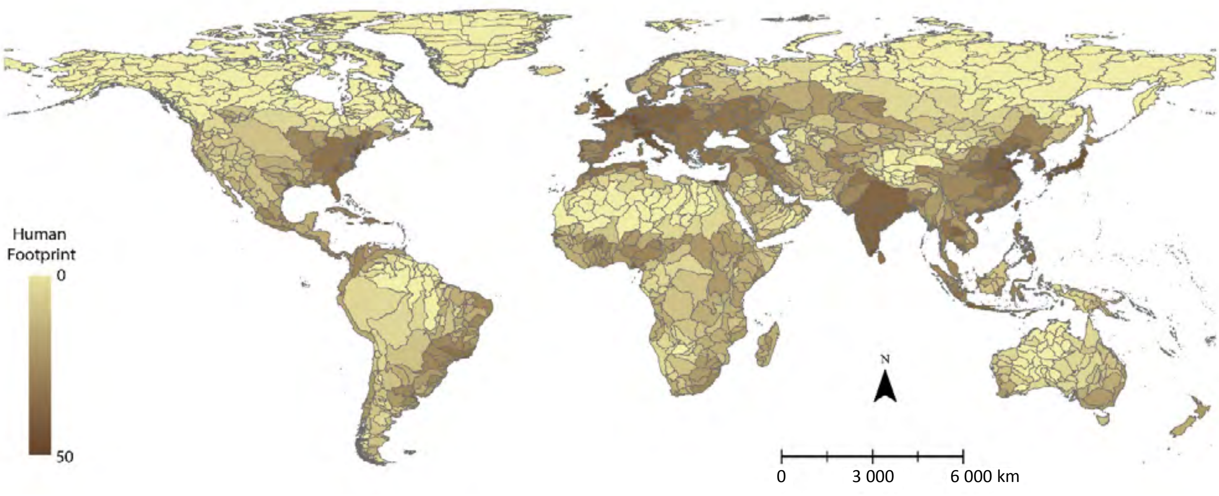


Source: Authors' own elaboration of threat data.

In terms of the spatial distribution of threats, unsurprisingly, the presence and severity of threats are closely associated with the presence and density of humans (Figure 6-9). Pressures resulting from habitat degradation and alteration pose substantial concerns globally, especially altered hydrological conditions from hydropower development (Figure 6-10) and altered physical conditions from land use change. Other emerging threats, such as impacts from pharmaceutical inputs and microplastic pollution (Reid *et al.*, 2019), follow human population trends but lack robust spatial information to detect localized trends. In some localities, however, not all changes appear to be overwhelmingly negative. In the United States of America, for example, land use change in riparian zones appears to be having a positive effect, with some signs of effective riparian protections such as decreased developed open space, barren land, urbanization, and agricultural activities in riparian areas (Stokes *et al.*, 2021). However, urbanization intensity is the greatest in lowest order streams, which may signal an increase of human distance in headwater streams, and forest composition has shifted from more deciduous forests to mixed forests, scrub forests and grasslands (Stokes *et al.*, 2021).

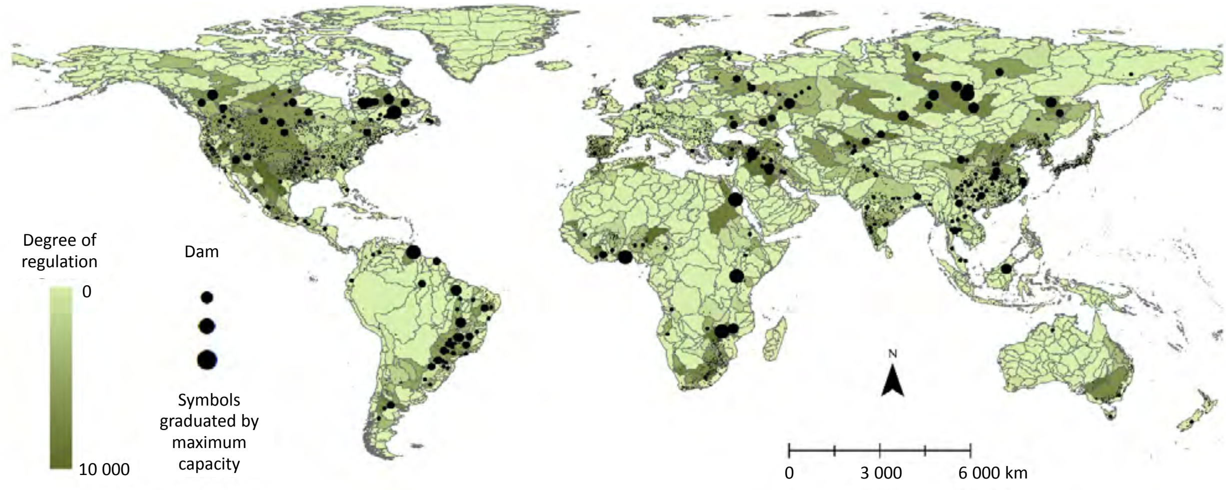
Existing indices (e.g. Human Footprint in Venter *et al.*, 2016) show some associations with level of threat to inland fisheries (Figure 6-10). Some threats are integrally linked with the presence of other natural resources (such as mineral deposits, shale or oil reserves), which mean their impacts are highly localized or regionalized but may still have downstream cumulative effects. For example, high intensity of irrigated areas, which amplifies the potential for threat impacts from agricultural water use, is relatively concentrated within certain global regions (Figure 6-11). Similarly, impacts from some climate-related factors (such as change in wind patterns or change in ice cover) are also highly regionalized. For example, lakes in the northern latitudes are most likely to be impacted by later freezing, earlier ice break-up and shorter ice duration (Wang *et al.*, 2022). Climate impacts follow predicted patterns of temperature and precipitation impacts. For freshwater fish and fisheries, however, impacts from increasing water temperature are predicted to be much more severe and more widely distributed than impacts from changes in stream flow (Barbarossa *et al.*, 2021). With acute or rapid onset threats, there is evidence that threat impacts are widely mixed but in the case of the COVID-19 pandemic, for example, basins with higher provisioning value (that is, supporting larger subsistence fisheries) were at least perceived to experience greater fishery pressures (Stokes *et al.*, 2020). Collectively, the analysis at the global scale suggests that nearly all inland fisheries are threatened by more than one stressor, and most are threatened by numerous stressors (Stokes *et al.*, 2021).

Figure 6-9: Human footprint (Venter *et al.*, 2016) by basins (Level 4 HydroBASINS), scaled by intensifying human influence on terrestrial ecosystems (0–50 continuous scale), which can be used as a predictor of cumulative human pressures and is based on eight variables (extent of built environments, crop land, pastureland, human population density, night-time lights, roads, and navigable waterways).



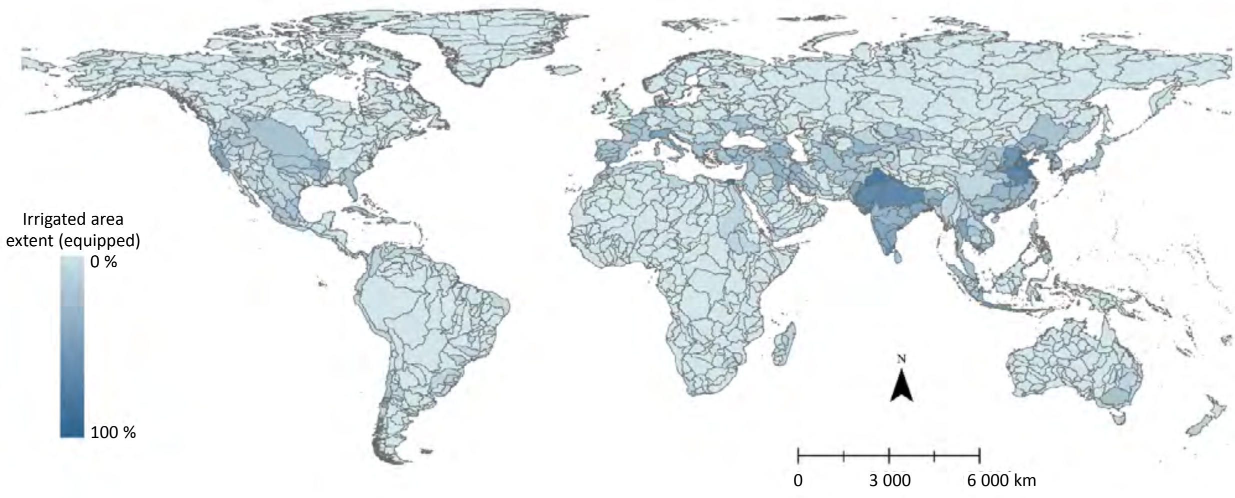
Sources: Data from the Human Footprint database (Venter *et al.*, 2016) have been used in the spatial format of HydroATLAS v1.0 (Linke *et al.* 2019) under a Creative Commons Attribution 4.0 International Licence (CC-BY-4.0).

Figure 6-10: Degree of regulation (DOR) by dams (green) and dams (graduated symbols by capacity) by basins (Level 4 HydroBASINS)



Sources: Authors' own elaboration. Where DOR data (Lehner *et al.,* 2011) have been used in the spatial format of HydroATLAS v1.0 (Linke *et al.* 2019) under a Creative Commons Attribution 4.0 International Licence (CC-BY-4.0).

Figure 6-11: Extent of irrigated land from 1900 to 2005 by basins (Level 4 HydroBASINS)



Sources: Authors' own elaboration using irrigation data from the Historical Irrigation Data (HID) version 1.0 dataset (Siebert *et al.* 2015) which have been used in the spatial format of HydroATLAS v1.0 (Linke *et al.* 2019) under a Creative Commons Attribution 4.0 International Licence (CC-BY-4.0).

Downscaling

Employing the basin threat assessment at a global scale provides a framework with which to compare basins around the world and the relative influence of individuals threats and threats by major categories. However, downscaling to individual basins can provide assessments across metrics of interest that can be used by national or basin level management authorities. These include metrics directly related to threats and pressures, such as the percentage of forest loss, number of dams under operation, proportion of species projected to be impacted by water temperature increases, and other non-threat metrics that may be useful for fishery managers (for example, the proportion of basin area considered to be protected area, the volume and length of lakes and rivers, and the number of species documented in the basin).

Examples are provided in this chapter of assessments for four basins where assessments have been developed with direct input from local experts (Lake Malawi along with the Mekong, Magdalena, and Senegal river basins) designated as basins of interest by experts. The Lake Malawi basin provides an example of a large transboundary lake body and the use of participatory mapping to visualize the influence of threats inside a large lake system. The Mekong River basin provides an example of a large, transboundary river–floodplain system with highly migratory fish species and a dynamic flood pulse hydrological cycle. The Magdalena River basin provides an example of a mid-size, well-studied tropical river experiencing high population density and rapid land use change. The Senegal River basin provides an example of a large, multi-species subtropical fishery where water infrastructure poses substantial concern.

Basin reports

Using global spatial data and localized input from experts, basin reports can be produced for any basin in the world. Reports can be customized to user preferences, needs and interests and are designed to provide an overview of the status of a fishery within a specified basin. In this chapter, we provide a basin summary report for each of the selected basins to demonstrate the utility of incorporating local weights based on expert knowledge and incorporating expert-derived maps from participatory mapping. These maps are intended to demonstrate the utility for basinlevel mapping and the information gained from downscaling global weights by local expert input. We note that these have been produced using input from a subset of experts. Additional expert input may further enhance the resolution and accuracy of threat maps and threat rankings.

For each basin, we first provide a descriptive summary of basin and fishery characteristics and documented threats to the fishery. Each basin report contains the following information:

- basin overview;
- key pressures;
- threat rankings;
- a threat map of the basin; and
- detailed spatial examination of key pressures.

The overview section includes catchment, lake, and river metrics; fish species diversity; estimated annual catch; and pertinent fishery dependence metrics. Key pressures highlight the primary four to five threats to the basin, as indicated by experts, using the established threat categories. Figure 6-12 and Figure 6-13 demonstrate the utility of threat mapping across the entire basin area; Figure 6-14 and Figure 6-15 demonstrate the utility of examining threats only where there may be fisheries (meaning, only where lakes or rivers are found). The latter may be particularly useful for basins with large arid areas or where a substantial part of the basin does not foster fish production.

Threat rankings are derived by local experts using an electronic survey. To indicate the influence of each threat on an individual fishery, experts assigned points (100 total) to all threats present in their fishery. Respondents indicated any threats not listed as "other" and were provided the option to input the type of threat. Average threat scores were calculated as the mean of each threat across all respondents, rescaled from 0 to 1. Average threat scores ("weights") are shown as a bar chart by the threat of greatest influence to the threat of least influence. The basin threat map (found in the centre of each basin report) visualizes threat within the basin of interest. Unlike the global map, which applies uniform threat scores to spatial input data to estimate threat across all basins, the basin threat maps use participatory mapping as a tool for local managers and experts to convey their understanding of threat in each basin. This serves as a useful comparison to the globally derived maps and can be a way of "ground truthing" the global estimates.

Finally, the righthand panel on each report shows spatial and statistics details about threats of high importance. Selected threats were chosen based on threat weights and examination of the threat map. Spatial processing tools (such as zonal statistics) provide an opportunity to summarize information on individual threats using remotely sensed data, which may otherwise be impossible or impractical to summarize. For example, using gridded climate prediction data examining projected impacts to fish species, it is possible to calculate the proportion of species that may be affected by warming temperature and extreme flows until various climate scenarios (see *Lake Malawi*). Summarized information on threats of high importance can allow managers or policy makers to visualize current or projected impacts, consider various mitigation opportunities, and track changes over time. Ultimately, incorporating expert input alongside spatially derived products and summarized threat data leverages the strengths of both sources to provide the best available information.

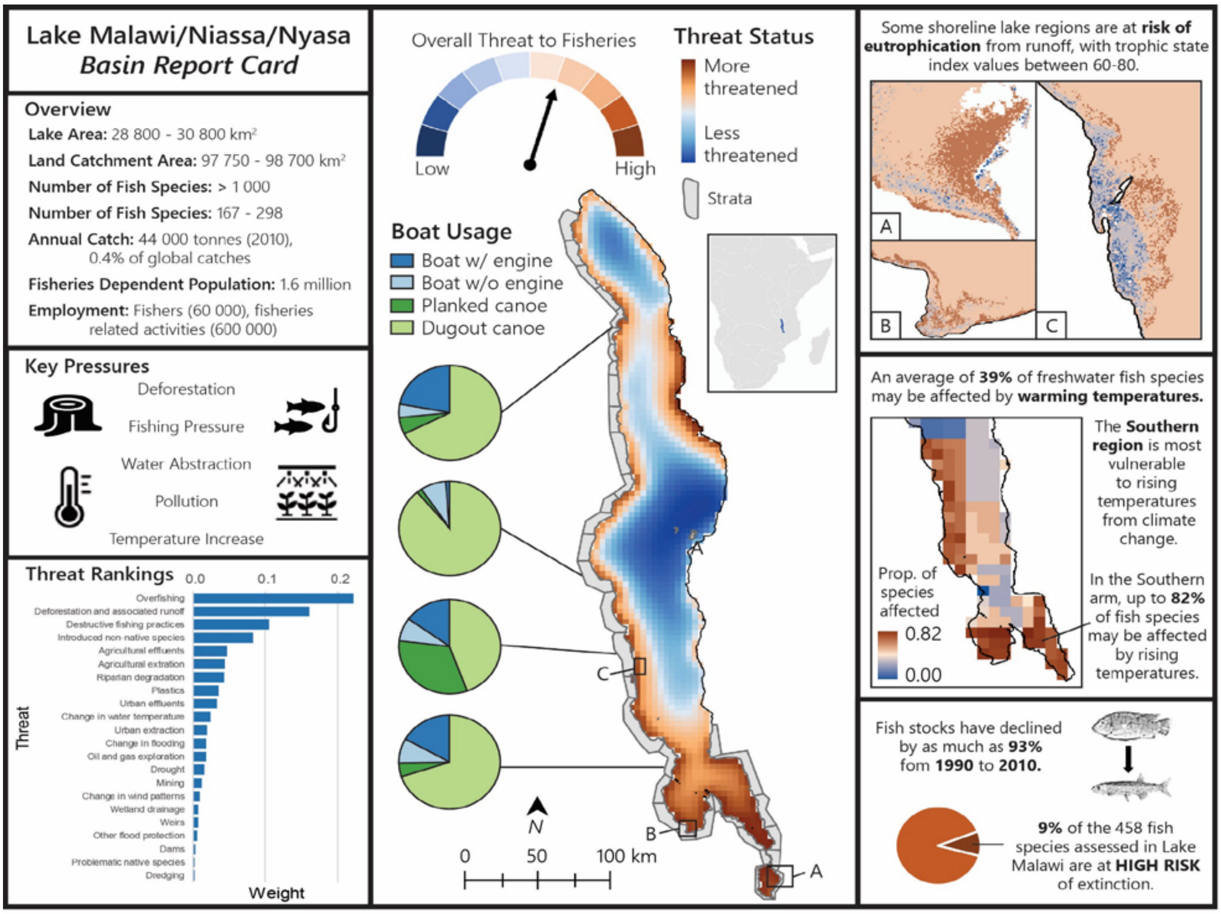
LAKE MALAWI

Basin and fishery description: The waterbody is known as Lake Malawi in Malawi, Nissa in Mozambique and Nyasa in the United Republic of Tanzania. Lake Malawi is the third-deepest (maximum depth 700 m, mean depth 264 m) and ninth-largest lake by surface area (28 800–30 800 km^2). The lake is permanently stratified into three layers, being anoxic below depth of about 170–200 metres (Weyl, Ribbink and Tweddle, 2010). Lake Malawi is the most species-rich lake in the world, containing about 800 species. There are 14 families of fish, of which 90 percent are cichlids and 99 percent of those are endemic (Ribbink, 2001).

The export of live fish for the aquarium trade provides an important source of employment and revenue for the local economy, but most of Lake Malawi's fish is harvested for food by industrial and artisanal fisheries (Weyl, Ribbink and Tweddle, 2010). The artisanal fishery comprises of more than 180 species (Irvine *et al.*, 2002). Assessing the status of one of the most species rich lakes in the world, is complicated by the multi-species nature of the fishery. It is estimated the annual catches from Lake Malawi could be about 80 000 tonnes, but at least 30 000–40 000 tonnes are harvested from Malawi (Weyl, Ribbink and Tweddle, 2010).

Observed threats: Lake Malawi is weakly stratified during the cold season, and climate change-induced warming of surface waters could reduce the vertical mixing of the lake (Vollmer, 2002). This could result in less nutrient supply, plankton production and a subsequent decline in fish production (Bootsma and Jørgensen, 2005). Unsustainable fishing is not considered an issue in the Mozambican and Tanzanian waters of Lake Malawi but is considered an issue in Malawi (Bootsma and Jørgensen, 2005). Even though annual catches have remained relatively stable at around 30 000 tonnes, Weyl, Ribbik and Tweddle (2010) believed catches had largely been maintained through increased fishing effort and the use of smaller mesh sizes, together resulting in a decline in CPUE.

Figure 6-12. Lake Malawi basin report card showing key pressures, threat rankings, and spatial distribution of major threats.



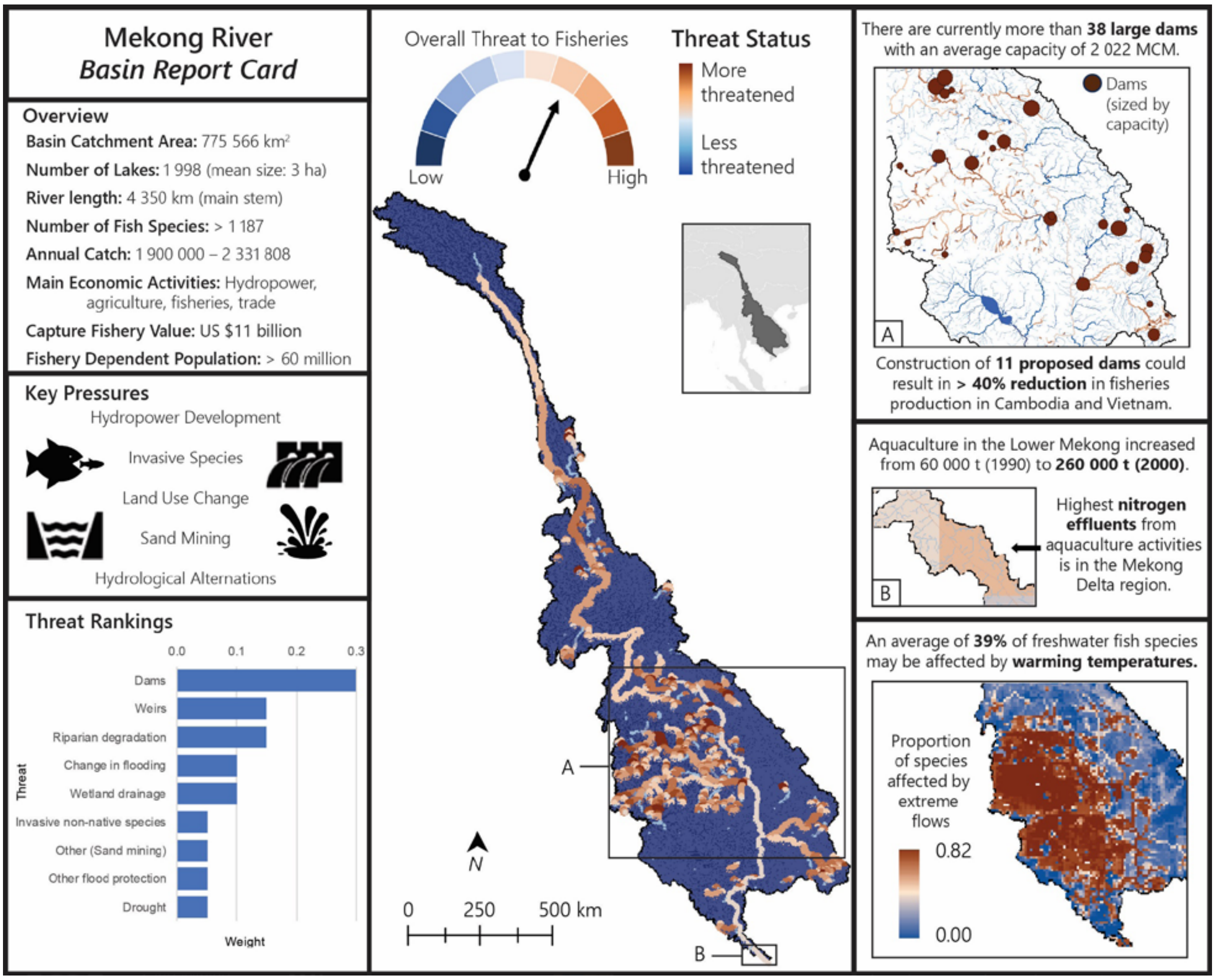
MEKONG RIVER

Basin and fishery description: The Mekong is the tenth-largest river in the world and flows through a wide range of diverse topography. The Tibetan Plateau, Three Rivers Area and Lancang Basin form the Upper Mekong Basin. The Northern Highlands, Khorat Plateau, Tonle Sap Basin and Mekong Delta make up the Lower Mekong Basin (MRC, 2024). Fish biodiversity is high with between 801 and 1 200 species within the basin, owing to the complex geology, terrain and flow conditions (Coates *et al.*, 2003)

The fishery of the Lower Mekong Basin (LMB) is considered the world's largest, and the diversity of species and habitats gives rise to the use of a wider range of different gear and fishing activities (Welcomme, 2001). Participation in fishing activities is high and it is estimated 64–93 percent of rural households in the LMB are involved in fisheries (Coates *et al.*, 2005) and more than 40 million people are classed as dependent or engaged in fisheries (World Bank, 2012). The fishery in the LMB is worth about USD 17 billion per year (Nam *et al.*, 2015), but most fish are caught by small-scale subsistence fishers and do not enter formal market chains (Lynch *et al.*, 2016). Of the up to 1 200 species between 10 to 20 species are believed to make up much of the catch (Coates *et al.*, 2003, 2005). It is difficult to ascertain accurate catch information as large-scale surveys are often unreliable because of the difficulty in covering the huge diversity of gear and fishers across such a large region (Hortle, 2009; Chapter 3, this volume).

Observed threats: The fisheries of the Mekong basin face a range of threats. Dams have been identified as a key threat to fisheries in the basin. There are currently 371 dams in operation or under construction along the Mekong and a further 98 dams are planned or proposed for the basin (Winemiller *et al.*, 2016). The ecological impact of dams is through the loss of connectivity between important life stage habitats and alterations of river flow and change from a principally lotic to an increasingly lentic system (Pelicice, Pompeu and Agostinbo, 2015), which would impact 90 percent of species which have flow related migration triggers (Baran, 2006). With renewed interest in hydropower development, hydropower dams have emerged as the biggest threat to fisheries in the Mekong River Basin, particularly for migrant species. Fisheries developed in the associated reservoirs would be unlikely to compensate for lost fish production, with reservoir fisheries predicted to only replace about 10 percent of the capture fishery (ICEM, 2010). Indeed, modelled predictions estimate that development of 11 mainstream hydropower dams would lead to reduction in fish yield of 238 377 tonnes in Cambodia and 358 514 tonnes in Viet Nam (DHI and HDR, 2017).

Figure 6-13. Mekong River basin report card showing key pressures, threat rankings, and spatial distribution of major threats.



SENEGAL RIVER

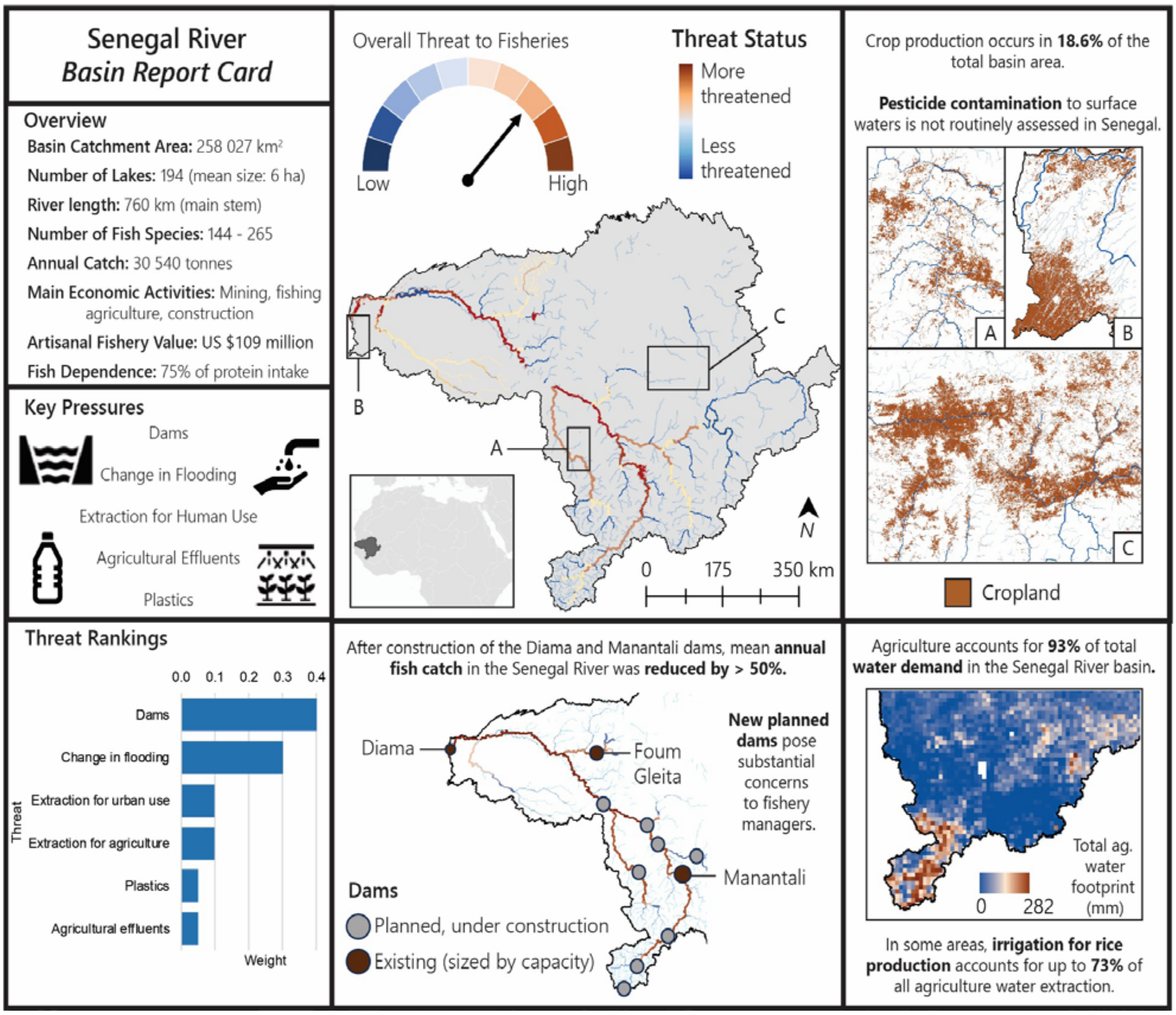
Basin and fishery description: The Senegal River is the second largest river in West Africa after the Niger River and is principally located in the Sahelian zone, an area particularly sensitive to the effects of climate change. The Bafing River is the largest tributary of the Senegal River (760 km long) and most of the water supply comes from the Bafing, which rises in the Guinean zone where rainfall is much higher than the average for the basin. The Bafing is dammed by the Manantali (Mali) dam. The Senegal River basin can be categorized into three sections: The Upper Basin, The Valley, which forms a 10–20 km long floodplain, and The Delta (AU-IBAR, 2015).

There are 144 described species in the Senegal River, two species are endemic; *Enteromius ditinensis* and *Synodontis tourei*, and there are no documented fish introductions (Froese and Pauly, 2023). Fishing is the second largest economic activity after agriculture within the basin and makes a significant contribution to food security and nutrition, employment, and export revenue to member states. The volume of catch largely depends on the water level of the floodplain in The Valley, and catch composition comprises around 20 species, which account for 90 percent of the landings. Annual fishery estimates of between 26 000 and 47 000 tonnes have been suggested by The United Nations Educational, Scientific and Cultural Organization's World Water Assessment Programme (UNESCO-WWAP, 2003), Cheikh Oumar *et al.* (2006), Nieland and Béné (2008) and the African Union – Interafrican Bureau for Animal Resources (AU-IBAR, 2015).

Observed threats: The construction of dams within the Senegal basin has meant the basin has become increasingly engineered (Dumas *et al.*, 2010). Increased levels of salinity downstream of the Diama Dam in the delta region have led to a decline of between 50–70 percent of fish stocks (AU-IBAR, 2015). There are currently four dams in operation (Manantali, Gouina, Felou and Gourbassi), one dam under construction (Koukoutamba), and two upstream dams under study (P. Tous, pers. comm). The construction of the dams has disrupted the annual flood cycle on the river and led to a decline in the number of fishers, and the production of the fishery has declined (N'Diaye, Bouvier and Waaub, 2007). Even though there was a redistribution of fishing effort to the newly formed reservoirs, catches from the Valley floodplain have declined, with an annual net loss of 11 250 tonnes (AU-IBAR, 2015).

Water management at the Manantali dam is a major livelihood issue in the valley. The current management model favours power generation and does not allow for artificial flooding, which drastically reduces the productivity of fishing and traditional agriculture. The flooding of the Valley floodplain currently depends exclusively on excess rainfall in the other sub-basins, particularly those of the Falémé and the right bank tributaries which are in Mauritania. Currently, only 18 percent of the plain is flooded each year. According to Bruckmann *et al.* (2021), the September flood must exceed a peak flow of 3 000 m^3/s to flood 100 000 ha, which corresponds to about 50 000 ha of cultivated land in the Valley floodplain of the Senegal River and would enable the production of several thousand tonnes of additional fish.

Figure 6-14. Senegal River basin report card showing key pressures, threat rankings, and spatial distribution of major threats.



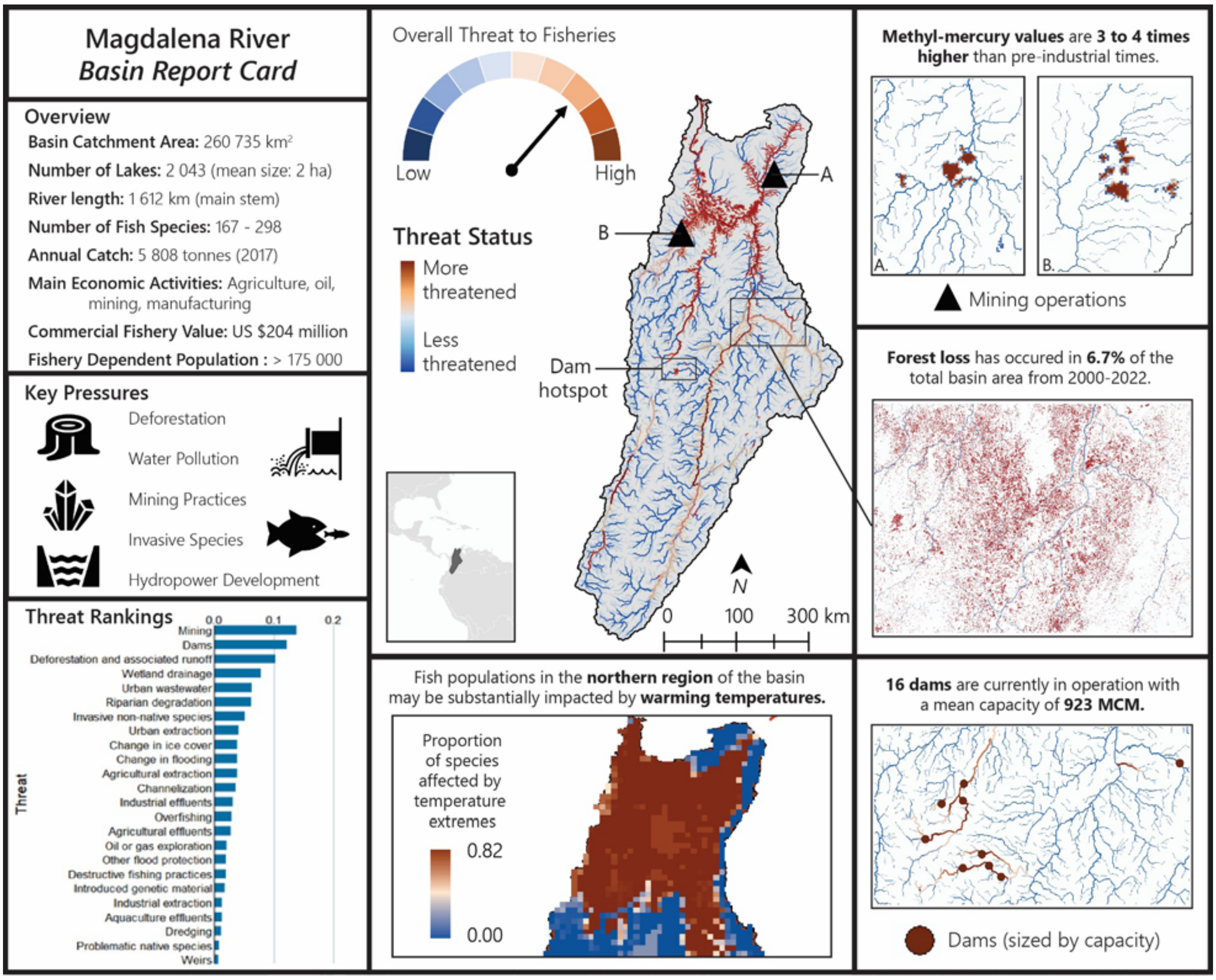
MAGDALENA RIVER

Basin and fishery description: The Magdalena River traverses Columbia from North to South, with a length of 1 612 km and discharge volume of 7 100 m^3/s and runs between the Central and Eastern Andes mountain range. The Magdalena Basin covers 24 percent of the territory in Colombia, supports the largest fishery in Columbia, and is densely populated by 80 percent of Colombia's population (Galvis and Mojica, 2007). The river consists of three major tributaries; the Cauca, Sogamoso and San Jorge rivers, and can be separated in three topographic areas; the Upper, Middle and Lower Magdalena Valley. The Lower Magdalena Valley supports an expensive floodplain covering an estimated 22 000 km^2.

There are between 144–213 fish species in the Magdalena basin (Barletta *et al.*, 2016; Froese and Pauly, 2023), and endemism is high with 55 percent of species endemic to the basin (Barletta *et al.*, 2016). The Magdalena Basin constitutes 55 percent of the inland capture fisheries production in Colombia and supports 35 000 fishers (Mojica, 2002). The main fish species in the fisheries are from the families Prochilodontidae and Pimelodidae, which are caught by part- and full-time fishers (Barletta, *et al.*, 2016). Fish catches have declined, and the catch composition has changed progressively since the 1970s, when annual catches were estimated at between 60 000–80 000 tonnes (Galvis and Mojica, 2007). A drought caused by El Niño caused a further decline in catches in the early 2000s, but catches have since stabilized (SEPEC, 2017).

Observed threats: Agricultural expansion has led to the loss of 55 percent of the basin's forest cover (Cormagdalena, 2001), deforestation continues at an annual rate of 2 percent (Restrepo and Restrepo, 2005), and more than 2 000 km^2 of floodplains have also been drained (DNP and FAO, 2003). This has led to a loss of nursery habitats and increase in sedimentation that has clogged channels and lagoons in the lower valleys (Barletta *et al.*, 2016). Due to an expansion in agriculture and mining within the basin, there has been an increase in levels of organic, heavy metal and agricultural pollution. Gold mining has been responsible for introduction of mercury, cyanide, lead, zinc and copper in the river (Barletta *et al.*, 2016), and mercury accumulation in fish was above accepted levels for human consumption (DNP and FAO, 2003).

Figure 6-15. Magdalena River basin report card showing key pressures, threat rankings, and spatial distribution of major threats.



6.4 OPPORTUNITIES FOR TRACKING TRENDS IN INLAND FISHERIES

The threat framework presented in this chapter leverages remote sensing tools for understanding threats with improved spatial and temporal resolution and for tracking emerging threats. Remote sensing technologies, including satellite imagery, and the resulting publicly available geospatial data products have become essential for evaluating global environmental change and advancing biodiversity conservation. When paired with *in situ* measurements and field-based data, remote sensing can serve as a powerful monitoring tool (e.g. Zong *et al.*, 2023). Rapid developments in the resolution, coverage and diversity of indicators that can be derived from remotely sensed data will continue to enhance the utility of this work directly for fisheries indicators but also more broadly in examining fisheries biodiversity and projected changes to fish habitats. It is designed in a way that can be built upon as these technologies emerge and offers potential for integration into user-interface platforms or applications, which are currently under consideration for development.

6.4.1 Utility of a basin monitoring tool

During the United Nations Decade of Restoration, environmental managers are seeking ways to restore and conserve biodiversity. The conservation, protection and restoration of freshwater environments is essential for food security, poverty alleviation, clean water, and livelihood provisioning; therefore, a balance is needed between sustainable harvesting of aquatic foods whilst also protecting biodiversity. Understanding how inland fisheries are influenced by external pressures and which basins are most vulnerable is an integral component to addressing this intersection (Lynch *et al.*, 2017).

At a global level, the basin threat mapping tool provides a consistent assessment framework for inland fisheries, and the associated ecosystems upon which they depend, and provides a visual and quantifiable indication of the relative threats to inland fisheries at the basin, sub-basin, and fishery levels. This system can operate as a tracking tool for basins to allow countries to assess the status of their inland fisheries at low cost, which would enable them to plan for future needs in management, food security, livelihoods, and recreational activities, and would provide a measure of progress towards the UN Sustainable Development Goals (FAO, 2021). One advantage of this framework is that because it uses only publicly available data with global coverage, countries and stakeholders with limited capacity may still be able to monitor fisheries and report data to FAO, or against policy goals, such as the SDGs or Global Biodiversity Framework (GBF) targets.

At a basin scale this tool has the potential to be applicable to a wide range of stakeholders including researchers, fisheries managers, policy makers, basin organizations (or basin managers) and stakeholders from other wateruser groups. This tool also has use as part of Environmental Impact Assessments (EIA) to establish a baseline of the current status of a basin, including land use, deforestation and pollution, ahead of any proposed development within a basin. The ability for local basin fishery experts and managers to apply their own threat weights and fish catch data, based on their local knowledge, ensures that the tool is applicable at the local scale at which fishery managers will be working. This tool is low maintenance, requiring little additional effort for use and minimal upkeep over time. Higherresolution spatial data may be incorporated as it becomes available. For basins that include “sentinel” fisheries or are part of a sentinel fisheries programme (Section 6.4.2), that provide regular monitoring the threat mapping tool could be updated more often to provide real-time tracking of these important basin fisheries. This will ensure that the threat mapping tool will remain relevant over a long period.

More broadly, the data products and framework used for the threat assessment may be useful if integrated with similar interfaces or tools for watershed management across sectors. For example, the System for Earth Observations, Data Access, Processing and Analysis for Land Monitoring (SEPAL) is a big-data platform developed by FAO for forest and land monitoring through interactive exploration of satellite data in a user-friendly interface. Aligned with the priority for integrated resources management, collaborative efforts that build upon existing platforms may offer a novel way to support land use and water use policies.

6.4.2 Conceptualization of indicator and “sentinel” fisheries

It is well established that sufficient and regular monitoring of all inland fisheries is not feasible (Beard *et al.*, 2011). Instead, indicator fisheries can act as barometers for similar, but less wellmonitored fisheries in the same region and can provide a costeffective realtime management and condition assessment of fisheries within a basin (Henry *et al.*, 2020). There are few examples of indicator fishery surveys being used in inland waters, although some species have been used as indicators of regional stock status or as indicators of environmental disturbance in freshwater ecosystems (ICES, 2018, Christophe, Rachid and Mario, 2015; Gibbons and Munkittriek, 1994). Combining a set of indicator fisheries or using particular species within a subset of river basins, or elements of a fishery developed under a "sentinel" fishery monitoring programme, could provide much needed continuous records of otherwise data-poor fisheries and indicate the overall state and health of a basin and its fisheries (Ainsworth, Cowx and Funge-Smith, 2023).

Basins developed under a "sentinel" fisheries programme can be integrated within the basin monitoring tool (Section 6.4). Indicator fisheries can help address the limitations of national aggregated catch data and help to inform conservation priorities by identifying the impact and extent of basin threats, biodiversity hotspots, important areas of fish production, and future pressures using threat predictions. Factors that may influence the selection and utility of a basin as an indicator or possible "sentinel" fishery – that is, one that can be used in systematic monitoring – include: the availability of robust standardized fisheries data (for example total catch by species, catch per unit effort of primary gears, change in species composition of catch and size of fish caught); the presence of a well-documented species that can serve as a candidate indicator species, such as "index" salmon rivers in the ICES region (ICES, 2021); and cultural significance of the species and the availability of local and traditional knowledge, especially in data-poor situations.

Other factors that could also be considered in the selection of indicator and "sentinel" fisheries, used to suggest a subset of priority basins in Ainsworth, Cowx and Funge-Smith (2023) are:

- the contribution of a fishery to food security and nutrition;
- high levels of employment provided by the fishery;
- multiple and single species fisheries occurring together; and
- where the impacts of threats are predicted to impact the fishery.

This could provide the basis for a network of basins and fisheries that could be regularly monitored. In addition, such a network should encompass a wide geographic range – and consist of various habitat types – as well as be a good representation of other inland fisheries within the same region. This would provide opportunities for assessment at broader scales. To be effective, indicator fisheries should be linked to management processes. While not available for every basin, this could include basin management bodies that could assist in the collection of data and facilitate discussions between different water-use sectors to improve a basin's fishery and water resources.

6.4.3 Utility to support global policies, goals and targets

Despite their importance, inland fisheries have rarely been included in global policy frameworks, and where mentioned, they lack explicit inclusion targets (Elliott *et al.*, 2022). The standardized and scalable design of the basin-level inland fisheries assessment framework allows for use within global sustainability goals, which are often required to be applicable at national, regional, and global levels. The basin assessment method and threat mapping tool can therefore contribute not only to improved integrated resources management but also to contribute to improving and strengthening governance, including in transboundary cases. The threat mapping tool has been proposed for use as an indicator to monitor inland fisheries for the post 2020 Global Biodiversity Framework (GBF), as currently there is no inland fisheries indicator. Although the basin assessment method focuses on threats to inland fisheries, it also serves as a metric for ecosystem health and its capacity to support fish production. This tool could also be applied to the SDGs for monitoring inland fisheries, which could allow countries to monitor inland fisheries using the same framework for the GBF and the SDGs.

The multi-policy utility of the threat mapping tool would simplify the need for multiple indicator tools and streamline the adoption of a global monitoring tool for inland fisheries. The threat mapping tool outlined in this chapter, in combination with fisheries monitoring programmes, could be a powerful tool to assess the threats to a basin's fisheries, monitor the catch and contribution to food supply of a basin fishery, and initiate action – where required – to improve and conserve a basin's fishery and aquatic habitats. In summary, the basin level threat assessment framework for inland fisheries offers a timely and cost-effective opportunity for fishery managers, stakeholders, and policymakers to track and monitor the status of inland fisheries and their habitat.

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7. INLAND FISHERIES OF THE WORLD BY MAJOR SUBREGIONS

The following sections provide a series of regional summaries on the state of inland fisheries in countries reporting inland fisheries. In this chapter, subregional and country summaries are provided for countries in the regions of Africa, Asia, the Russian Federation, Europe, Americas, Oceania and Arabia. The subregional and country reports provide details regarding inland fisheries around the world that contributes to provide global picture. To inform this, and provide a systematic approach, information was sought at the country level regarding key features of the inland fisheries including:

- Inland aquatic environments important for inland fisheries and the species and species diversity supporting inland fisheries in the country, the fishers and the gears used
- Production and productivity of inland fisheries, including key commercial, subsistence and recreational fisheries, catch volumes and key value chain activities, and contribution to livelihoods and food security. Statistics presented in the tables are based on information reported to FAO for 2021 but this is complemented by additional country-level data from different sources.
- Policy and institutional mandates/strategies related to inland fisheries and the key challenges that need to be addressed through fisheries management and integrated water resources management.

In practice, the amount of information available and coverage of these issues differed between countries such that it was not possible to provide entirely consistent reporting. Nevertheless, the global picture that emerges from the subregional and country summaries is one within which inland capture fisheries provide critical livelihood opportunities and welfare functions, although in practice, these benefits can be specific to particular populations and locations.

While natural waterbodies and wetlands, including rivers, lakes, ponds, swamps and marshes can be important locations for fisheries, changes to aquatic environments resulting from human interventions, including infrastructure development and irrigated agriculture, can also create new water bodies such as reservoirs and canals. These can also become the sites of new fisheries, often supported through stocking and the creation of enhanced and culture-based fisheries. In some locations, restoring fish and fisheries is part of the justification for initiatives to remove or modify water infrastructure and restore watercourses. In both cases, there are opportunities to increase the contributions of inland fisheries for food and/or recreation, illustrating the continued role and relevance of inland fisheries around the world.

Often, fisheries are particularly important at certain times of the year, such as during the productive flood recession period. There are also significant links and interdependencies with other livelihood activities such as agriculture. These interdependencies can be particularly significant in some cases, where fishing and fisheries provide livelihood opportunities that can make the livelihood strategies viable. This is most evident in cases where fisheries provide welfare functions and safety nets.

Critically, inland fisheries and their management fulfil roles beyond food production alone. Fisheries are important for cultural reasons for many populations and recreational fisheries and fisheries for ornamental fish can also be important in parts of the world. Catches retained from recreational fisheries can sometimes be significant, also can make important contributions to food security. Given the nature of inland aquatic environments, fishers often employ adaptive strategies such as using different gears at different times of the year and moving in response to changes in fish abundance and distribution.

Examples from around the world highlight how inland fisheries can provide opportunities to maintain and restore environments, enhance environmental connectivity, and improve water quality and nutrient flows. As many of the country reports indicate, the dispersed and dynamic nature of many inland fisheries means that they are often not fully documented or recognized, remaining invisible and thus at risk of being overlooked. There continues to be a need to improve the information base for inland fisheries.

7.1 AFRICA

Subregion	Inland capture fisheries catch (tonnes in 2021)	Percentage global inland capture fisheries catch	Population (2021)	Per capita inland fish production (kg/year)
Northern Africa	16 125	0.14	100 252 776	0.16
The Sahel	329 250	2.90	110 569 738	2.98
Nile Basin	455 292	4.01	285 950 678	1.59
Africa Eastern Coast	200	0.00	21 791 450	0.01
Africa Western Coast	588 072	5.18	353 394 105	1.66
Africa Great Lakes	1 361 386	11.98	208 350 569	6.53
Congo Basin	298 788	2.63	109 528 257	2.73
Southern Africa	264 498	2.33	198 947 702	1.33
TOTAL	**3 313 611**	**29.16**	**1 388 785 275**	**2.12**

7.1.1 Northern Africa

Country/territory	Inland capture fisheries catch (tonnes in 2021)	Percentage of global inland fish catch	Population (2021)	Per capita inland fish production (kg/year)
Morocco	15 500	0.14	37 076 584	0.42
Tunisia	625	0.01	12 262 946	0.05
Algeria	0	0.00	44 177 969	0.00
Libya	0	0.00	6 735 277	0.00

The Northern Africa subregion is extremely arid with few permanent rivers and freshwater lakes. There are reservoirs and coastal lagoons where inland fishing activities take place. Total reported production for this subregion is 16 125 tonnes (2021), representing 0.14 percent of global inland fish production.

Morocco

Continental aquatic ecosystems in Morocco are very diversified, represented mainly by rivers (including the Sebou, Dra, Moulouya, Rbia, Tensift and Sous), natural lakes and reservoirs, with a total reservoir area of over 500 km^2 that support small capture fisheries (Vanden Bossche and Bernacsek, 1991). In addition, there are also coastal lagoons, including Merja Zerga and Nador. Biodiversity is low, with 40 native species and around 20 endemic species. In addition, around 20 species have been introduced. Important fisheries targets include native species such as brown trout (*Salmo trutta*), common barbel (*Barbus barbus*) and European eel (*Anguilla anguilla*) and introduced species such as rainbow trout (*Oncorhynchus mykiss*), pike-perch (*Sander lucioperca*), common carp (*Cyprinus carpio*) and Nile tilapia (*Oreochromis niloticus*). Reported catches in Morocco began to increase in 2002, rising from less than 1 000 tonnes to more than 15 000 tonnes by 2022. This increase can be explained by the fact that inland fisheries in Morocco are mainly based on reservoir stocking (Naji *et al.*, 2023).

Fishing is concentrated on migratory species in estuaries, mainly glass eels together with small-scale fishing in reservoirs. since European eels were included in Appendix 2 of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), fishing quotas for glass eels has been managed through a quota system with the total allowable catch (TAC) set at 2 000 kg per year (ANEF, 2023). Catches are intended exclusively for grow-out at authorized aquaculture facilities (ANEF, 2023). Small-scale reservoir fishing accounts for most landings, with the 15 000 tonnes of annual production produced by around 3 000 fishers (ANEF, 2023). Almost all fishing is related to aquaculture, with eel fishing supplying culture facilities while much of rest of the inland fisheries are instead supported by stocking (Laamiri, 2014). On average, more than 20 million fingerlings of all species are stocked annually. Aside from commercial fishing and aquaculture, inland fisheries are also managed in ways that support recreational fishing and the improvement of water quality through use of fish and fisheries to address eutrophication (Naji *et al.*, 2023). The number of recreational fishers fishing in inland waters has been estimated to be 33 830 people. There is little information on catches, but these were suggested to be around 300 tonnes, of which 46 percent was retained for consumption (Embke *et al.*, 2022).

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Tunisia

Four small river systems discharge into the Mediterranean Sea. The country also has a developed water infrastructure that includes 37 dams, 258 hill dams and 918 hill lakes, covering an area estimated at 20 000 ha and capable of retaining 2 billion m^3 of water. In addition to inland waters, Vanden Bossche and Bernacsek (1991) identify seven important coastal lagoons with a combined surface area of 550 km^2; the largest being Bibane (230 km^2), Bizerte (150 km^2) and Ichekeul (100 km^2).

Inland capture fisheries are largely based on stocking reservoirs and small-size lakes (Naji *et al.*, 2023; Mili *et al.*, 2016). Stocking began in the late 1960s using endemic species such as barbel (*Luciobarbus callensis*) and European eel (*Anguilla anguilla*). Towards the end of the 1980s, a national program for the stocking of dams was set up and currently Tunisia has about 60 stocked waterbodies spread over 12 governorates and stocking involves two groups of species. The first are those species reproducing naturally in Tunisian waters such as barbel, roach (*Rutilus rutilus*), rudd (*Scardinius erythrophthalmus*), common carp (*Cyprinus carpio*), pike-perch (*Sander lucioperca*), wels catfish (*Silurus glanis*), largemouth black bass (*Micropterus salmoides*) and Nile tilapia (*Oreochromis niloticus*). The second group cannot reproduce and include mullet (*Mugil cephalus* and *Chelon ramada*) and Chinese carp (*Hypophthalmichthys nobilis*, *Ctenopharyngodon idella* and *Hypophthalmichthys molitrix*) which are subject to regular stocking.

The average annual production from the inland fisheries over the last ten years is around 500 tonnes. Inland fishing activity is dependent on obtaining a fishing permit or authorization to operate from national administration. Currently, about 30 dams and hill lakes are operated through 153 fishing permits.

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Algeria

There are 11 river (*oued*) basins that discharge into the Mediterranean Sea, the majority of which are intermittent (*wadis*). Several internal river basins have oases, marshes and salt ponds (*chott*), particularly in the southern governorates. Several of these sites have been designated Ramsar zones. While there are no important freshwater lakes, there are 80 large dams built mainly for irrigation and drinking water supply (ANBT, 2023), 53 of which have been selected as fishing sites. There are 21 large dams constructed mainly for irrigation. Inland fisheries production was estimated to be 2 131 tonnes in 2020 (Naji *et al.* 2023) and according to the Ministry of Fisheries and Fishery Resources (2022) there have been recent efforts to stock reservoirs and dams and lakes in the northern provinces with species including Nile tilapia (*Oreochromis niloticus*), largemouth black bass (*Micropterus salmoides*) and common carp (*Cyprinus carpio*). There are also eel fisheries in Algeria, although these are considered highly threatened (Juffe-Bignoli and Darwall, 2012). Algeria no longer reports any inland fisheries catches to FAO.

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Libya

Libya has extremely limited renewable surface freshwater resources. There are several short, seasonal rivers (*wadis*) with sometimes very powerful floods (Vanden Bossche and Bernacsek, 1991). There are a number of major dams designed to control the flow of these wadis and create water reserves. Some of these reservoirs have been stocked, notably the Wadi Kaam dam (1 300 ha) The main focus has been on fisheries based on stocking, including at Wadi Kaam reservoir (Khoms city, stocked in 2008 and 2015); Wadi Mjinine (Tripoli area, stocked in 2015, 2017 and 2018) and Abou Dzira Lake (near Benghazi stocked dates not available). These reservoirs support some recreational fishing, although Wadi Kaam reservoir dried up in 2021 leading to the death of all fishes in it. Libya does not report any inland fishery production.

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7.1.2 The Sahel

Country/territory	Inland capture fisheries catch (tonnes in 2021)	Percentage of global inland fish catch	Population (2021)	Per capita inland fish production (kg/year)
Mali	107 100	0.94	21 904 983	4.89
Chad	103 000	0.91	17 179 740	6.00
Niger	47 200	0.42	25 252 722	1.87
Burkina Faso	29 731	0.26	22 100 683	1.35
Senegal	26 419	0.23	16 876 720	1.57
Mauritania	15 000	0.13	4 614 974	3.25
The Gambia	800	0.01	2 639 916	0.30

The Sahel subregion includes three of the continent's largest floodplains: the Inner Niger River Delta, Lake Chad and the Senegal River valley. This subregion is subject to very high climatic variability, with the last third of the twentieth century being particularly arid, with a very marked drop in production in these three basins. Other factors have a direct impact on fisheries production, notably competition for water – especially for irrigation and hydroelectric power generation. Despite an improvement in rainfall since the early 2010s, water extraction and reduced flooding are preventing production from returning to its optimum level. The number of full-time fishers is relatively small, but this should not obscure the fact that there are a very large number of fishers/farmers, particularly in the Inner Niger River Delta and around Lake Chad, where the average annual per capita availability of fish is 5 kg and 6 kg respectively, compared with an average of 3 kg for the subregion as a whole. Fishing in the subregion has been affected by the security situation that has led to the large-scale displacement of populations.

Mali

While the northern half of Mali is covered exclusively by desert areas, the southern half is located on two major basins: the Senegal (formed by the Bafing and Bakoye rivers) and the Niger, which receives its tributaries on the right bank: the Sankarani (on which the Sélingué dam is located) and the Bani (formed by the Baoulé and Bagoye rivers) before forming the inner delta, which is one of the largest floodplains in Africa, covering an area of 40 000 km² during the highest floods. Flooding of the delta is essentially determined by rainfall in the upper basin in Guinea, where the Niger rises along with four of its major tributaries (Niandan, Tinkisso, Milo and Sankarani), but also by the amount of evaporation in the inner delta. There are also two main reservoirs: the Manantali (475 km²) on the Bafing and Sélingué (410 km²) on the Sankarani.

Biodiversity in the entire Niger Basin is high, with over 140 species of fish, including 2 endemic species. This is reflected in fishing catch compositions, which always include the following groups of species in varying proportions: *Alestes, Bagrus, Brycinus, Clarias, Heterobranchus*, *Hydrocynus, Labeo, Oreochromis, Sarotherodon* and *Tilapia*. Fishing is extensive and many fishing areas are on rivers, branches of rivers and ponds, or natural lakes. The 2012 UEMOA programme frame survey in Mali reveals the scale, identifying 2 425 fishing sites – 80 percent of which are in the Niger Basin. Many of these sites are villages but also include a mix of seasonal and permanent camps in the Mopti region (UEMOA, 2013). The 2012 survey also identified 32 670 fishing households, around 70 percent of whom also farm or, more rarely, raise livestock (UEMOA, 2013). The regions where households fish exclusively are found in the south of the country and involve migrants who do not have access to land. The fishers are almost exclusively Malian nationals and belong to the Bozo, Sonrhaï and Somono (Bambara) peoples.

The UEMOA survey reported that the fleet of pirogue boats comprises 53 250 craft, the majority of which are rigged pirogues. The motorization rate is fairly low at 11.5 percent. The main fishing gears are fixed and drifting gillnets, cast nets, traps, and longlines, in roughly similar proportions in all regions. The nets used are usually small-meshed, except on the Senegal River. Longlines are set with small hooks throughout the delta, and larger hooks in the south.

The main fishing season is from November to March, averaging seven fishing trips per week yielding 20 to 40 kg per trip (generally higher in the Inner Delta). In the low season, five or six trips per week is more usual and catches never exceed 5 kg per trip. Total annual production from the 2012 survey was between 73 000 and 96 000 tonnes, 70 percent of which is in the Inner Delta. This is consistent with reports to FAO (Toure, Abdel Hamid and Diadhiou, 2021). Given the productivity of the fisheries there are few attempts to enhance production, with fewer than 4 percent of villages reporting that they enhance water bodies with fry, fish or nutrients.

Most households (86 percent) also engage in fish processing or marketing (Andres *et al.*, 2020). Production for consumption and local markets represented around 75 000 tonnes, including 20 000 tonnes of smoked products. A further 60 000 tonnes of fish also passed through wholesalers and fishmongers to urban markets. In 2019, imports represented 80 000 tonnes and exports 5 000 tonnes, giving a total food availability of 205 000 tonnes, or around 10 kg per capita annually.

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Chad

Chad is largely located in the Lake Chad Basin and includes a large portion of the Chari and Logone basins, which it shares with the Central African Republic and Cameroon. These basins include two large floodplains, the Yaérés and Salamat that together cover more than 80 000 km², as well as lakes Iro, Fitri and Ounianga. The extreme southwest of the country is located in the Benue Basin, a tributary of the Niger, and includes Lake Léré on the Mayo-Kebbi. Lake Chad is regularly subject to major variations in its environment, altering the extent of the lake and reflected in local descriptions of "Medium Chad" and "Little Chad". During the great dry period of 1970–1980 the lake went through an extreme phase known as "Dry Little Chad", where waters in the southern basin no longer fed the northern basin – which practically dried up as a result (e.g. Raimond *et al.*, 2019). More recently, studies have shown that since the early 2000s the lake has recovered part of its surface area in the wet season (Pham-Duc *et al*, 2020) peaking at 14 000 km² in 2013. Biodiversity is high, with almost 150 fish species but with no endemism. The productivity of the waterbodies is environmentally driven, with potential yield estimated at between 144 000 and 288 000 tonnes per year, depending on the amount of rainfall in all the basins. Annual productivity also varies spatially, with potential yields estimated at 50 kg per hectare for rivers without flood zones and 100 kg per hectare for those with flood zones.

The resident human populations around the lake were estimated at around 2 million people in 2013, including 670 000 in the Chadian part of the lake. Among these populations, the Musgum and the Kotoko, practice traditional fishing and occupy cross-border territories. Elsewhere, the Buduma live mainly on the islands of Lake Chad, while the Bua and Barma live predominantly along the Chari River and its tributaries (e.g. Baroin, 2005). Some of these peoples carry out seasonal transhumance to a greater or lesser extent making it difficult to maintain a census of them. However there are an estimated 171 000 fishers in all assessment categories: including 17 000 full-time fishers and 154 000 farmer-fishers, and more than 20 000 people are involved in marketing alone. Annual production declared to FAO averages around 100 000 tonnes and has been relatively constant, which contrasts with the variability of the environment. The fish is largely sold to the capital, N'Djamena, as well as to the Maiduguri market in Nigeria.

Fishing is characterized by the extreme diversity of gear used, combining multiple traps used in isolation or to form weirs, as well as hand nets used on foot or from boats, gillnets and lines. Customary management systems are still operational in some areas, but modern regulations are tending to ban many types of gear and restrict the traditional power to grant access rights, leading to a significant increase in the number of fishers (e.g. Lake Fitri). Recently, the security situation has affected fishing in the Chad basin and led to large scale displacement of populations.

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The Niger

The Niger has around 4 100 km² of surface water, divided between the Niger River, which crosses the country for 550 km, as well as a section of Lake Chad representing around 3 100 km² and its tributary the Komadougou Yobe. In addition to these resources, there are 140 reservoirs and more than 1 060 ponds, of which only 275 are permanent. The main reservoir, at the Kandadji dam on the Niger, is due to be filled by 2025. Biodiversity is relatively high, with around 100 species of fish. Fish production can fluctuate, with potential production estimated at between 40 000–67 000 tonnes depending on weather conditions and the extent of Lake Chad. The prevalence of ponds that are fished collectively leads many fishers to migrate at least once a year to participate in fishing. More than half of these sites have conflict resolution mechanisms to manage fishing activities.

A survey carried out in 2012 (UEMOA, 2013) identified 500 fishing sites, occupied by more than 9 100 households. Around 20 percent of sites are in larger or smaller towns, and many of the remainder in permanent villages and camps. Most fisheries are based on natural productivity although reservoirs may be regularly stocked. Fishing is often combined with other activities and 95 percent of fisher households carry out another agricultural or livestock activity. Nearly 60 percent of these households have members engaged in fish processing or trading. Almost all fishers are of the Niger and belong predominantly to the Haoussa people, followed by the Songhai and Zarma.

The total number of pirogues identified in the 2012 survey was estimated 7 500, concentrated in the river regions, particularly in Tillabéry (54 percent) and Dosso (30.5 percent). The motorization rate is less than 1 percent. Passive nets are the most common gears, followed by longlines, cast nets and traps. The mesh sizes used for nets tend to be small to medium, while longline hooks are typically small. The main fishing season is between June and August. During this time, fishers make 6 or 7 trips per week, and slightly fewer in the low season. Catches per trip are highly variable ranging from 15 to 40 kg in the main season and less than 5 kg in the low season except for Diffa, where it reaches 15 kg. Total annual production is estimated at between 20 000 and 40 000 tonnes, with 75 percent coming from the Dosso, Tillabéry and Diffa regions (UEMOA, 2013). These results are in line with the data reported to FAO, which also reflects the high variability of production depending on hydroclimatic conditions throughout the basin.

Most fishing is for commercial purposes, with the fishers themselves selling their catch in almost 80 percent of cases. More than half of households also have a member involved in fish processing, except in Niamey, where the rate is close to zero. Fish is often processed and exported to Nigeria from Zinder and Diffa. The primary processing method is smoking, which is practiced all year round. In contrast, imports of fish are very low, at less than 9 000 tonnes in 2019. Annual fish availability is therefore in the region of 30 000 to 50 000 tonnes, representing a per capita annual availability of around 2 kg.

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Burkina Faso

Burkina Faso is located on four major watersheds: the Niger, the Mouhoun (Black Volta), the Nakembé (White Volta) and the Comoé. The Mouhoun flows through the Sourou floodplain. Other major rivers are the Nazinon, Bougouriba, Sirba, Pendjari, Léraba and Tapoa. There are more than 1 200 reservoirs that are important for inland fisheries, but only one-third of these are permanent. Perennial and seasonal surface water represents a maximum area of 200 000 ha, including 120 000 ha of surface water (rivers, lakes and ponds) and 80 000 ha of wetlands (MEEVCC, 2018). Burkina Faso's surface waters are home to 122 species of fish, including 3 species endemic to the upper Mouhoun, Bougouriba and Comoé basins. In 2020 Burkina Faso had 24 Ramsar sites which include floodplains (Sourou), natural lakes (Bam, Tingrela) and ponds (Oursi), as well as several artificial lakes (Bagré, Tapoa). Based on average productivity levels by type of environment (Lymer *et al.*, 2016), the potential fishery productivity can be estimated at 18 000 tonnes per year.

The frame survey carried out in 2012 as part of the UEMOA programme identified 616 fishing sites throughout the country, almost 80 percent of which are villages. Most fishing takes place in small dam reservoirs (41 percent), followed by stretches of river and ponds. Given the level of natural productivity, enhancement is limited with only around 4 percent of sites reporting enhancement measures, whether in the form of fry, fish or food.

The 2012 survey identified 11 800 fishing households, or 20 000 fishers, 17 percent of whom were women. These households collectively own almost 4 500 pirogues, generally made of planks, and the observed rate of motorization was zero. The vast majority (94 percent) of households engage in at least one other activity, including farming and livestock rearing. Around 5 800 households also process or trade fish, with a higher proportion of women involved in these activities (80 percent and 60 percent respectively). Half of fishing households market the fish themselves, and two-thirds process fish, mainly by smoking (80 percent of households processing fish). Fishers are predominantly nationals, belonging among others to the Gurunsi, Kassena and Nuruma groups in the upper valleys of the Volta rivers.

Around one-quarter of fishers migrate on a seasonal basis, usually to take part in the collective fishing in the residual ponds at the end of the dry season, which is organized in all regions of the country apart from the capital, where this tradition is gradually disappearing. The situation of insecurity and the large-scale internal displacement of the population in the northern half of the country mean that it is not possible to have an up-to-date assessment of the state of the fisheries. Gillnets, cast nets and longlines are the most used fishing gears in all regions of the country, although traps are still widely used in some areas. Most of the nets used are small-meshed and longlines use small hooks. The main fishing season is from August to December. During this season, the number of trips per week is six, during which catches per trip vary between 7 kg and 22 kg depending on the region. During the less productive season the number of trips per week reduces to four, during which time catches never exceed five kg per trip.

The average annual production estimated by the 2012 survey is between 20 000 and 23 500 tonnes, which is consistent with the official data reported to FAO of between 20 000 and 24 000 tonnes for the 2012–2020 period, but less than the 29 731 tonnes reported for 2021. The most common groups of species caught are Tilapia, Clarias, Alestes, Lates, Bagrus, Heterotis and Auchenoglanis. In addition to domestic production, fish imports have more than doubled over the last decade, rising from 53 000 tonnes in 2010 to over 130 000 tonnes in 2019. Apparent annual availability is therefore around 150 000 tonnes, or 7.5 kg per capita, with few regional disparities.

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Senegal

Senegal's hydrographic network is essentially made up of the Senegal and Gambia river basins, whose waters come from the Fouta Djallon massif in Guinea, and both of which have a large floodplain on Senegalese territory. Other major rivers are the Casamance, Sine and Saloum, which are permanently invaded by sea water up to 200 km from their mouths. Two other rivers cross Senegal, the Kayanga and the Anambé, which form the Geba river in Guinea-Bissau. The main natural lake is Lac de Guiers, a floodway of the Senegal River, and there is no dam within the Senegalese territory. There are also several ponds (*niayes*) on the coast to the north of Dakar, which are very fragile wetlands. Based on the surface area of the various aquatic environments and in particular the floodable zones, the production potential can be estimated at between 36 000 and 50 000 tonnes per year. This potential has been greatly reduced by the management of the Manantali dam, since over the period 2001–2018, the annually flooded part of the Senegal river valley now represents only 2 percent of the potentially floodable area (Bruckmann *et al.*, 2021). Senegal freshwater bodies are home to around 140 species, none of which are endemic.

The frame survey carried out in 2012 identified almost 530 fishing sites, mainly villages located on the Middle Senegal (Tambacounda) and Middle Gambia (Kedougou) rivers, which are major flooding areas. One-third of households in these areas have ponds reserved for collective fishing. These sites are occupied by nearly 8 900 households. For most households fishing is not the only livelihood activity and 85 percent also practise agriculture or livestock farming. Women also fish, although the fish catch by women may be excluded from estimates and contribute to under-reporting of production (Ba *et al.*, 2006). In 60 percent of households, at least one member of the household processes or trades fish. Barely 5 percent of households have fishing as the sole income-generating activity. Across the country, some 20 percent of households have at least one member who undertakes a seasonal migration for fishing. Most fishing households (97 percent) are nationals belonging to the Fula, Malinké, Diola and Wolof peoples.

Based on the 2012 survey, fishing households owned around 5 500 pirogues, most of them dugout canoes or plank canoes. The degree of motorization differed by location, with some showing a rate close to 11 percent while in other regions it was 0 percent. Fishing gears vary, with gillnets being the most commonly used fishing gear (32 percent of households), followed by longlines (22 percent) and driftnets and cast nets (16 percent). Large-mesh nets are the most used, as are longlines with large hooks. The productivity of the fisheries varies throughout the year and between years. The most productive period extends from July to December, with regional variations. During this period, fishing effort averages six trips per week with catches per trip of between 20 and 30 kg (up to 40 kg in Casamance), compared with fewer than five trips and 5 to 15 kg in the less productive periods.

Total production estimates provided by the frame survey are between 32 500 and 41 300 tonnes per year, which is in line with the data reported to FAO (30 000 tonnes on average over the period from 2011 to 2020 and 26 419 tonnes for 2021), but higher than the figures published by the Directorate of Inland Fisheries, which are between 11 000 and 14 000 tonnes per year over the same period (MPEM). The construction of the Diama dam (on the border with Mauritania) and the Manantali dam (in Mali) in the Senegal River basin has been implicated in reduced fishery production in part because of the effect on flows and seasonal inundation (Degeorges and Reilly, 2006; see also Chapter 5). The flooded area of the Senegal River floodplain is estimated to be less than 50 percent of its size prior to the construction of the Manantali dam.

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Mauritania

Mauritania comprises a large part of the Senegal River basin and its floodplain, corresponding to the regions of Guidimakha, Gorgol, Brakna and Trarza, as well as small endoreic basins in Hodh and Assaba. There are several natural lakes (Rkiz, Aleg, Mâl) with a total surface area of up to 20 000 ha. The main reservoir is Foum Gleita on the Gorgol, with a surface area of 170 km². The total potential production of these water bodies can be estimated at around 27 500 tonnes.

There is no census of fishing households in the Mauritanian part of the basin. Partial censuses were carried out by IMROP in 2009 and 2016 on natural and artificial water bodies, recording nearly 600 fishers equipped with nearly 500 pirogues, half of them fishing on the Foum Gleita reservoir, located on the Gorgol. Most of the fishers are from Peul and Soninke communities, as well as a few Malian fishers.

According to the IFAD report (2016), the considerable reduction in periods favourable for fishing in the valley has led to the departure of many professional fishers. This was the case for several dozen fishers from Gouraye (opposite Bakel, Senegal) who moved to the Foum Gleita lake as early as 1987. In Kaedi, the largest urban centre on the river, only around 20 fishers are still working. Ninety percent of the fish consumed in Kaedi comes from fishing grounds on the Gorgol and in the Foum Gleita reservoir.

In Mauritania, there are no consolidated data outside the Foum Gleita reservoir. According to the IFAD report (2016) notes that the best fishing period is between November and February, corresponding to 60 percent of annual catches. Catches from the reservoir reached 500 tonnes in the early 1990s, before dropping to 200 tonnes in the mid-2010s. This reflects a drop in fishing effort between February and June following the ban on small-mesh nets, which could catch from 500 kg to 1 tonne of wandonne (*Brycinus leuciscus*) per day. At peak times, daily yields are estimated at an average of 20 kg per net and per longline. Overall national production reported to FAO in 2021 was 15 000 tonnes. However, as most inland fish in in the country come from the Senegal River and associated floodplain, declines in catches from this river are likely to affect both Mauritania and Senegal. There are some recreational fisheries identified in inland waters with around 4 000 people participating but no further information is available.

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The Gambia

The country takes its name from the River Gambia, which rises in Guinea, flowing for 220 km in rapids (upper basin) before crossing Senegal for 480 km, receiving most of its tributaries in a wide floodplain (middle valley), and finally entering the Gambia, where it flows for another 500 km to its mouth in the Atlantic (lower valley). There is no slope in the lower valley and the sea penetrates up to 180 km from the mouth. There are no natural lakes or reservoirs but work on the Sambangalou dam in Senegal started in 2023 as part of an OMVG (Organization for the Development of the Gambia River) programme.[22] Based on a floodplain of 2 000 km² outside the estuary, the production potential of inland fisheries using methods from Lymer *et al.* (2016) has been estimated at just over 10 000 tonnes per year. The fish fauna is extremely varied in the three sections of the river, and the lower valley has around 100 species, none of which are endemic. The river is managed through the OMVG, which brings together the Gambia, Guinea, Guinea-Bissau and Senegal. This basin organization is not involved in managing fisheries.

The last frame survey was carried out in 2006 and covered all artisanal, river and marine fisheries (GoTG, 2006). The administrative fishery divisions make it easy to do so, as three of the five national divisions are located in the coastal zone and under the influence of marine waters. The frame survey identified 69 sites in this coastal section of the river, occupied by 480 fishers including 250 nationals – 155 from Senegal and 70 from Mali. These fishers also employ around 1 200 people, one-quarter of whom are unsalaried. Households included in the survey have an average of eight people, and 56 percent of household heads are full-time fishers. Fishing takes place between six and ten months of the year, and around 15 percent of fishers report migrating on a seasonal basis. Due to the nature of the aquatic environment, nearly 90 percent of fishers use pirogues, most often dugout canoes. The motorization rate is around 20 percent. While a variety of gear types are used, the most common are fixed and drifting gillnets, cast nets and longlines. Fish is most often sold by the fishers to wholesalers, either fresh or processed. The most important processing method is drying followed by smoking. There

22 More information can be found at https://www.pe-omvg.org/

are no production estimates for the freshwater fishing zone, but the catch data totals reported to FAO have been falling steadily for several years, from 5 000 tonnes in 2010 to less than 800 tonnes in 2021.

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7.1.3 Nile Basin

Country/territory	Inland capture fisheries catch (tonnes in 2021)	Percentage of global inland fish catch	Population (2021)	Per capita inland fish production (kg/year)
Egypt	330 142	2.91	109 262 178	3.02
Ethiopia	60 650	0.53	120 283 026	0.50
South Sudan	32 500	0.29	10 748 272	3.02
Sudan	32 000	0.28	45 657 202	0.70

This subregion comprises most of the Nile River Basin, including tributaries, apart from the headwaters in Uganda. It has a wide variety of environments, including the Blue Nile, the White Nile, the Sudd, the Egyptian coastal lagoons, Lake Tana and the Ethiopian Rift Valley lakes. There are two major reservoirs (Lake Nasser and the Great Ethiopian Renaissance Dam, which was completed in 2023) as well as numerous small artificial lakes. Fisheries are therefore highly diversified, ranging from receding-water fishing, combined with other agricultural activities on the floodplains of the Sudd, to the highly motorized fisheries of the major reservoirs. Total inland fish production for the subregion is estimated to be 455 292 tonnes (2021) representing about 4 percent of the global total.

Egypt

The Nile is the only river in Egypt and runs for 1 300 km through the country. The floodplain, which was once entirely covered by permanent marshes, has been drastically reduced by the construction of the Aswan Dam and the impounding of Lake Nasser. This has impacted the productivity of the river fisheries, although that has been partly compensated for by the development of fishing in the reservoirs. The Nile delta contains several marine or brackishwater lagoons, the largest of which (Bardawill and Burullus) are both Ramsar sites and cover an area of about 2 500 km². Other smaller lakes are associated with the oases in the western part of Egypt. Egypt has also many freshwater reservoirs distributed along the river, the most important being Lake Nasser with an area of 5 250 km² (83 percent of which is in Egypt and 17 percent in Sudan). Sedimentation in Lake Nasser is extremely rapid and is exacerbated by evaporation, which reduces the volume of water available in the lake and contributes to coastal erosion in the delta area. Egypt's inland aquatic and brackishwater environments are home to nearly 100 species of fish, including 10 introduced species (Froese and Pauly, 2021). Inland fisheries production is currently limited to the River Nile, the reservoirs and a few nonbrackish lakes, representing a potential of around 92 000 tonnes.

There are estimated to be about 25 000 boats operating in Egypt's inland waters, of which about 10 000 are on the Nile River and about 15 000 on the lakes and lagoons. These small (4–6 metre) sailing boats have a short range and land at about 700 different sites along the river. Fisheries management in Egypt is the responsibility of the General Authority for Fish Resources Development (GAFRD). Statistics on landings and fishing fleets are collected but are not published on a regular basis or made available to the public. Statistics on fishing effort and social and economic parameters are limited. According to the 2005 Integrated Water Resources Management Plan, 700 000 people were dependent on inland fishing and related activities. However, no updated estimates are available.

Recorded catches from inland fisheries exceed those from marine fisheries, although it is likely that the statistics include catches from coastal lagoons. In Lake Nasser, catches were reported to be around 35 000 tonnes in the early 1980s. This number fell to around 18 000 tonnes in 2016 due to environmental factors and high fishing pressure but recovered to around 26 000 tonnes in 2019. Fishers' own consumption, under-reporting and discarding of spoilt fish means that a proportion of catch may not be recorded (Van Zwieten *et al.,* 2011). Catches are dominated by Nile tilapia, catfish and mullet, whose respective abundance varies according to climatic factors. Catches from brackishwater inland coastal lagoons are collected both for consumption but are also sold as fry for aquaculture (Saleh, 2008). The very high population concentration along the Nile River largely explains why value chains are typically very short. Around Lake Nasser, in contrast, there is a significant processing industry that includes gutting and filleting, as well as salting for some species. Within this fishery, there are estimated to be 30 jobs generated per 100 tonnes of fish caught, of which 18 are for fishers and the remainder post-harvest. A large share of the available jobs is occupied by young people but practically none by women.

Egypt is one of the few countries to include the needs of fisheries in its assessment of water requirements. The 2005 Integrated Water Resources Management Plan recognizes that fisheries rely greatly on water resources and are directly affected by water allocation policies. It is estimated that a minimum of 8.5 km^3 of fresh and drainage water is required annually to sustain the present ecological conditions including fish production from the Delta lakes. There is no fisheries management plan by area or by type, and the principles of ecosystem-based management and the precautionary approach are not applied. In addition, Egypt has no mechanism for consultation with other actors, including the private sector and professional organizations, so management decisions remain totally centralized.

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Ethiopia

Ethiopia's hydrographic network is divided into 4 major basins: the Nile Basin which includes the Abbay River (Blue Nile), the Tekeze and Mereb rivers (which join in Sudan to form the Atbara River [Black Nile]), and the Baro River; the Awash endoreic basin, which ends in Lake Abbe on the Ethiopia–Djibouti border; the endoreic basin of the River Omo, which ends its course in Lake Turkana on the Ethiopia–Kenya border; and the basin of the River Jubba composed of the rivers Ganale, Weyib and Dawa, and the River Shebelle. Most of the rivers in Ethiopia are seasonal and about 70 percent of the total runoff is obtained during the period June–August. There are around 20 lakes larger than 10 km² and around 100 smaller lakes, all of which (except for Lake Tana) are in the Rift Valley. Lake Tana, which is the source of the River Abbay, is the largest lake in Ethiopia (3 500 km²) and represents 52 percent of the total lake area. Of the lakes, only Zeway is freshwater, while the others are alkaline. In addition to the lakes, 14 percent of the country's area is made up of marshes, rivers and floodplains. Collectively, these wetlands are critical areas supporting high levels of biodiversity and are often vital to the livelihood strategies of local communities.

Fish biodiversity is also high, with 165 native species, 42 of which are endemic (mainly cyprinids, including 18 species belonging to the *Labeobarbus* genus alone). In addition, 11 species have been introduced (mainly trout, pike and carp) for restocking, fish farming and recreational fishing. The potential fish production from Ethiopian waters is highly variable and depends on rainfall within the basins. A recent review based on estimated habitat productivity suggests annual production between 115 000 and 125 000 tonnes (Tesfaye and Wolff, 2014), which is in line with estimates based on the average productivity of African freshwater (Lymer *et al.*, 2016). These estimates do not consider the impoundment of the Grand Ethiopian Renaissance Dam, whose reservoir is expected to increase in area to 1 875 km², representing a potential additional annual production of 15 000 tonnes. However, this is likely to be offset by loss of fisheries productivity downstream of the dam.

Reported landings in Ethiopia have risen from 9 200 tonnes in 2003 to 60 650 tonnes in 2021. The most common species in 2021 was tilapia (22 800 tonnes), followed by North African catfish (17 900 tonnes) and cyprinids (12 400 tonnes). Inland fisheries provide livelihood opportunities for around 15 000 fishers for whom fishing is their main activity, as well as to around 20 000 people engaged in activities ancillary to commercial fishing. Fishing techniques are diversified, with the use of gillnets, longlines and beach seines in the commercial fisheries of the large lakes, with traditional techniques still in use by several groups. This is particularly the case in the Omo River Basin, where the Karo and Kwegu practise a combination of fishing and recession agriculture. In the Gambella region on the Baro River, more than 30 000 households of the Nuer and Anuak practice subsistence fishing and transhumance across the border with South Sudan. For other groups, fishing can play a more central role. For example, the Zay, who live on the islands of Lake Zeway, are totally dependent on fishing. For the Dassanech in the Omo valley, fishing has become far more important following the loss of their land and the abandonment of livestock farming.

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South Sudan

The climate of South Sudan is equatorial, with more or less daily rainfall. The main river system is that of the White Nile that crosses South Sudan from south to north, this portion being known as the Bahr al Jabal and includes virtually all its major tributaries up to its confluence with the Blue Nile. These tributaries include the Adar and the Sobat on the right bank, the Bahr al Zeraf (a branch of the Nile), and the Bahr al Ghazal on the right bank. The latter river has a huge basin covering the western half of South Sudan and includes numerous tributaries (Bahr al Arab, Lol, Jur) whose confluences are merged in a vast marsh area. The confluence of the Bahr al Ghazal and the White Nile forms Lake No (with an area of 100 km²), upstream of which the White Nile crosses another large marsh area known as the Sudd. There have been historic proposals to divert water from the Nile away from the Sudd via the Jonglei Canal, with a view to increasing the flow of water to the Sudan and Egypt. This project was launched and around two-thirds of the canal was dug. While this project now seems to have been abandoned, it has already had a serious negative impact on the Sudd and its fisheries. It appears that the flood regulation function of the Nile system by the Sudd marshes is important and potentially undervalued.

Based on recent estimates based on satellite data and vegetation cover, the Sudd area includes around 9 000 km² of permanent swamps and a total area subject to inundation and flooding of between 41 000 km² and 49 500 km² (USAID, 2021; UNEP, 2013; Rebelo, Senay and McCartney, 2012). The shallow floodplains (referred to locally as *touch*) flood during July to September. From November the waters recede, isolating the floodplain, which then drains through river channels and by February is dry, leaving several lagoons and pools of varying depths that make up a major fishery. The surface area of watercourses is also significant, and there are other wetlands, particularly in the Sobat basin. Assuming a conservative productivity index of 70 kg per hectare for floodplains (Lymer *et al.*, 2016), South Sudan's potential production would be in the region of 250 000–280 000 tonnes per year. Fish biodiversity is relatively low, with only 100 species, of which only 2 are endemic.

Published literature regarding the fisheries of South Sudan is scarce. There are no comprehensive stock assessment studies that were conducted in the country and existing fish yield estimates are based on studies conducted in the former Sudan – that is before the secession of South Sudan from the Sudan in 2011. Fluet-Chouinard, Funge-Smith and McIntyre (2018) estimated fish production in South Sudan at 55 percent of the total inland capture fishery production of the former Sudan. A fish consumption model estimate for inland fishery production for the former Sudan (212 083 tonnes in 2009) is more than three times the FAO estimate for the former Sudan in the same year (66 000 tonnes) or six times the current FAO figure for South Sudan of 32 500 tonnes. This estimate is not inconsistent with the production potential estimated based on surface area estimates of aquatic environments.

The dominant peoples in the Sudd are the Nuer, Dinka, Shilluk and Anuak all of whom are indigenous to the Nile Valley. These groups have developed traditions that have allowed them to adapt to the inundated and seasonally variable conditions across the Sudd through a combination of nomadic agropastoralism, non-timber forest product collection and fishing. Specific practices include the seasonal construction of settlements on small islands in flooded areas and traditional fishing techniques. According to the 2016 Comprehensive Agricultural Development Master Plan (CAMP), which provides data from the 2013–2015 situation analysis, there are an estimated 12 000 professional fishers and further 210 000 subsistence fishers (GoRSS, 2016). The report also indicates that more than 1.7 million people depend directly on fishing for their subsistence, food security or income.

Annual per capita fish consumption in South Sudan is estimated to be around 17 kg. The CAMP stresses the fact that fishing is extremely dispersed throughout the country's rivers and wetlands, with a very high level of household subsistence fishing. The main forms of preservation and post-harvest processing are drying and smoking fish. Until 2012, there was significant trade in fish towards Sudan, and Khartoum in particular, that was estimated to be up to 20 000 tonnes. In addition, unquantified amounts of fish are imported from Uganda, mainly fresh tilapia, Nile perch and dried small pelagic fish.

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The Sudan

The Sudan has a desert climate with little rainfall throughout the year. Towards the south of the country it has an unstable climate, with a pronounced rainy season of variable duration. Sudan is located in the Nile Basin and includes the confluence of the White and Blue Niles at Khartoum, as well as the Atbara River. Most of the other rivers are intermittent. The only coastal river outside the Nile Basin is the Baraka, which forms the Tokar Delta in the Red Sea. Sudan has several permanent freshwater lakes (Er-Rahad, Kundi, Keilak and Abyad), several temporary lakes, and alkaline volcanic lakes (Dariba and Malha). The largest wetland is the Khor Abu Habil Inner Delta, which is part of the three wetlands that have been designated as Ramsar sites. Artificial reservoirs were also formed in the country with the construction of dams. These include Sennar and Roseires on the Blue Nile, Jebel Aulia on the White Nile, Khashm El-Girba and Setit Complex on the River Atbara, Merowe in the Northern state, and

Lake Nubia in the north of Sudan as part of the Egyptian High Aswan Dam's reservoir. There are also many small traditional reservoirs (*hafir*), some of which are perennial. Biodiversity is fairly high, with 130 species of freshwater fish, 8 of which are endemic.

Capture fishing activities are centred around the Nile and its tributaries, the seasonal floodplains and the four main reservoirs. Over the period 2012–2021, after the secession of South Sudan, production from Sudan's continental fisheries averaged 33 100 tonnes, peaking at 38 000 tonnes in 2018 and 2019 and the current production figure for 2021 reported to FAO is 32 000 tonnes. Two-thirds of these catches are made up of cichlids (principally *Oreochromis niloticus*), with the remaining third not detailed.

In 2017, there were an estimated 2 230 small fishing boats and 605 motorized boats. There is a wide variety of boats used for fishing on the Blue Nile and White Nile, the result of the adaptation of ancient navigation traditions and new technologies (Mohammed, 2012). A total of 13 686 people were registered as inland fishers in 2017, 11 percent of whom were women. Among the peoples practicing subsistence fishing in the Blue Nile region are the Kwama and the Komo Ganza, who – in addition to fishing – also raise livestock.

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7.1.4 Africa Eastern Coast

Country/territory	Inland capture fisheries catch (tonnes in 2021)	Percentage of global inland fish catch	Population (2021)	Per capita inland fish production (kg/year)
Somalia	200	0.00	17 065 581	0.01
Djibouti	0	0.00	1 105 557	0.00
Eritrea	0	0.00	3 620 312	0.00

The Africa Eastern Coast is an arid subregion with very few permanent rivers and freshwater lakes. The main basin in this subregion is the Jubba-Shebelle that originates in Ethiopia and flows to the sea through Somalia. Inland fisheries are limited but largely unknown and the subregional total production is estimated to be only 200 tonnes.

Somalia

Somalia has several river basins, the main one being the Jubba and Shebelle rivers, whose tributaries all originate in Ethiopia. There are also a large number of coastal rivers, all of which are intermittent but feed important wetlands in the coastal valleys. The River Jubba is permanent, while the River Shebelle has periods during the *hagaa* (July–September) and *jilaal* (January–March) seasons when it dries up completely. Both rivers flow through narrow floodplains and marshes in their downstream sections, which are the most productive areas for fisheries. There was some commercial-scale fishing carried out prior to the civil war (UNEP, 2005) and the potential of these areas has been estimated at up to 1 600 tonnes per year (USAID, 1988) using habitat area models. This estimate is subject to uncertainty due to the limited data available on the productivity and extent of aquatic environments. Biodiversity is low, with 58 species of freshwater fish, 7 of which are endemic. Several species are considered to be in danger of extinction but there is no recent information on their status.

Fishing activity is undocumented (Vanden Bossche and Bernacsek, 1991) and appears to have always been limited. It is notable that the Gosha people (living in the Jebba valley) and the Boni (hunter-gatherers living in the far south of the country and in Kenya) are likely to practise some subsistence fishing. Catches from inland fisheries were estimated at 400 tonnes in 1990 and 200 tonnes in 2000 (UNEP, 2005). Somalia has not declared any catches to FAO since 1986, with the current estimate being 200 tonnes per year.

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Djibouti

Djibouti consists largely of volcanic plateau and desert. There is no permanent fresh surface water in Djibouti. A few wadis are fed rarely and flow mainly into Lake Abbé, which borders Ethiopia and is an endoreic saline lake. Lake Assal is also endoreic and over-salted due to its altitude below sea level. There is one medium-sized lagoon, the Ghoubet Kharab and has no significant inland fishery outside of the Ghoubet Kharab. Djibouti does not report any inland fish catches to FAO.

Eritrea

There is no permanent natural surface water in Eritrea, only wadis fed very irregularly and intermittent lakes such as Lake Abaeded, which crosses the border with Ethiopia. The resulting climate is arid and semi-arid with limited water resources. According to estimates by the Ministry of Information (GoE, 2021), there were 785 dams in 2021, including 200 with a capacity of over 100 000 m^3 and 30 with a capacity of over 1 million m^3. The largest dams are Kerkebet, Gahtelai, Msilam, Logo, Gerset, Fanco-Rawi, Fanco-Tsimu and Bademit, with a surface area totalling almost 0.4 km^3. According to a survey conducted in 2018 (BS&E, 2019), over 20 percent of the reservoirs have been stocked with tilapia, carp and catfish.

Endemic fish fauna is limited and Lake Abaeded is home to Eritrea's only endemic freshwater species, the cichlid *Danakilia dinicolai*, while the other species reported in FishBase are more likely to be brackishwater species found on the coast (Froese and Pauly, 2024). At least two species of tilapia have been introduced as well as Clarias catfish and carp. Fishing is practised occasionally by about 1 500 fishers using small-mesh nets and hand lines. There is no record of any recreational fishing (Embke *et al.*, 2022). Total production is estimated at 30 tonnes per year and is mainly subsistence fishing, although Eritrea reports no inland fisheries production.

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7.1.5 Africa Western Coast

Country/territory	Inland capture fisheries catch (tonnes in 2021)	Percentage of global inland fish catch	Population (2021)	Per capita inland fish production (kg/cap/year)
Nigeria	362 792	3.19	213 401 323	1.70
Ghana	81 000	0.71	32 833 031	2.47
Guinea	42 000	0.37	13 531 906	3.10
Côte d'Ivoire	31 840	0.28	27 478 249	1.16
Cameroon	31 550	0.28	27 198 628	1.16
Benin	29 000	0.26	12 996 895	2.23
Togo	6 300	0.06	8 644 829	0.73
Sierra Leone	1 940	0.02	8 420 641	0.23
Equatorial Guinea	1 000	0.01	1 634 466	0.61
Liberia	500	0.00	5 193 416	0.10
Guinea-Bissau	150	0.00	2 060 721	0.07

The subregion is a relatively humid tropical climate zone characterized by a large number of coastal river basins of varying size that drain into the Atlantic Ocean. The largest basins are the Volta, Sanaga, Benue and the Niger. The basins are located within the region, except for the Niger-Benoué complex, most of which is located in the Sahelian zone. The productivity of the river basins is highly variable, and many coastal rivers have been impounded which has contributed to a significant reduction in floodplains production. The dam downstream of the Volta River system resulted in the largest artificial lake in the world, Lake Volta. Many rivers also end in coastal lagoon complexes, deltas and tidal estuaries. The total declared production of these countries was 588 000 tonnes in 2021, representing just over 5 percent of total global production and equating to an average annual per capita availability of 2.1 kg annually. However, this is unlikely to be evenly distributed as coastal populations will typically consume marine fish, except during the rainy season when marine waters can become less accessible, suggesting that inland populations will tend to have a higher consumption of freshwater fish.

Nigeria

Nigeria is located in several major basins and sub basins. The River Niger enters Nigeria in the northwest and receives the Sokoto river. Downstream of the Kainji dam, it is joined by the Kaduna River, then receives the Benue from Cameroon before ending its journey in the third-largest delta in the world. These two rivers drain more than half of Nigeria's territory. The northeastern quarter of the country is taken up by the Yobe Basin, which is made up of its two main tributaries, the Hadejia and Jama'are, which form the Yobe and are joined by the Komadougou just before it flows into Lake Chad. In the southeast, the Imo and the Kwa Ibo rivers flow into the Atlantic, as well as the Cross River (Oyono) from Cameroon which forms a wide cross-border delta. Finally, in the extreme southwest, the Ouémé Basin is shared with Benin. Between the three deltas there are several small coastal rivers, including Ogun and Osun (Oshun), and extensive lagoons.

The largest freshwater wetlands are in Chad (Hadejia-Nguru-Gashua wetlands and Lake Chad itself), Niger (Sokoto-Rima floodplain, Lokoja, Jebba and Lower Kaduna wetlands) and Benue (Makurdi wetlands) basins. Nigeria has 11 designated Ramsar sites, including 9 freshwater sites. Of these, freshwater wetlands, rivers and permanent waterbodies account for around 9 000 km², and associated floodplains for just over 52 000 km² – including the marshes around Lake Chad which have been extensively and regularly flooded since the early 2010s (Ottaviani, De Young and Tsuji, 2017; Pham-Duc *et al.*, 2020). Nigeria also has more than 320 dams of various sizes, with a total surface area of about 4 000 km². The largest are Kainji (1 500 km²) and Jebba on the Niger, Shiroro on the Kaduna, Dadin-Kowa and Kiri on the Gongola River, Kafin-Zaki, Tiga and Challawa Gorge on the Yobe, and Goronyo on the Rima River. Most of the large dams were designed for hydroelectricity and irrigation. There do not appear to be any cases of fish stocking in the main dams.

Fish biodiversity is high, with around 330 species, of which 20 are endemic to the area, particularly the lower Niger Delta and coastal rivers. Most of these endemic species are in danger of extinction. Apart from the common carp, there does not appear to have been any species introduction other than accidental. In fish catches, bagrids and clariid species accounted for 25 percent of total catches in 2021 with cichlids accounting for a further 18 percent. On the basis of estimates of the average productivity of the various types of environment (Lymer *et al.*, 2016), the production potential of Nigeria's natural surface freshwater can be estimated to be around 290 000 tonnes per year, with large reservoirs potentially adding around 25 000 tonnes, and the brackishwater of the deltaic and estuarine zones (mainly Niger and Cross rivers) over 100 000 tonnes – bringing the total estimated potential production to around 415 000 tonnes. These estimates are consistent with the data reported to FAO, which average 350 000 tonnes over the last ten years, equivalent to about 60 percent of the regional total.

Fisher numbers are high and there were more than 878 000 fishers in 2012, with likely as many or more people also indirectly involved in fishing activities (Ottaviani, De Young and Tsuji, 2017). Apart from fisheries on large reservoirs, catches in inland waters are based on a very wide variety of fishing gears, with the vast majority of fishers traditionally operating on a small scale to exploit fish according to flood cycles. Several groups are considered to be highly dependent on fishing for their livelihoods. In the Lake Chad Basin, these include the Buduma, who live on the islands of the lake, and the Kotokos. Other groups such as the Awori on the Ogun River, whose women fish intensively, are also dependent on fishing. Other groups are also fisher-farmers along the Niger and Benue rivers and their tributaries, or on the rivers forming the Yobe upstream from Lake Chad. Several groups have settled around reservoirs because of the loss of productivity of the floodplains downstream of the dams, but some communities have succeeded in having the creation of dams abandoned so that they can maintain all their sources of livelihood (IUCN, 2011). There is little information on recreational fishing in inland waters, although Embke *et al.* (2022) suggest that there may be over 200 000 people participating and that catches may be around 387 tonnes. Of these catches it is suggested that 43 percent is retained for consumption.

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Ghana

The inland waters of Ghana include most of the catchment area of the Volta rivers (Mouhoun, Nakambé, Nazinon and the Oti/Pendjari) as well as several coastal rivers, including the Tano, the Bia and the Pra rivers in the southwestern region. Lake Volta, impounded between 1961 and 1966, is the largest reservoir in the world, with a capacity of 148 km^3. Lake Volta in Ghana was created in 1964 with the completion of the Akosombo hydroelectric dam, creating an enormous reservoir of around 8 500 km^2. A major fishery developed soon afterwards, exploited by around 72 000 fishers in the late 1990s, and now probably numbering over 100 000. The traditional fishers who operated on the Volta rivers were joined by many others who gradually became professional. The lake is highly productive, with an annual yield of at least 300 kg per hectare and one of the highest effort densities recorded in African lakes and reservoirs. Reported landings are likely to be underestimated: according to FAO statistics, inland fishing generated 81 000 tonnes of fish in 2021, but other estimates suggest annual production may be at least 250 000 tonnes (van Zwieten *et al.*, 2011). About one-third of the catch is used for local consumption, while the remaining two-thirds is marketed in various forms throughout Ghana and within the region. The fisheries authorities provide no details on the composition of catches.

Ghana's fresh waters are home to a high level of biodiversity, with more than 210 species, at least 60 of which are important to fisheries. There are 9 endemic species, mainly found in the coastal rivers of the southwest, several of which are threatened by gold mining. As in floodplains, the size and composition of the fish community in Lake Volta is highly dependent on seasonal and inter-annual fluctuations in water levels. Each year, between 115 km² and 1 800 km² (average 640 km²) of the lake shore dries up and is then flooded, creating new habitats for fish. The annual flooding of large areas of land, which are grazed during the dry season, explains the high productivity as the waters of the river and reservoir are relatively low in nutrients. This means that interannual fish production fluctuates according to the size of the flow, similar to many floodplains.

The fishers around Lake Volta have adopted a wide variety of fishing gears over the years to exploit this production, some of which has been adapted from other river or lagoon fisheries, including various forms of pens designed to concentrate the fish known as *atidza* and *nifa-nifa*; gillnets with mesh sizes ranging from 25 mm to 195 mm used in different habitats; seines, including various forms of beach seine and purse seine; a wide range of more or less elaborate traps; longlines; handlines; harpoons; and hawks, among others (van Zwieten *et al.*, 2011). There are no details on any recreational fishing in Ghana. Fisheries management has shifted to a policy of co-management that recognizes the authority of traditional powers in the management of inland fisheries and their legitimacy in decentralized management bodies.

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Guinea

The mountain massifs and tropical climate make Guinea "the water tower of West Africa", the source of several of the region's main rivers, including the Niger, the Senegal and the Gambia. Guinea's available freshwater is estimated at 226 km³ per year and consists of a river network of 6 250 km with 1 161 watercourses. Around 12 percent of the country's total surface area is in the Senegal River Basin (Bafing and Bakoye), 39 percent in the Niger Basin (Niger, Mafou, Niandan, Tinkisso, Milo and Sankarani) and 49 percent in the coastal basins, several of which are shared with Guinea-Bissau (Corubal, Compony), Sierra Leone (Kolente/Great Scarcies), Liberia (Saint-Paul, Lofa, Mano) and Côte d'Ivoire (Cavally). The Konkouré is the main river whose basin is entirely located in Guinea. There are no natural large lakes, but Guinea does have several reservoirs, notably on the Konkouré (Kaleta, Souapiti and Garafiri), and larger dams are planned on the Niandan (Fomi) and Bafing (Koukoutamba). Biodiversity is high, with over 250 species of fish, 36 of which are endemic. Based on the average productivity indices for the various water environments (Lymer *et al.*, 2016), potential production of inland fisheries can be estimated at 24 000 tonnes, including in the reservoirs of the main dams. This is about half of the 42 000 tonnes reported to FAO in 2021.

In 2010, the National Fisheries Observatory received support from FAO to conduct a frame survey of inland fisheries throughout Guinea. The survey identified 555 fishing sites (villages and camps), mostly in the northeast of the country (Upper Niger Basin), and almost 13 000 fishers belonging to 6 150 households. Of these households, around 20 percent were full-time fishers owning pirogues and having no other source of income, 45 percent were fishers owning pirogues and engaged in agriculture as a secondary livelihood activity, and 35 percent were farmer-fishers without a pirogue This demonstrates that fishing is both on foot and with pirogue. Among the households surveyed, there were approximately 9 300 people engaged in fish processing (83 percent of whom were women). The survey also identified more than 6 000 fishmongers present at the fishing sites, as well as 600 pirogue builders and 275 fishing gear traders.

The total number of pirogues recorded is 7 350, with a very low rate of motorization. Pirogue ownership was limited to the fishing households that engaged in seasonal migrations following fish (see also Chapter 6). The number of fishing gears owned by households was estimates at almost 35 800, dominated by gillnets (25 percent of households), longlines (23 percent), cast nets (17 percent), isolated or dammed traps (16 percent) and drift nets (11 percent). The peak fishing season corresponds to the dry season, i.e. the period during which waters recede. During this season, full-time fishers will achieve catches of around 500 kg per week, compared with 130 kg for fisher-farmers and 50 kg for fishers on foot. In the less-productive periods, these yields are typically half as high, except for fishers on foot who fish for subsistence. According to survey estimates, total production is around 32 000 tonnes a year for the country as a whole, with 20 500 tonnes produced during the peak season. The Upper Niger region dominates with 60 percent of catches, followed by the coastal basins (30 percent).

The contribution of inland fisheries to food security is difficult to assess, as there is significant trade in fish from rivers to the coast and a reverse flow of marine fisheries products to inland fisheries regions. Considering only the population of the major fishing regions, annual per capita food availability is estimated to be around 7 kg in the Upper Niger and 4 kg in the forest basins. Traditional management methods are still in use in most regions, particularly among the Somono, the fishing caste within the Malinke people. However, there are signs of privatization of certain areas and the use of large collective fishing nets. Guinea is a member of the Niger Basin Authority (NBA), the Organisation for the Development of the Gambia River (OMVG) and, since March 2006, the Organisation for the Development of the Senegal River (OMVS).

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Côte d'Ivoire

The hydrographic network within Côte d'Ivoire is extensive, with the Cavally (forming the border with Liberia), Sassandra, Bandama and Comoé rivers – the main courses of which are over 3 500 km long. Côte d'Ivoire also has several large reservoirs (incuding the Kossou on the Bandama and Buyo on the Sassandra) totalling almost 170 000 ha, as well as numerous small lakes. There are also extensive brackish coastal lagoons totalling around 120 000 ha. Based on the productivity indices of the various freshwater environments (Lymer *et al.*, 2016), the inland fisheries production potential can be estimated at between 40 000 and 42 000 tonnes per year. Biodiversity is high, with 200 species of fish recorded, including 13 endemic species. The production potential of rivers and reservoirs is threatened by activities other than fishing, including intensive deforestation in recent decades, as well as by pollution from the agricultural and mining industries in certain regions.

The most recent frame survey was carried out in 2012 as part of a regional initiative along with other UEMOA countries. This survey suggested that participation in inland fisheries and lagoon fishing involved around 21 000 people belonging to 12 700 households spread across 1 350 sites, half of which are villages. Around 15 percent of these sites are located around the coastal lagoons. Fishing is mainly carried out by full-time fishers, although almost half of all households have other livelihood activities (principally farming or livestock rearing). In 70 percent of households, at least one member is involved in fish processing or marketing. Around 15 percent of households only fish for subsistence and not for commercial purposes. The majority of these fishers are Ivorian (58 percent) and Malian (28 percent) and belong to the Akan, Bozo (Malian), Krou and Mande peoples.

Fishing is from pirogues and on foot and there are an estimated 11 400 pirogues (plank and dugout canoes). The motorization rate is very low (2.3 percent) and mainly relates to pirogues operating in the coastal lagoons. The principal fishing gears include set nets (33 percent of households), followed by traps (19 percent), longlines (17 percent) and cast nets (12 percent). Mesh sizes and hook sizes vary significantly from region to region. In more than half of households, the catch is sold directly by the fishers, but it may also be given to another member of the household for sale and, more rarely, for processing. The main preservation method is smoking, which is practised in 80 percent of cases and at all times of the year. The majority of landing sites have no fishing support equipment or services, and the fishers' settlements have limited access to education, health and drinking water infrastructure and services.

The main fishing season is from August to January, when the fishing effort is between five and seven trips per week when catches per trip vary between 15 and 30 kg, compared with three to five trips at other times when catches per trip rarely exceed 10 kg. According to the 2012 frame survey, total production is estimated at between 35 000 and 44 000 tonnes per year, excluding around 6 000 tonnes in coastal lagoons. These values are consistent with declarations made to FAO since 2014 and the 31 840 tonnes reported in 2021. The composition of the catches from the survey includes more than 20 fish families.

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Cameroon

Cameroon's surface waters cover around 14 000 km², 10 000 km² of which are floodplains, and the remaining permanent waters, including lakes and rivers. The country is situated on four major basins. The Atlantic Basin, which is unique to Cameroon, comprises three groups of rivers including the western coastal rivers (Mungo, Wouri, Manyu), the Sanaga, which is 920 km long and drains a basin of around 140 000 km², and the southern coastal rivers (Nyong, Kienké, Lobé, Ntem). The remaining three are also shared basins, consisting of the Congo (several tributaries of the Sangha), the Niger (mainly the Benue and its tributaries) and the Chad (mainly the Logone and Mayo). The north of Cameroon contains part of the Yaérés floodplain, itself part of the Lake Chad Basin, and between 8 and 40 percent of the surface area of the lake, depending on how much of Lake Chad is flooded. Cameroon also has several natural lakes and several reservoirs, the largest of which is the Lagdo reservoir on the Benue, which is subject to heavy sedimentation. Other existing dams are located on the Sanaga and its tributaries and the surface area of existing reservoirs exceeds 2 000 km².

Biodiversity is very high, with over 600 species of fish identified in all regions of Cameroon, including at least 120 endemic species. Based on estimates of the productivity of the various existing freshwater environments (Lymer *et al.*, 2016), the potential annual production can be estimated at more than 90 000 tonnes. When compared with the 31 550 tonnes reported to FAO in 2021, this reported figure is low compared to the estimates of the other countries bordering Lake Chad and local observations of reservoirs and flooded forest fishing (Ottaviani, De Young and Tsuji, 2017).

The estimated number of fishers is 177 000, including those involved in processing and marketing. The extent and diversity of the fishing areas is large and includes fishing in Lake Chad itself, the floodplains of the Logone, in rivers, both natural and artificial lakes, as well as the flooded forests in the south of the country. The latter are exploited by the Baka and the Fang peoples in the Ntem river. One very special form of fishing of note is canal fishing in the Yaérés, which involves digging channels to direct fish towards traps as the river waters recede. This form of fishing, which used to be communal, is now increasingly practised by family or private groups and has led to numerous conflicts, particularly between the Kotoko and Mousgoum people.

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Benin

Benin has a relatively narrow marine coastline and the hydrographic network is fairly dense, with a total surface area of 130 000 ha spread over four main basins: the Ouémé River (412 km long) and the Kouffo (125 km long) are located entirely within Benin, while the Niger River forms the border with Niger (120 km) and the Mono (425 km) forms the border with Togo. There are also around 300 dams and reservoirs associated with these rivers, some of which are used for fish farming and some which are enhanced through stocking. The inland surface waters also include a vast group of brackish coastal lagoons (around 30 000 ha). Natural productivity is enhanced in several environments by extensive (and growing) numbers of brush parks (*acadjas*) and *whedos* (ponds that retain trapped fish that are fed and harvested later in the season). Such structures occur along the West African coast in Ghana, Togo and Nigeria, but are nowhere as developed as in Benin. Benin is home to 155 species of freshwater fish, including 2 species endemic to the central swamp forests. The production potential has been estimated at 28 000 tonnes per year for freshwater bodies (excluding coastal lagoons) and this corresponds closely to the 29 000 tonnes of inland fish production reported to FAO.

The frame survey carried out in 2012 (UEMOA, 2013) identified around 690 fishing sites, the vast majority of which were villages and permanent camps, spread mainly over the lagoons and along the Ouémé and Mono rivers. The survey also identified 40 500 households fishing in the river-lake and lagoon systems, representing 82 900 fishers. Some 80 percent of fishers were men and the majority of households (over 70 percent) also engage in another activities including agriculture and livestock raising. Fish processing and marketing are can also be important activities and 65 percent of fishing households reported that at least one member is involved in fish processing or marketing. The majority of fishers are nationals of Benin, typically belonging to the Fon and Adja peoples, although fishers from other countries can be found in areas bordering the Niger and Nigeria. The canoe fleet operating on the inland waters comprises 52 500 craft, of which only 11 percent are motorized, mainly operating in the lagoons. Gillnets (35 percent) are the most frequently used gear, followed by traps (20 percent), cast nets (18 percent) and longlines (16 percent). Mesh size and hook size vary greatly between regions.

The period from October to January, which corresponds with the receding water, is the most productive fishing season in all regions. Fishing activity never exceeds six trips per week, even in the most productive times but can go down to three in low season. Catches average between 15 and 30 kg per trip during the most productive season and up to 10 kg at other times. Average annual production estimated by the 2012 survey is 99 000–113 000 tonnes, which is much higher than the productivity estimate or the official data reported to FAO. This difference could be due to over-representation of the higher yields in the lagoon area (Ganvié), where *acadjas* are very common and hence typically have higher production. Fish is sold both fresh and processed. Fresh products are sold directly by the fishers in around 50 percent of cases. Smoking is the main form of processing and is practised all year round. Traditional forms of management are still widespread in river systems and floodplains. In the lagoons, however, there has been an increase in the privatization of space by certain groups through the installation of more and more permanent *acadjas*.

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Togo

There are three main river basins in Togo. Most of Togo lies in the Mono basin, whose estuary (a Ramsar site) borders Benin. To the west, the Oti (or Pendjari) marks the border with Ghana, where it joins the Volta. There are other small coastal rivers and a few coastal lagoons, but no major freshwater lakes. The largest reservoir (180 km²) is Nangbeto on the Mono, but several others are planned. There are some 115 species of fish, 2 of which are endemic.

The frame survey carried out in 2012 identified around 220 fishing sites, one-quarter of which are on the Nangbeto reservoir. These sites are occupied by 3 650 households. Less than 10 percent of fishing households are full-time fishers. Instead the majority practice diversified livelihoods that include agriculture or livestock raising. Over 75 percent of these households also have a member who processes or trades in fish. Fishing is essentially a commercial activity for households, and in more than half the cases the fish is sold directly. Half of the households involved in processing use smoking and do so all year round. Other techniques (drying and fermentation) are much less common. The vast majority of fishing households are Adja-Evé, but there are also a few Beninese and Ghanaian fishers. Households in the north of the country are the most likely to make seasonal migrations for fishing, and almost 15 percent of housing sites have ponds where collective fishing is carried out. Traditional management systems are still operational in half of the sites, except for the lagoons.

Fishing is practiced using a wide variety of gears, the most common being gillnets, cast nets, longlines, lines and traps. Net mesh sizes are smaller in the south than in the north, while longlines are set with small hooks everywhere. The most productive fishing season is from June to August. Fishing effort never exceeds six trips per week during the most productive period and four at other times. Yields per trip are typically between 20 and 30 kg during the productive period and less than 10 kg during less-productive times. Total production has been estimated at between 11 500 and 15 000 tonnes per year, compared to production reported to FAO for 2021 of 6 300 tonnes. The species composition of catches is diverse, reflecting the variety of gears used and include *Lates niloticus* and species of bagrids, cichlids, *Heterotis* and *Labeo*.

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Sierra Leone

Sierra Leone has seven main rivers with a total length of around 2 160 km: the Great Scarcies (Kolente in Guinea, with which it forms the border), the Little Scarcies (whose source is in Guinea), the Rokel, the Taia (or Jong), the Sewa, the Moa, and the Mano River (which rises in Guinea and forms the border with Liberia). There are no significant floodplains. The main hydroelectric structure is the Bumbuna dam on the Rokel, and a second is to be built upstream of the first. There are many brackishwater lagoons but few freshwater lakes, the largest of which is Sonfon (260 ha). Sierra Leone has no Ramsar sites. Data are insufficient to estimate potential production. However, records of annual catches of around 16 000 tonnes provide an indication of the potential. According to FishBase (Froese and Pauly, 2024), 30 families of fish comprising around 160 species have been identified in inland water bodies, of which 14 are endemic. The main cause of environmental degradation of aquatic environments is mining and logging.

In 2018 the total number of fishing sites on inland waters was 154, occupied by about 1 000 households (MFMR, 2019, cited in Kemokai, 2019). This represents a rapid increase from 54 sites in 2010. Production data have not been reported to FAO for several years and estimates of around 2 000 tonnes per year (1 940 tonnes in 2021) are likely to be underestimates. Several groups of people are involved in fishing activities, but the Temne are known for fishing throughout the year, drying their catch and are involved in trading much of it. In other groups, fishing is mainly for household consumption, with only between 10 and 20 percent entering local markets. The primary gears used are gillnets, traps and weirs, longlines and hook and line. The dominant species in catches include cichlids (60 percent), clariids, notopterids and claroteids. Mullets also contribute to catches in estuarine and lagoon areas (Kassam *et al.*, 2017).

In many parts of Sierra Leone, traditional leaders impose temporary area closures (MFMR, 2017). In some areas, fishers use individual marks to identify their gear in collective fishing areas (Lohmeyer, 2002). On the Moa River and certain lagoons, the management system is very elaborate. There are *nyeilolomui* (fish observers) who are responsible for monitoring, controlling and supervising fishing activities at community level. All the villages along the main rivers and lakes have such an authority, which is highly respected. The post is held for life, and the fisheries wardens are remunerated in kind or in cash on a voluntary basis by the fishers. Offenders are brought before the village chiefs, usually resulting in the confiscation of fishing gear and/or the imposition of fines (Lohmeyer, 2002).

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Equatorial Guinea

While there are no large rivers in the country, the mainland of Equatorial Guinea lies largely in the basin of the Mbini, a river that rises in Gabon under the name Woleu. The other major river is the Ntem, which also rises in Gabon and forms the border with Cameroon as far as its cross-border estuary, the Rio Campo. Both these rivers have small floodplains. To the south, a series of short rivers meet in the Rio Muni estuary, which borders Gabon. Biodiversity is relatively high, with around 115 species of fish, 10 of which are endemic.

Although no production figures are available, inland fisheries make a significant contribution to the food security of non-coastal populations. Potential annual yield has been estimated at 1 000 tonnes (Matthes cited in Vanden Bossche and Bernacsek, 1990). Estimates of production using consumption estimates (Balhabib *et al.*, 2016), have suggested that catches from inland and estuarine waters might be greater than this given the waterbodies and floodplain environments. With one exception, FAO has estimated production since 2001, with the 2021 estimate 1 000 tonnes. Data and information on inland fisheries in the country remain an important constraint.

There are no data on the number of fishers, but it is known that there is a long and intensive history of fishing in inland waters among several of the groups of people living in the country. The Balengue and Bissio use a wide range of catching techniques, including the construction of artificial pools in which women fish using hand nets or baskets. Among the Fang, who make up 80 percent of the population, the Mvae and Ntumu have a particularly rich nomenclature of inland water categories and their dynamics. They use over 30 different fishing techniques and gears, some of which, such as dam fishing, are practised only by women.

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Liberia

Liberia has six major rivers that drain 70 percent of its territory and originate from the Nimba Mountains in Guinea. These are: the Mano (forming the border with Sierra Leone), Lofa, St Paul, St John, Cestos and Cavalla (Cavally), which forms the border with Côte d'Ivoire. There are also several small coastal rivers that drain around 30 percent of the country. Most rivers are relative shallow and rocky, with numerous waterfalls that make them unsuitable for navigation. There are also vast areas of marshland in the inland valleys and numerous coastal lagoons, including Lake Piso, one of the largest brackish lagoons in West Africa and a Ramsar site. The total length of the rivers is 1 800 km, and the various freshwater bodies cover 15 050 km² (14 percent of Liberia's total surface area). The main hydroelectric dam is at Mount Coffee on the St Paul River and there are plans for further dams on this river. Potential annual inland fish production could be in the order of 4 800 tonnes, based on an average productivity level of 30 kg per hectare for rivers (Lymer *et al.*, 2016). Liberia's fresh waters are home to around 160 species of fish, 8 of which are endemic.

The fishing communities belong to a number of different groups, including the Krahn and Mano on the Cavally River, although their numbers are not known. Fishing is carried out using a variety of fishing gear, including gillnets, hook and line and traditional traps. Fishing targets a range of fish species and life stages at different times of the year and fishing involves both men and women. Crustacea (e.g. *Macrobrachium* spp.) can be important for women and are caught for sale (e.g. Sharkey, Arthur and

Daniels, 2021). Fishing households will often be involved in other livelihood activities, principally agriculture. The main fishing season is during the period that the waters recede, although in the rainy season coastal inland waters can become more important as the weather makes the marine fisheries less accessible, emphasizing the importance of lagoon and estuarine catches. However, it is possible that these are included in the marine fishery statistics and thus not reported as inland fisheries. Lagoon catches have been estimated to range between 3 970 tonnes and 7 100 tonnes per year (Belhabib *et al.,* 2013). Total annual inland capture fisheries production is estimated at 4 000 tonnes per year and the FAO estimate for 2021 is only 500 tonnes. However, there is no systematic monitoring to corroborate these estimates. Inland fisheries account for around 25 percent of the fish consumed by people living in rural areas. It should be noted that the first-ever frame survey of inland fisheries has been underway since June 2023 (Mr. Kpadeh, Director of Aquaculture and Inland Fisheries, National Fisheries and Aquaculture Administration, personal communication, 2023).

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Guinea-Bissau

Guinea-Bissau has a dense hydrographic network. The two longest rivers are the Corubal and the Geba, which have their source in Guinea. The other rivers, which have their basins entirely in Guinea-Bissau, are the Cacheu, the Mansoa, the Cacine and the Cumbijã (the Rio Grande de Buba is a ria with no significant freshwater source). All these rivers have estuaries that are home to predominantly marine fauna. The only freshwater bodies are therefore the upstream parts of the Corubal, Geba and Cacheu rivers (less than 200 km in Guinea-Bissau) as well as the small Lake Cufada (150 ha). Excluding the estuaries the total annual production potential can be estimated at 3 000 tonnes. There are around 100 species of freshwater fish, none of which are endemic.

The frame survey that was carried out in 2012 identified 60 fishing sites, 95 percent of which are located on the Geba and Corubal rivers. These sites are occupied by almost 800 households, all of whom are also engaged in agriculture activities and are involved in fish processing and marketing. Apart from a very small minority of fishers from Mali, the households are national and belong to the Fulani and Mandinga. These households own 470 non-motorized dugout canoes, although fishing involves both canoes and foot-based activities. The gears used include gillnets, seines and longlines. The mesh sizes of the gillnets are small and the hooks on the longlines are also small.

The main fishing season is during the dry season, from April to August. Fishing effort is generally low, with four to five trips per week whatever the time of year. Yields per trip vary and range between 20 and 30 kg during the main fishing season and do not exceed 5 to 6 kg at other times. Catches are dominated by silurids and cichlids. In 80 percent of cases, the catch is sold by a member of the household, if not directly by the fishers. The main processing method is smoking, which takes place all year round. Drying is rarely practised, and only in February and March. There is virtually no collective fishing. Estimates put total production at between 2 300 and 3 000 tonnes a year, 75 percent of which comes from the Rio Geba. This compares with the estimate provided by FAO of 150 tonnes.

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7.1.6 Africa Great Lakes

Country/territory	Inland capture fisheries catch (tonnes in 2021)	Percentage of global inland fish catch	Population (2021)	Per capita inland fish production (kg/cap/year)
Uganda	621 987	5.47	45 853 778	13.56
United Republic of Tanzania	414 105	3.64	63 588 334	6.51
Malawi	170 560	1.50	19 889 742	8.58
Kenya	103 090	0.91	53 005 614	1.94
Rwanda	32 094	0.28	13 461 888	2.38
Burundi	19 550	0.17	12 551 213	1.56

The Africa Great Lakes subregion includes three of the world's largest lakes (Lake Victoria, Lake Tanganyika and Lake Malawi) and several other major lakes. Some of these lakes have the highest levels of freshwater fish species diversity in the world, and several have experienced species introductions that have led to profound changes in ecosystems and trophic networks. Productivity has also been modified, with an increase in catches in all the countries in the area, first in the 1990s and then from the end of the 2000s with the development of several fisheries for small pelagic cyprinid, clupeid and alestid fish. The total declared production of these countries is 1 361 350 tonnes in 2021, which represents an increase of 29 percent on 2015 (1 053 694 tonnes) and a doubling of 2002 production. The share of small pelagic species, which averaged 15 percent until 2006, has increased significantly and now exceeds 50 percent.

Outside the Great Lakes, there are several river and floodplain fisheries. The fisheries in the subregion can be divided into three main categories: commercial management, of which the Nile perch (*Lates niloticus*) fishery is the main example, forms of co-management, principally based on the establishment of Beach Management Units (BMUs), as well as forms of traditional management, typically in the more dispersed fisheries of less commercial importance.

Uganda

Uganda lies entirely within the Nile Basin. The country has a vast system of permanent lakes (38 500 km²), a complex network of rivers (2 000 km) and vast expanses of permanent marshland and seasonally flooded areas (a total of 26 000 km² in 2008, according to the Ministry of Water and Environment). Uganda has 45 percent of the surface area of Lake Victoria (31 000 km²), 46 percent of Lake Albert (2 450 km²) and 29 percent of Lake Edward (675 km²). Lakes George (250 km²) and Kyoga (1 720 km²) are located entirely in Uganda. Lake Kyoga is very shallow and is more of a vast depression that is permanently flooded. In the early 2000s, it merged with Lake Kwania because of rising water levels. These lakes are connected by branches of the Nile and several other rivers, including the Katonga, Kafu and Nkusi. The rivers in the north of the country, notably the Achwa, feed directly into the White Nile (Al Jabal River). Only the Suam River, which marks the border with Kenya, belongs to the Lake Turkana Basin. Potential annual production is estimated at over 320 000 tonnes. Biodiversity is high, with 290 species, 21 of which are endemic. More than 75 species are considered vulnerable or critically endangered, notably among the cichlids of Lake Victoria. Apart from the Nile perch, half a dozen species have been introduced (carp, trout, pike and other tilapias).

If an attempt is made to estimate the total fisheries potential using productivity parameters by type of environment (Lymer *et al.*, 2016), the result is approximately 320 000 tonnes per year. In reality, the productivity of the Great Lakes is much higher than what was estimated before the development of small pelagic fisheries (Kolding *et al.*, 2019), which have become dominant in lakes Victoria and Albert. The reported catch data for 2021 of over 622 000 tonnes are therefore entirely realistic. According to FAO (FAO, 2023), half of these catches come from Lake Victoria, 37 percent from Lake Albert and 9 percent from Lake Kyoga. However, it is highly likely that catches from Lake Edward are underestimated, and that the 4 percent attributed to other water bodies and wetlands completely overlook subsistence fishing in marshes and wetlands.

In 2021, the official catches were made up of 44 percent small pelagics, including cyprinids (*Rastrineobola argentea*) and alestids (*Brycinus* sp.), 15 percent Nile perch (*Lates niloticus*) and 10 percent cichlids. Except on the larger lakes, where fishing techniques are highly mechanized and use light attraction, traditional fishing techniques are still widely used in rivers and floodplains, involving a wide range of different gear, including weirs and traps. It is estimated that 70 percent of the small pelagic fish caught are used as animal feed or exported to Kenya for the same purpose. The actual annual per capita availability of fish is therefore much lower than it could be (above 12 kg), and actual consumption depends largely on the proximity of small-scale fishing areas. Nevertheless, it is estimated that over one-third of Ugandans rely on fish for protein (FAO, 2023).

According to the most recent estimates (FAO, 2023), there are almost 280 000 full-time fishers and over 217 500 subsistence fishers, the majority of whom are women. The groups most heavily dependent on fishing for their livelihoods include the Twa and Basua in the forest areas bordering the DRC (Semliki river), and the Baruli, Kenye and Kuku in the Victoria Nile plain and Lake Kyoga. There have been recurring conflicts between these communities and national park managers over access to fishing areas.

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The United Republic of Tanzania

The United Republic of Tanzania is located on 21 basins, including the Nile, Zambezi and Congo. Of these 21 basins, 10 of them flow into the Indian Ocean and drain half the country, while the others are endoreic. Inland waters account for approximately 64 000 km², including large parts of the shared Great Lakes, Lake Victoria (51 percent), Lake Tanganyika (46 percent) and Lake Malawi (20 percent), as well as other lakes located entirely within Tanzania, many of which are endoreic and alkaline, such as Rukwa, Eyasi, Natron, Manyara, Balangida and Burigi, and have a reduced fish fauna. There are also several small freshwater lakes in the Lake Victoria region and in the Pangani River Basin. The main rivers are the Rufiji (and its tributary Kilombero) and the Pangani, whose basins cover 68 000 km² and 44 000 km² respectively. The main tributary of Lake Tanganyika is the Malagarasi River, while the Ruhuru River is the main tributary of Lake Malawi. There are many wetlands, with the largest marshes located in the Malagarasi and Rufiji basins. The river system has 13 dams, of which Mtera, Kidatu and Nyumba ya Mungu are the largest. Potential annual inland fisheries production is estimated at over 450 000 tonnes. Biodiversity is high, given the Tanzanian portion of lakes Malawi, Victoria and Tanganyika, with nearly 900 species of fish, including around 100 endemic species, notably cichlids. Nearly 200 species are threatened.

The inland fisheries are currently exploited by an estimated 130 000 fishers, operating 42 000 small canoes. The main groups of fishers are from the Luo on Lake Victoria, the Nyakyusa on Lake Malawi and the Ngendereko on the Rufiji and Kilombero. Over the last two decades, production has varied minimally around an average of 300 000 tonnes per year, two-thirds of which comes from Lake Victoria. Total catches have been rising since 2019, reaching 414 105 tonnes in 2021. Catches are dominated by two species: the Lake Victoria sardine *Rastrineobola argentea* or dagaa (a cyprinid) with production of 136 700 tonnes in 2021, destined for regional markets after drying, and the Nile perch (*Lates niloticus*), production of which was around 132 000 tonnes in 2021. Nile perch is the subject of a low value-added processing industry (filleting and freezing) in which 12 private companies operate. Processed fish is mainly destined for export outside the African continent. There is also a major fishery targeting sardines and sprats from Lake Tanganyika (*Stolothrissa tanganicae* and *Limnothrissa miodon*), known collectively as dagaa in Tanzania but also as kapenta/matemba (with production of around 48 000 tonnes in 2021). Finally, a small fishery on Lake Malawi involves the cyprinid *Engraulicypris sardella* or usipa, which amounted to 5 600 tonnes in 2017, representing one-third of Tanzania's total catch in the north of Lake Malawi.

Outside of the lakes, river fisheries are very important for food security, particularly in the floodplains of Kilombero and Rufiji, as well as in the delta. These fisheries have not been assessed recently, but have an estimated production of at least 20 000 tonnes. However, the fisheries of the Rufiji and in particular its delta have been impacted by the dams on the Rufiji, which have greatly reduced flooding and therefore fish abundance, as well affecting other livelihood activities and opportunities of the local populations.

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Malawi

Lake Malawi/Nyassa, with a surface area of 30 800 km², covers 20 percent of the country and more than half of the lake is under Malawi's jurisdiction. Lake Malawi is a deep Rift Valley lake (maximum depth 758 m) and the richest fishing grounds are those located in Malawi. Lake Malawi's tributaries in Malawi include the South Rukuru, with a basin of 12 110 km², and the Bua and Linthipe rivers, with basins of 10 700 km² and 8 560 km² respectively. There are ten large reservoirs for urban water supply and limited irrigation capacity. Other lakes include Lake Malombe (390 km²), to the south of Lake Malawi, which is a shallow lateral expansion of the River Shire. Lake Chilwa is an endoreic lake with extreme variations in water level such that it can dry up almost completely in some years, but can extend to 2 590 km² at its highest water level, when surrounded by an additional 1 000 km² of marshland. Its average surface area is around 750 km². Lake Chiuta is a smaller endoreic lake and covers around 200 km² when full. The Shire River (520 km is the country's main waterway, flowing from Lake Malawi into the Zambezi. Most of its course is in Malawi and the river floods vast areas to form the Elephant Marsh and Ndinde swamps, which are also fed by the Ruo River that forms the border with Mozambique. The total system covers around 1 030 km² at high water, but is reduced to 480 km² at low water. There are three operational hydropower dams along the Shire River, Nkula, Tedzani and Kapichira, with a combined capacity to generate 339 MW of electricity. A fourth, Mpatamanga (350 MW potential), and fifth, Kholombidzo (100 MW potential), have been proposed. Together, the three existing dams and their operation, as well as water abstraction for agriculture, affect natural flow variability along the river, reducing both wetseason flooding and dry-season drying of habitats (Brown *et al.*, 2022).

Lake Chilwa and the Elephant Marsh are the two Ramsar sites in Malawi to date. Potential national inland fisheries production can be estimated at 136 000 tonnes per year based on average productivity indices for different freshwater environments (Lymer *et al.*, 2016). This compares to the figure reported to FAO in 2021 of 170 560 tonnes. The difference may be due to the fact that the productivity of African Great Lakes is much higher when small pelagic fisheries are developed (Kolding *et al.* 2019).

Lake Malawi has high biodiversity and is home to more than 1 000 species of fish, including 800 cichlid species, 99 percent of which are endemic. The biomass of offshore pelagic fish in Lake Malawi has been estimated at 168 400 tonnes. This biomass is dominated by cichlids (81 percent) but also includes catfish (15 percent) and cyprinids (4 percent). Potential yields from Lake Malawi are low due to a particular feature of the lake's ecosystem. It has been shown (Menz, 1995, cited in Kolding *et al.*, 2019) that more than half of adult pelagic fish production is based on consumption of fly larvae (*Chaoborus edulis*) rather than direct consumption of herbivorous zooplankton. This additional step in the food chain results in a less efficient conversion of primary production into fish (Allison, 1995, cited in Kolding *et al.* 2019).

The total number of boats on Lake Malawi has been estimated at nearly 16 000, mainly pirogues. Large-scale mechanized fishing is carried out in the south of the lake, targeting small pelagics using the *chilimira* net, a technique unknown in the other Great Lakes. This is a conical seine net, 20–90 metres wide and 5–50 metres high. The mesh size of the bag ranges from mosquito netting to 25 mm. The gear is used at night with lights to catch the small cyprinid, *Engraulicypris sardella,* known as usipa. The gear is towed by two pirogues and a plank boat with a total crew of nine. During the day, use of the net targets the larger pelagic haplochromine cichlids, the utaka, as it can be quickly prepared for this purpose by removing the mosquito net bag. Utaka fishing is mainly practised in the shallower southern arms of Lake Malawi. A total of 3 124 *chilimira* nets were counted throughout the Malawian part of the lake during the 2015 frame survey, including 675 nets in the southeastern arm alone.

Total catches from Lake Malawi rose between the early 2000s and the early 2020s, from 40 tonnes in 2001 to more than 220 000 tonnes in 2018, apparently stabilizing at around 170 000 tonnes since then. The evolution of artisanal catches is characterized by a gradual replacement of larger species (tilapiine cichlids, clariids) by smaller species (haplochromines and usipa). Catches of cichlids have doubled from 26 000 tonnes in 2001 to 50 000 tonnes in 2021. Over the same period, catches of usipa have risen from 6 000 to 100 000 tonnes, with a reported peak of 150 000 tonnes in 2018. Most of these catches are made up of small fish that are dried in the sun. A recent study (Torell *et al.*, 2020) estimated post-harvest losses in 2017 at around 11 000 tonnes at the various stages of the value chain, i.e. around 5.5 percent of catches. According to the latest frame survey, inland capture fisheries directly employ around 60 000 fishers and indirectly more than 500 000 people in the processing and marketing of fish as well as the construction and repair of boats and engines.

Outside of the lakes, the importance of river fisheries and flooded areas should be emphasized, in particular the Elephant Marsh, which are home to around 1 500 fishers. Catches in this region vary depending on the extent of flooding and are estimated at between 2 000 and 12 000 tonnes a year, with an average of around 8 500 tonnes. Various types of fishing gear are used, including traps and hand nets in the northern parts of the marsh and gillnets in the more open water areas in the south. Daily yields from the Elephant Marsh are estimated at 11 kg per fisher. The fish is processed at landing sites and accounts for up to 3 percent of the food consumed by an average household (Forsythe and Turpie. 2016).

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Kenya

Kenya is particularly rich in surface freshwater, largely influenced by the Great Rift Valley containing five drainage basins. This includes 6 percent of the surface area of Lake Victoria (4 130 km²), almost all of Lake Turkana (7 500 km²) and several other medium-sized lakes including Baringo (160 km²) and Naivasha (140 km²). Lake Naivasha is also a Ramsar site, although the introduction of the common carp has altered the ecosystem. Kenya also has a river system dominated by the Tana River (950 km) and its delta which covers over 1 300 km², and the Galana River, major tributaries of Lakes Turkana and Victoria. There are more than ten reservoirs, including on the Tana (Gitaru, Kumbaru, Masinga) and the Turkwel rivers. Other major rivers have their source in Kenya, notably the Ewaso Ng'iro, which joins the Jubba-Shebelle system under the name Lagh Dera in Somalia. The main wetlands and floodplains are located on the Ewaso Ng'iro and the lower Tana rivers, covering an area of over 3 000 km². Potential production based on aquatic ecosystem productivity (Lymer *et al.*, 2016) is estimated at 120 000 tonnes per year, but productivity will be affected by the high variability of catches in Lake Turkana and the impact of hydroelectric dams on floodplains. Catches reported to FAO for 2021 were 103 090 tonnes. Biodiversity is high, with around 350 species of fish, 27 of which are endemic.

Inland fishery production rose dramatically with the development of the Nile perch (*Lates niloticus*) fishery in Lake Victoria and then afterwards with the development of the silver cyprinid (*Rastrineobola argenta*) fishery. Inland fisheries are dominated by catches from Lake Victoria (80 percent of production), while catches from rivers and small lakes are estimated at 2 percent of national production. There has been no recent census of inland fisheries although available data indicate that there are over 45 000 fishers on Lake Victoria and about 3 000 fishers on Lake Turkana (ACARE). The main groups of people fishing are the Luo on Lake Victoria and the Pokomo on the lower Tana River. The main fishing techniques include night netting for small pelagics (dagaa) and various types of nets and lines for Nile perch. Inland fish catches amounted to 98 000 tonnes in 2020, after peaking at 150 000 tonnes in the early 2010s. These catches are dominated by Lake Victoria sardines (omena/dagaa/mukene), whose production has been steadily increasing throughout the lake and reached 54 000 tonnes in Kenya in 2020. The other major species are Nile perch, which has been declining steadily for two decades (19 000 tonnes in 2020) and tilapia (also 19 000 tonnes in 2020). The River Tana has been affected by hydroelectric dams and associated water management that has reduced the effect of flooding. This has affected the fisheries, including in the ways that fishers have gradually shifted from using traditional fishing gears to gillnets.

Fish processing industries are mainly located on the shores of Lake Victoria. Some 20 units process some 25 000 tonnes of raw product annually, mainly Nile perch for export as frozen fillets. Exports, long dominated by the trade in frozen Nile perch fish fillets, have declined from 20 000 to around 8 500 tonnes over the past two decades. Reflecting the changes in the fishery, exports are also now instead dominated by traditionally processed products (salted/dried and smoked) supplying the regional market. Imports are dominated by fresh and frozen products (mainly tilapia) for direct human consumption. The total quantity of products available has not changed over the last 20 years, at around 150 000 tonnes per year, although the share of inland fisheries has decreased. While fish availability has been stable, the population has been growing, leading to a decline in average annual per capita fish consumption from 4–5 kg in the 2000s to less than 3 kg in 2020. Average consumption figures also mask the strong regional differences in fish, and inland fish, consumption. There is a small amount of recreational fishing estimated to be almost 5 000 participants (0.01 percent of the population). Catches are estimated to be only around 10 tonnes annually (Embke *et al.*, 2022).

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Rwanda

Rwanda's surface waters consist mainly of several dozen freshwater lakes inserted in vast wetlands covering about 1 000 km². The majority of these lakes belong to the Akagera River Basin (a tributary of the Nile River) and are located at an altitude of over 1 200 m. They are temperate lakes with an estimated total surface area of 345 km². The other lake system consists of the Rwandan part of Lake Kivu (42 percent of the lake covering an area of 995 km²), which is shared with the Democratic Republic of Congo and is located in the Congo Basin, a very deep basin rich in nutrients. The river system also includes the Ruzizi River, which links Lake Kivu to Lake Tanganyika. Additionally, Rwanda has many small reservoirs.

The primary productivity of Rwanda's lakes is low (oligotrophy) and their fish diversity is also low, with an average diversity of 30 species per lake, and a total of 71 native species including 3 endemic species at the national level. In addition, at least 10 species have been introduced since the 1950s for repopulation or breeding purposes. The fish targeted by capture fisheries are mainly composed of small species that are highly resilient to fishing. The only large species targeted are predatory *Clarias* catfish. The ecology and fishing in the Kivu have been the subject of several recent studies (including Guillard and Richard, 2017; Darchambeau, Isumbisho and Descy, 2012; Snoeks *et al.*, 2012). The ecology and fisheries of other lakes have been studied much less, apart from Lake Ihema which has been the subject of an in-depth monograph providing recommendations for fisheries management (Plisnier, Franck and Micha, 1988). An estimated 7 500 fishers operate on all the lakes of Rwanda, fishing on foot or using dugout canoes, of which there were an estimated 1 200 in 2017 (Kolding *et al.*, 2019). A variety of fishing gears are used, including gillnets, longlines, traps and cast nets and many are traditional types.

Generally yields are low (Balagizi *et al.*, 2017) and total fishing catches in Rwanda are estimated at 32 094 tonnes in 2021. This is higher than the 24 000 tonnes in 2018 (Kolding *et al.*, 2019), of which a little less than 10 000 tonnes came from Lake Kivu. Lake Kivu is an important fishery where the main species targeted is the Tanganyika sardine (*Limnothrissa miodon*), locally called isambaza, that was introduced in 1959. This small pelagic represents on average 70 percent of the catches in Lake Kivu, while catches from other lakes are made up of tilapias, carps, catfish and lungfish (the latter also introduced). Most fish are consumed or sold fresh, except when catches are very important or when markets are quite far from the landing site. The main form of processing is drying for small species, especially isambaza. Other species and especially catfish may be smoked, but this is typically in relatively small quantities. Average annual per capita fish consumption remains modest at 7 kg, although it has risen from 1.3 kg in 2010 (Kolding *et al.*, 2019).

Rwanda's lakes are not very productive and, due to the very small number of species present, food webs are simple and vulnerable to natural or anthropogenic changes such as pollution, degradation of shoreline habitats (where most species reproduce) or excessive fishing pressure. In several lakes, the introduction of species has taken place without any monitoring (MINAGRI, 2011), which may have caused changes in the ecosystems. The productivity of Rwanda's lakes could change with the effects of ongoing climate change, including increases in water temperature, changes in rainfall patterns with prolonged droughts or, on the contrary, extreme rainfall (Balagizi *et al.*, 2015). In addition to the effects on fish biology (growth and reproduction), indirect effects of climate change may result in bank erosion, leading to eutrophication in some lakes, habitat modification and reduced primary productivity.

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Burundi

Burundi's aquatic environments include part of Lake Tanganyika (8 percent of the total surface area, or around 2 200 km²) and Lake Rugwero (100 km²). The main watercourses are parts of the Ruzizi and Malagarasi rivers (tributaries of the Tanganyika) and the Kagera (a tributary of Lake Victoria), as well as almost 1 200 km² of swamps. Based on estimated aquatic productivity, potential inland capture fisheries production is estimated at between 22 500 and 27 500 tonnes. This is not inconsistent with the production figure of 19 550 tonnes in 2021. Biodiversity is high with nearly 250 species of fish recorded. However, the fisheries typically target a small number of species, with the main species fished are the two Lake Tanganyika sardines, lumpu (*Limnothrissa miodon*) and ndagala (*Stolothrissa tanganicae*), as well as predators (*Lates* spp.) of the Nile perch family.

The fisheries are mainly small-scale and, according to the last census conducted in 2015, the number of canoes amounted to about 1 640 and the number of fishers to 11 600. This represents a continued increase compared to the censuses conducted in 2001 and 2011 when the number of canoes was 460 and 730 respectively, and the number of fishers was 3 000 and 8 200 respectively. In 2015, some 90 percent of the canoes were motorized using various gears, while the non-motorized catamarans used large dip nets (*apollo*) and lights (*lamparos*) for night fishing. Capture fisheries production over the last 20 years has seen fluctuations between 10 000 and 15 000 tonnes per year but has stabilized at around 20 000 tonnes per year since 2015. Over around the same period, fishing effort has quadrupled and effort has been shifting from the two small pelagic species to other species, particularly predators such as Nile perch.

Burundi remains a net importer of fish. These imports began only about ten years ago and remained stable at between 2 500 and 3 000 tonnes per year, but more recently has increased to around 5 000 tonnes in 2020. These imports are almost exclusively dried and smoked products from the United Republic of Tanzania and Uganda. Some fish is also imported from China. The only fish products exported by Burundi have been ornamental fish but since 2017 this trade seems to have stopped. Combining capture fisheries production, aquaculture and imports, total food availability is estimated to have increased from less than 10 000 tonnes in 2001 to 26 000 tonnes in 2020. This equates to an apparent average annual per capita consumption of fish of below 2.5 kg.

There are several threats to the fisheries sector, including changes in the rainfall regime (drought and/or increased erosion) as well as increased surface water temperatures. These changes may affect the primary productivity of Lake Tanganyika and consequently its overall productivity and the availability of fisheries, especially sardine populations. Another threat is related to the impacts of hydroelectric and hydroagricultural developments on the lake's tributaries, including projects on the Kagera and Ruzizi rivers, and the risks of pollutant release from urban development and hydrocarbon exploration.

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7.1.7 Congo Basin

Country/territory	Inland capture fisheries catch (tonnes in 2021)	Percentage of global inland fish catch	Population (2021)	Per capita inland fish production (kg/cap/year)
Democratic Republic of the Congo	220 500	1.94	95 894 118	2.30
Congo	39 128	0.34	5 835 806	6.70
Central African Republic	28 000	0.25	5 457 154	5.13
Gabon	11 160	0.10	2 341 179	4.77

The Congo Basin subregion is made up of countries associated with the central African rivers system and located in the basins of the Congo, Oubangui, Sangha, and Ogooué rivers. The rivers in the northern half of the Central African Republic are tributaries of the Chari system. Monitoring of inland fisheries is virtually non-existent, and FAO has regularly estimated catches in these countries over the last ten years. Fisheries production is very likely to be underestimated, particularly in the Democratic Republic of the Congo, where the potential is considerable regardless of the approach used to estimate it. Subsistence fishing is widely practised due to the proximity of water bodies in most regions.

The Democratic Republic of the Congo

The surface freshwaters of Democratic Republic of the Congo include a large number of lakes with a combined surface area of 28 000 km², including significant portions of several Great Lakes (Edouard, Albert, Kivu, Tanganyika and Mweru) shared with neighbouring states to the east. These freshwaters are dominated by the rivers and floodplains of the Congo River Basin, 64 percent of which (2 450 000 km²) is located in the Democratic Republic of the Congo. This basin includes more than 34 000 km² of rivers and more than 60 000 km² of permanently or seasonally flooded areas (Welcomme and Lymer, 2012). The most notable shared sub-basins are the Oubangui (shared with the Central African Republic and the Congo), the Kasai and the Kwango (Angola). The largest flooded areas are found in the Cuvette Centrale at the confluence of the Oubangui and Kamalondo on the Luapula. Biodiversity is high and the Congo River Basin alone contains more than one-third of the 3 200 species of freshwater fish on the African continent, but inventories of aquatic biodiversity in the Democratic Republic of the Congo are old and incomplete.

As in most floodplain river systems, fishing is combined with other livelihood activities and practised by a large proportion of the rural population as a seasonal subsistence activity, as well as by full-time fishers for commercial purposes. The total number of fishers was estimated by FAO in 2017 at over 440 000. Fishing techniques are extremely diverse, adapted to all types of environment and fish life histories, and are practised on foot or with boats – of which there are an estimated 67 000, 16 000 of which are motorized.

The annual productivity of the Congo River system is high and has been estimated at 178 tonnes per cubic kilometre, which represents an exploitable potential of more than 700 000 tonnes (Funge-Smith, 2018). An estimate of the same order of magnitude (620 000 tonnes) was obtained using estimates of annual productivity by aquatic environment type based on Lymer *et al.* (2016). Catch statistics reported to FAO are lower than these estimates and average 230 000 tonnes over the last ten years, with a catch of 220 500 tonnes reported for 2021. This is likely a result of under-reporting as it equates to the predicted production for the Congolese part of the Great Lakes alone. Indeed, a census carried out in 2018 on Lakes Edward and Albert estimated the number of fishers on the Congolese shores of these two lakes at approximately 40 000. A survey conducted in 2019 and 2020 on the catches of these fishers in the Congolese part of the two lakes provided an estimate of 29 000–39 000 tonnes for Lake Edward and 41 000–47 000 tonnes for Lake Albert. There are no equivalent data for the parts of lakes Tanganyika, Kivu and Mweru within the Democratic Republic of the Congo. Total annual fish production in the Democratic Republic of the Congo may therefore be over 1 million tonnes, as suggested by Fluet-Chouinard, Funge-Smith and McIntyre (2018) using household consumption estimates.

There are two main fishing seasons, the first of which corresponds to low water, running from July to November (with its peak in September) and then from March to April, for a total of seven months annually. A survey carried out in 2020 with the support of FAO gathered social and economic information on fisheries in nearly 190 sites in eight regions of the country (Equateur, Haut-Katanga, Haut-Lomami, Kasaï, Kwilu, Maï-Ndombe, Sud-Kivu and Tshopo). According to the survey, most fishers (85 percent) migrate on a seasonal basis. Fishing techniques and management methods vary enormously due to the diversity of environments and people involved in fishing. In the basin, depletion fishing in artificial ponds, particularly practised by women, has been documented by several authors (Béné *et al.*, 2009; Comptour, Caillon and McKey, 2016).

The estimated per capita annual consumption of 5.7 kg appears to be an underestimate and may not fully account for the contribution of the extensive subsistence fishing in the country as well as other products imported via the informal market. In addition, fishing is not uniformly distributed so the average consumption figure can mask the very wide regional disparities in the availability of fish products. According to a recent study in the markets of Kinshasa (Swana *et al.*, 2019), the price of imported fish is much lower than that of locally caught fish, partly due to the difficulty of supplying fish products to the urban centres. Large flows of fresh or processed fish products for these markets come from South Sudan, Zambia and Angola.

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The Congo

The surface waters of the Congo essentially belong to two basins. One is the coastal basin of Kouilou-Niari and the other the Congo River Basin – notably the Lower and Middle Congo (Pool Malebo region), the Sangha (which rises in Cameroon) and the Oubangui (which forms the border with the Democratic Republic of the Congo to the north). Other major rivers such as the Likouala and Likouala-aux-herbes join the Congo at the same level as the Sangha. Finally, the Ogooué and several of its tributaries have their source in the western part of the Congo (Batéké plateau). The northern half of the country is covered by a dense hydrographic network covering almost 140 000 km², half of which is marshland and flooded forest (Cuvette Centrale). Some 45 000 km² of this network is shared with the Democratic Republic of the Congo. There are also numerous small lakes along with the Conkouati, Loubi and Malonda coastal lagoons. Biodiversity is very high, with at least 400 species of fish identified, including 40 endemic species belonging to ten different families.

Inland fisheries in the Congo are concentrated mainly in the northern half of the country along the Congo River and the Sangha Basin. The annual production potential of continental fisheries based on aquatic ecosystem types (Lymer *et al.,* 2016) is estimated at 100 000 tonnes per year, but fishing pressure remains low, particularly in the Likouala region where population density is very low. The General Census of Agriculture carried out between 2014 and 2017 recorded more than 31 000 households engaged in fishing. A partial frame survey was carried out in 2018 in four northern departments of the country, which identified 280 fishing sites, including many camps and around a hundred villages. These sites are occupied by 5 300 households fishing full-time or as their primary activity but also engaged in agricultural activities. Most fishing households make seasonal migrations to fishing areas at the start of the receding water.

Total catches reported to FAO are relatively stable at an average of 39 000 tonnes over the last ten years, but these figures are not based on any monitoring system. The composition of these catches is not detailed, but it is known that at least 27 families of fish are represented. There is significant trade with the Central African Republic and the Democratic Republic of the Congo. Fish is sold fresh as well as processed (smoking and braising), although processing methods are quite basic and do not allow for long preservation times.

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Central African Republic

The Central African Republic is situated on two major river basins, to the north where it forms part of the Sahelian Chad basin with the Logone and the Chari, and to the south with that of Congo Basin with the Oubangui (which covers most of the country) and the Sangha. The Chari is made up of a large number of rivers which have their source in the Central African Republic and Chad, and only joins the Logone a short distance from Lake Chad. The Oubangui is made up of two long rivers, the Mbomou, which rises in South Sudan, and the Uélé, which originates in the Democratic Republic of the Congo near Lake Albert. The Middle Oubangui receives the Lobaye before entering the Cuvette Centrale. The Central African Republic has no major natural lakes. The main reservoir is created by a dam on the Mbali river, a subtributary of the Oubangui. The only dam on the Oubangui at Mobaye has not been completed and has created a particular local ecosystem where fishing is highly productive. Freshwater fish biodiversity in the Central African Republic is estimated to include over 200 species, including 12 endemic species.

The floodplains of the river systems cover a considerable area (30 000 km²). Based on estimates of aquatic environmental productivity (Lymer *et al.*, 2016), the annual production potential can be estimated to be at least 150 000 tonnes. This is much higher than the estimated actual production of 28 000 or the single official report to FAO produced in 2012 of 32 000 tonnes but does appear to be consistent with the low population density throughout much of the country, except for the many sites along the Oubangui river.

Fishing is a widespread activity throughout the rivers, with a large numbers of people practising fishing as their main activity. Of particular note are the Sangha, who have a system of customary land ownership that governs usage rights on the tributaries of the Sangha, while there is open access on the main river. In the Chari basin, the Gbaya fish individually but organize collective fishing which involves building dams.

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Gabon

Gabon is almost entirely within the Ogooué basin, which rises in the Congo. The main tributaries within this basin are the Ivindo, Okano and Ngounié rivers. The estuary at the mouth of the river is a vast marshy delta with numerous lagoons. The other rivers are the Nyanga in the south and the Komo, Mbini and Woleu in the north. There are no lakes of note apart from the Onangué. There is a dam (Grand Poubarra) on the Upper Ogooué and at least two others are planned on the Komo and its tributaries (Mbei). Freshwater fish biodiversity is very high, with 330 species identified, 70 of which are endemic.

The 2020 General Census of Agriculture (RGA) provides an opportunity to update some of the data from the 2007–2008 fisheries frame survey. The total number of people fishing in inland waters is estimated at 10 700, including 2 900 women and 7 800 men. This number is an increase on the 2007 census, which counted just under 4 400 fishers, including 800 women. The distribution of these fishers shows a very high concentration in Wolou-Ntem and Ogooué-Ivindo regions that are far from the coast and have no major urban centres. These regions accounted for 50 percent of fishers according to the RGA. This result differs from the frame survey, which counted only 20 percent of fishers in these regions. The difference between these figures could be explained by the fact that the RGA takes into account people who have declared fishing as a secondary activity after farming, whereas the frame survey would only have targeted full-time fishers.

According to the 2007 frame survey, fishers operated from around 390 villages and camps and own just over 2 000 pirogues. Motorized boats are found mainly in the lagoons in the coastal zone (Ogooué maritime). The most productive fishing season extends from June to October, i.e. during the receding and early low-water periods. A variety of fishing gears are used and while dominated by gillnets, there is a wide range of traditionally made gear including harpoons, traps, hand nets and weirs, which are often used simultaneously. Catches reflect the diverse fishing locations and gears and include a large number of species, but very little information is available due to the lack of systematic monitoring and the wide variety of local names that are used.

Official production figures have been stable for several years at around 11 000 tonnes per year (11 160 tonnes in 2021), which seems to reflect the number of fishers and the highly seasonal nature of the fisheries. However, this figure is not based on any rigorous monitoring system and could be underestimated if subsistence fishing by farmer-fishers is included.

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7.1.8 Southern Africa

Country/territory	Inland capture fisheries catch (tonnes in 2021)	Percentage of global inland fish catch	Population (2021)	Per capita inland fish production (kg/cap/year)
Zambia	105 125	0.93	19 473 125	2.30
Mozambique	100 000	0.88	32 077 072	6.70
Angola	24 173	0.21	34 503 774	5.13
Zimbabwe	22 734	0.20	15 993 524	4.77
Madagascar	8 608	0.08	28 915 653	–
Namibia	2 800	0.02	2 530 151	–
South Africa	900	0.01	59 392 255	–
Eswatini	65	0.00	1 192 271	–
Lesotho	55	0.00	2 281 454	–
Botswana	38	0.00	2 588 423	–

Southern Africa, including the island of Madagascar, is rich in river and lakes. Freshwater environments are dominated by the Zambezi basin with its vast floodplains, and the Limpopo basin. Numerous coastal rivers also play an important role in Angola and Mozambique, while artificial reservoirs are particularly important in South Africa and Zimbabwe. Madagascar has around a hundred coastal rivers and Lake Alaotra is also an important area for inland fisheries.

Across the region, data on inland fisheries are scarce, but the number of people engaged in subsistence or commercial fishing is certainly very large, including in non-permanent systems such as Namibia and Botswana. The potential of Angola in particular is highly likely to be underestimated, given the importance of the river network and the wetlands found throughout the country.

Zambia

Zambia has a particularly extensive and diverse set of surface freshwater ecosystems belonging to both the Congo and Zambezi basins. Most of Zambia lies within the Zambezi Basin, where the Zambezi River itself receives several of its major tributaries, including the Lungwebungu, Cuando, Kafue and Luangwa. The Upper Zambezi and its tributaries flow through very large floodplains, the Barotse floodplain, the Luena Flats and the Lungwebungu floodplain, which together cover more than 7 500 km², while the Kafue flats also cover almost 6 500 km² and the Luangwa floodplain just under 2 500 km². Other important wetlands are the Lukanga and Busanga swamps, of 2 600 km² and 2 000 km² respectively. The Congo Basin in Zambia is occupied by a small part of Lake Tanganyika (around 6 percent of the basin by area) and Lakes Mweru and Bengweulu, fed mainly by the Chambeshi River and connected by the Luapula River which feeds the Congo River. The Bengweulu marshes cover around 9 800 km². Lake Mweru Wa Ntipa is intermittent.

The main artificial lake is Lake Kariba on the Zambezi, which is 5 400 km² (of which 45 percent is in Zambia). The lake has experienced a decline in water level in the period 2022–2023, affecting both hydroelectric production and the fisheries. The other major dams are Itezhi-Thezi and Kafue Gorge on the Kafue, and Mulungushi and Mita Hills on the tributaries of the Luangwa. At least one more dam is planned at Batoka Gorge on the Zambezi. Fish biodiversity is very high, with almost 450 species, largely due to the presence of Lake Tanganyika (the Zambezi basin is home to just 250 species). However, relatively little is known about the fauna of Lake Mweru.

The vast expanse of floodplains and temporary marshes around the lakes give Zambia enormous production potential, to which the potential of river and reservoir fisheries must be added. This contributes to the country being the largest producer of freshwater fish in the region with production in 2021 of 105 125 tonnes reported to FAO. This compares with an annual potential production estimated at a minimum of 195 000 tonnes based on the average productivity indices of the various freshwater environments (Lymer *et al.*, 2016).

Fisheries in the Bengweulu swamps have been closely studied (e.g. Huchzermeyer, 2013) and it was found that the main fishing season lasts seven months with average daily yields of around 7.5 kg per fisher. Annual yields per area were estimated at 217 kg per hectare based on the use of a wide range of gears including weirs of traps and gillnets. For the trade in fish products, fish are dried and packaged in 70 kg bags. The products are bought locally by traders at an average price of 3 USD per kg.

Fishing is practised by many communities throughout these environments, sometimes for centuries. People with a long history of fishing include the Twa/Batwa in the Kafue flats, who use a fishing technique unique in the world consisting of placing completely covered platforms in the marshes to detect fish in the shade and then harpoon them. The yield using this technique was estimated to be 100 kg per fisher per day. On the Upper Zambezi, the Luvale have also been present for centuries, as have the Lozi in the Barotse floodplain The latter are known for their *Kuomboka* Festival, which marks the transhumance from the flood zone to higher ground at the start of the rainy season. Several traditional fishing gears are still used on the Bangweulu and Mweru lakes to catch endemic small pelagic fish chisense (*Engraulicypris moeruensis*) and kasepa (*Microthrissa moeruensis*). Modern techniques and adaptations are developing fast, including the use of large nets and light to fish at night, as is common on Lake Tanganyika for kapenta (*Limnothrissa miodon* and *Stolothrissa tanganicae*).

It is estimated that more than 300 000 people make their living directly or indirectly from fishing, including the processing and trade of fish products (Mutale, 2020). According to FAO, the share of fisheries in GDP in 2018 was about 0.4 percent. These figures do not reflect the importance of capture fisheries for the food security and livelihoods of fisheries-dependent communities, especially women and vulnerable people. Official capture fisheries production comes mainly from the three large lakes (Mweru, Kariba and Tanganyika) and exceeded 100 000 tonnes in 2021. The production in the Zambian part of the Lake Kariba fluctuated around 15 000 tonnes between 2007 and 2019 (Imbwae, Aswani and Sauer, 2023). The per capita average annual availability of fish products has long been underestimated at around 6 kg, which does not reflect the importance of subsistence fishing in many parts of the country. The most recent national estimates of apparent consumption are in the order of 12 kg. However, in the floodplains, household surveys show that actual consumption is well above the national average, up to five times greater in the Barotse plain. According to the Zambia Household Survey, fish provides 23 to 43 percent of women's dietary protein (and 24 to 26 percent of dietary fat) and is by the far the predominant source of animal protein in the Zambian diet (Alaofe *et al.*, 2014). Taking into account consumption linked to subsistence fishing has led to an estimated additional production of at least 100 000 tonnes, which does not appear in the official statistics (Fluet-Chouinard, Funge-Smith and McIntyre, 2018).

Since the early 2010s, Zambia has been a net importer of fish and the vast majority of imported products are small marine pelagics, including from Namibia (90 percent), China and South Africa. In 2020, the quantities imported reached 83 000 tonnes, down from previous years (128 000 tonnes in 2018). Exports are negligible, at around 3 000 tonnes in 2020, but there are very significant informal trade flows between the Democratic Republic of the Congo, Zimbabwe and Angola involving dried and smoked fish products.

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Mozambique

Mozambique's coastline is criss-crossed by many small coastal rivers. The most important are the Rovuma (which marks the border with Tanzania), the Messaio, the Lúrio, the Ligonha, the Licungo, the Pongoé and the Buzi. In the south of the country, the coastal rivers originate in South Africa (Incomati, Maputo), Zimbabwe (Save) or Eswatini (Umbeluzi). The largest shared basin is that of the Zambezi, which enters Mozambique at the point of the three borders with Zambia and Zimbabwe, and whose Cahora Bassa dam is one of the largest in southern Africa, with a reservoir of 55 km^3 and a surface area of 2 665 km^2. The other major shared river basin is the Limpopo, which rises in South Africa and receives its largest tributary in Mozambique, the River Lepelle (formerly Olifants). This river supports the Massingir dam (150 km^2).

The largest natural lake is Lake Malawi (Nyassa), around 20 percent of which, or 6 400 km^2, is under Mozambique's jurisdiction. The Ruo River, a tributary of the Shire, joins the Zambezi in Mozambique, and forms 80 km of the border with Malawi. Aside from Lake Malawi (Nyassa), there are two other small endoreic freshwater lakes shared with Malawi, Chiuta and Chirua (Chilwa), which are surrounded by extensive swamps. Mozambique also has several brackish coastal lagoons. The Mozambican part of Lake Malawi (Nyassa) is a Ramsar site, as is the Zambezi Delta. The annual fish production potential can be estimated at least 90 000 tonnes based on the average productivity indices of the various freshwater environments (Lymer *et al.*, 2016). This is close to the 100 000 tonnes reported for 2021 to FAO. Biodiversity is very high but probably underestimated, with 366 species of freshwater fish, 30 of which are endemic, most of which are in Lake Malawi (Nyassa). The Cahora Bassa reservoir has only 37 species.

The Mozambican part of Lake Malawi (Nyassa) has steep shores and the fisheries mainly target small pelagic species (haplochromines and *Engraulicypris sardella* or usipa). Surveys carried out in the districts bordering the lake between 2000 and 2015 identified catches of around 4 000 tonnes, 64 percent of which were usipa. According to the latest available statistics, the contribution of small-scale fishing was 28 400 tonnes in 2020. Pelagic fisheries in the Cahora Bassa reservoir are highly mechanized. They target kapenta (*Limnothrissa miodon*) using catamarans, which consist of double-hulled pontoons with a winched crossbeam to lower and raise a fine-mesh (8 mm) circular net. Lights are placed on the surface of the water above the submerged net. After one or two hours of light attraction, the lights are switched off and the net is hauled up. Most platforms are not motorized but are towed by a mother platform to the fishing grounds each evening.

The fisheries of the Cahora Bassa reservoir are influenced by Lake Kariba as the kapenta has spread downstream together with Nile tilapia (*Oreochromis niloticus).* Fishing methods have also spread as the pontoon method was developed on the Zimbabwean side of Lake Kariba in 1976 and introduced to Cahora Bassa in 1994. This fishery is practised along almost the entire length of Lake Cahora Bassa. Currently, 248 pontoons are operated by 52 fishing companies. This represents the maximum allowed under the reservoir management plan. The annual production potential is estimated at 16 000 tonnes, but production remains at around 7 000 tonnes. Fish is largely exported to South Africa, Zambia, Zimbabwe and the Democratic Republic of the Congo. Artisanal fisheries on the reservoir were estimated to have produced 30 700 tonnes in 2020.

A partial census carried out in the provinces bordering the Sofala Bank (Nampula, Sofala and Zambezi) after the passage of Cyclone Idai updated the situation of the fishers in the coastal waters of this region. The survey identified 160 fishing sites, mainly on rivers, with more than 9 700 fishers operating 4 400 non-motorized pirogues. A total of 6 000 fishing gears were identified, dominated by gillnets. The Zambesi Delta fishery has been estimated to be able to produce between 15 000 and 19 000 tonnes (Welcomme cited in Turpie, 2008). Additional inland fish production is derived from the Limpopo and Save estuaries.

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Angola

Angola is located in nine different basins. The basins entirely within Angola include: in the north, a group of coastal rivers (Mbridge, Loge, Dande and Bengo); in the center, the Kwanza Basin; and in the south, another group of coastal rivers including the Longa, the Queve, the Catumbela (which supports two dams) and the Coporolo, which is intermittent due to the more arid climate. The cross-border basins include the tributaries of the Congo (Kwango, Kwilou and Kasai) to the north, the Zambezi (and its tributaries Luena, Cuando and Lungwebungu) to the east, the Okavango (Cuito and Cubango) to the southeast, the Cuvelai-Etosha to the centre-south and the Cunene to the southwest. The Chiloango River flows through the enclave of Cabinda. There are few major natural lakes, but nearly 25 reservoirs, the largest of which are on the Kwanza River (Cambambe, Lauca, Capanda, Caculo Cabaça) and on the Cunene (Matala and Calueque). The major floodplains are located in the Zambezi and Cuvelai basins. Moxico Province is crossed by the Luena, Zambezi and Lungwebungu rivers. The region is largely covered by chanas, areas that are flooded for several months of the year. Biodiversity is not well known, and the number of species listed in FishBase of 360 species (Froese and Pauly, 2024) may be an underestimate, given that more than 70 endemic species are known.

Fishing is a widespread activity, although it is practised differently depending on the environment and the people concerned. There are more than 1 140 villages with 21 450 fishing households (representing some 13.5 percent of the population). Most fishers are peoples from the Luvale and Chokwe. Pirogues are rarely used and are only motorized where there is family transport to fishing areas, which can be dozens of kilometres away. Fishing takes place mainly during the months of receding water and the low-water period, from April to September. The gears used are diverse and includes gillnets, baited hooks, traps, hand lines and hand nets. Collective fishing gear is also used. After harvesting, fish is systematically dried (smoking and salting are not among the conservation techniques used). Dried products for sale are typically stored in batches of 250–1 000 fish, which are sold by the fishers themselves, but there are also networks of buyers from all over eastern Angola and Zambia who visit the fishing grounds to buy dried fish products as they are produced. The traditional authorities in each locality, the *Sóba*, control access through the distribution of fishing grounds and the regulation of fishing seasons.

The River Kwanza flows through a floodplain dotted with some 20 lakes, the largest of which is Lake Ngolome (1 500 ha). In this region, fishing is practised for between six and eight months of the year by 300–400 fishers, most of whom are Kimbundu peoples, using cast nets, traps, longlines and small-mesh (37 or 40 mm) set nets. The very small mesh nets that have traditionally been used to catch a small alestid species have been banned. The dominant species caught include fish from the cichlid, alestid, cyprinid, clariid, mochokid and schilbeid families. Average gillnet catches per trip vary between 50 kg and 150 kg. The fish are sold in the capital as either fresh or smoked products.

The province of Uíge is located on the river basins of the Congo (Kwango, Kwilu, Lonje, Luquiche) and the northeastern rivers (Mbridge and Loge) and has an estimated 23 000 fishing households, or 7.5 percent of the population. According to the 2018 survey, 77 percent of fishers in this region do not own a boat and 63 percent migrate seasonally to fish. The main fishing season is from May to September. Activity remains limited, with an average of just two trips per week. Catches per trip during the main fishing period vary on average between 50 kg and 80 kg. Around half of the fish produced is sold fresh and the other half is processed, mainly by smoking.

In the Cuito-Kavango (Okavango) basin in Angola, a survey published in 2009 by the Permanent Okavango River Basin Water Commission (OKACOM) indicated that the majority of fishers have a secondary activity such as farming or hunting, but that virtually the entire population fishes during the receding- and low-water periods, including women and children. Dugout canoes are common and fishing gears are dominated by traditional gear, including traps, baskets and handlines, with only full-time fishers using gillnets. The species caught are dominated by *Hydrocynus* sp., *Clarias* sp., *Serranochromis* sp., *Tilapia* sp. and *Oreochromis* sp. Average daily yields vary between 3 kg and 10 kg. Catches are often consumed fresh locally but are also dried or smoked (especially *Clarias* sp.) when sufficiently abundant.

Other important fishing areas are poorly documented, particularly the Upper Kasai and the Cuando River, as well as in the north of the Cuvelai Basin, where the population is mainly of the Owambo people. Fishing in these areas takes place throughout the flood season in the receding channels (*oshana*). Fishing involves all the members of the households, which number around 40 000 (Calunga *et al.* 2015).

Overall, it appears that the number of fishers in Angola's inland waters is higher than previous estimates and the data from the Ministry of Fisheries, which indicated 40 650 fishers and 8 875 women processors in 2020. Official production is also significantly underestimated (22 000 tonnes per year on average over the period 2011–2021 and 24 173 tonnes in 2021) because there is no monitoring system. The productivity of the flooded areas of the upper Zambezi in Moxico is likely to have been underestimated at 20 000 tonnes per 20 000 km² (Vanden Bossche and Bernacsek, 1990). Consequently, the potential is likely to be greater than 200 000 tonnes and the contribution of inland fisheries to food and nutritional security is certainly higher, particularly in non-coastal regions.

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Zimbabwe

Zimbabwe has five distinct river basins, the most important being the Zambezi, which covers the northwestern half of the country (and includes the Gwayi, Shangani, Luenha and Munyati rivers), and the Limpopo, which covers the south of the country (including the Changane, Umzingwani and Shashe rivers). The southeast is occupied by the headwaters of the Pungwe, Buzi and Save coastal rivers. Permanent rivers and streams cover over 5 700 km^2 and wetlands make up 3 percent of Zimbabwe's total surface area, about 11 700 km^2. There are more than 136 large reservoirs (Mhlanga and Mhlanga, 2013), the largest of which are the Kariba dam (5 400 km^2, 55 percent of which is in Zimbabwe and 45 percent in Zambia), Lake Mutirikwi (90 km^2), Lake Manyuchi on the Mwenezi river (33 km^2) and Lake Chivero on the Manyame River (26 km^2). All reservoirs and impoundments cover 6 521 km^2 (GoZ, 2020). Together, the large reservoirs could represent a production potential of around 52 000 tonnes based on a productivity of 80 kg per hectare, while the rivers and floodplains could represent a further potential of 60 000 tonnes based on a productivity of 50 kg per hectare (Lymer *et al.*, 2016). This compares with the estimates that FAO has been providing for inland fisheries production since 2001, which have fluctuated around 25 000 tonnes since the end of the 2000s and is currently (2021) estimated to be 22 734 tonnes. Biodiversity is high, with over 140 native species, whilst there is no endemism. More than 15 species have been introduced for various purposes (including aquaculture and recreational fishing).

Production on the Zimbabwean side of Lake Kariba has been estimated at 5 000 tonnes, to be compared with the estimate of 15 000 tonnes for the Zambian side. This difference can largely be explained by the difference in access regimes, with Zimbabwe imposing strict restrictions and placing a large part of the lake in a protected area. There is also a major difference in the application of management measures, with Zimbabwe imposing a *de facto* ban on small-mesh nets, which limits the possibility of catching the small but abundant Lake Tanganyika sardine (*Limnothrissa miodon*), which currently accounts for a large proportion of catches in the Zambian part of the lake (9 500 tonnes in 2021). Several communities have traditionally practised fishing, notably the Tonga, who are now excluded from fishing in Lake Kariba, the Lozi upstream of Lake Kariba, and various other groups (Doma, Manyika, Sena) downstream of the lake. It is worth noting the recent creation (April 2023) of the Buzi, Pungwe, and Save (BUPUSA) Watercourse Commission between Zimbabwe and Mozambique, which manages all the water resources in these three basins.

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Madagascar

Of the African islands (Madagascar, Cabo Verde, Comoros), only Madagascar has a substantive inland fishery. Madagascar has around 100 coastal rivers divided into five major groups of basins: the northern slope of the Montagne d'Ambre (Ambohitra) with seven rivers covering 11 200 km²; the Tsaratanana slope with six main rivers covering 20 000 km²; the eastern slope, with very short rivers due to the relief covering 150 000 km²; the southern slope with four rivers covering 48 800 km² and finally the western slope which covers 365 000 km² and includes the country's largest rivers, namely the Sofia, the Mahajamba, the Betsiboka, the Mahavavy Sud, the Tsiribihina and the Mangoky. The Mangoky Delta, known as Volirano, is the largest in Madagascar at 2 000 km². Several watercourses support hydroelectric dams, particularly in the eastern basin and the tributaries of the Betsiboka, and others are planned. Lake Alaotra is the largest freshwater lake, with a surface area of 430 km², 230 km² of which is marshland, which varies according to the season. The other major lakes are brackishwater lakes, mainly located in the western basin. Around ten lakes and marshes are Ramsar sites. Biodiversity is high, with 190 species of fish, at least 80 of which are endemic.

The regions where inland capture fisheries are most common are Lake Alaotra, where the Sihanaka are mainly fishers and livestock breeders, with the women responsible for processing and marketing the fish. On the northwestern coast, the Sakalava fish in both the sea and the river, and their villages are mainly spread along the rivers. On the southwestern coast, the Mikea fish in brackish lakes. On the southeastern coast, the Antaifasy fish in rivers, lagoons and the Pangalanes Canal. There is a targeted freshwater shrimp fishery in the south.

Quantitative data on inland fisheries are scarce, except for Lake Alaotra, which has been the subject of many detailed studies. According to the most recent (Lammers, 2020; Wallace, 2016), the number of fishers reached 12 000 in 2014, up from 7 000 in 2010. This increase concerns all types of gears (gillnets, cast nets, handlines and traps) with the consequence of a very marked decrease in catch per unit effort (CPUE) and in the average size of fish caught, 80 percent of which are smaller than 13 cm. Total catches, estimated at 2 000 tonnes in 2000, appear to have stabilized at less than 1 000 tonnes since the early 2010s. Catches are largely dominated by cichlids, and all other species have been introduced.

Total production declared to FAO for 2021 is 8 608 tonnes. From 2012 onwards, inland fisheries production data have been based on marketing data, i.e. booklets filled in by collectors and sent monthly to the statistical services of the ministry responsible for fisheries, which compiles them to produce annual estimates. Between 2018 and 2021, it was assumed that a large proportion of these field data would not reach the central level, which explains the drop in estimated production from the previous estimates of around 30 000–35 000 tonnes to below 10 000 tonnes (N. Randrianarijaona, head of the inland fisheries department, personal communication). It should be noted that the production data for rice–fish farming are based on an area of 150 000 ha with an average yield of 200 kg per hectare.

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Namibia

Namibia is at the centre of several river basins. In the northwest the Cunene, which originates in Angola, marks the border between these two countries without entering Namibia, and the Cuvelai, which ends its course in the Etosha salt lake. This basin is made up of hundreds of drainage channels (*iishana*) that are occasionally flooded. To the east, the Oma'ako is one of the Okavango's intermittent tributaries, which supports a dam. To the northeast, the Caprivi strip is crossed by the Okavango and then flanked by the Zambezi and the Chobe/Kwando, which forms Lake Liambezi (100–300 km²). To the south, the Fish River is one of the main tributaries of the Orange River and supports several dams. Another intermittent tributary of the Orange, which rises in Namibia, is the Nossob. There are also two small freshwater karst lakes, Otjikoto and Guinas, which contain an endemic species of cichlid. Biodiversity is high, with at least 150 species, 5 of which are endemic. The Cuvelai basin alone is home to 45 species (CUVECOM, 2019).

Potential production is difficult to estimate due to the extreme variability of the environment. However, the productivity of Lake Liambezi at full fill (2011–2012) has been estimated at 106 kg per hectare, and the gillnet fishery operated by more than 300 boats produces almost 3 200 tonnes annually (Simasiku, 2014). The Cuvelai River Basin floodplain covers an area of around 8 000 km², which represents a potential of almost 40 000 tonnes based on an average productivity of 50 kg per hectare (Lymer *et al.*, 2016). This productivity could go some way to explaining why this region, which covers only 5 percent of Namibia's territory, is home to more than 40 percent of the population – more than 1 million people. The basin is traditionally dominated by the Owambo people, for whom fishing is a communal enterprise. The women actively fish with large conical baskets in the *oshana* basins, while the men build traps on the narrower streams, consisting of dams (*olua*) with conical baskets (*omidiva*) in the openings.

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South Africa

The hydrographic network of South Africa is dominated by the Orange River, which rises in Lesotho and flows into the Atlantic Ocean 1 860 km further on after forming the border with Namibia. The main tributary of the Orange River, the Vaal, is 1 200 km long. The other tributaries are the Fish River, whose basin is mainly located in Namibia, and the Molopo, which is intermittent but has extremely powerful floods. The second-largest basin is the Limpopo, which rises in the Transvaal and forms the border with Botswana and Zimbabwe for almost the entirety of its 1 600 km length. The Limpopo continues its course in Mozambique, where it flows into the Indian Ocean after receiving numerous tributaries. It is one of the country's major waterways. The south of the country has a large number of coastal rivers, including the Olifants, Great Fish and Great Kei. This southern river network supports a very large number of dams, more than 500 public and nearly 4 000 private, of which only 7 have a reservoir larger than 1 km^3 and only 5 cover an area of more than 100 km^2. The Kwazulu-Natal region is particularly rich in natural lakes. Biodiversity is relatively modest, with almost 160 fish species, 30 of which are endemic. The majority of these endemic species are threatened with extinction due to a number of factors including pollution, dams and competition with several of the 22 introduced species. These introduced species originate variously from the African continent, Europe and North America.

Based on a model using environmental and production data from a sample of 425 dams, the annual production potential of all South African water bodies has been estimated at 15 000 tonnes (Britz *et al.*, 2015). The productivity of inland waters is considered too low to support large-scale commercial fisheries. However, recreational fishing is reported to take place on 69 percent of reservoirs and involves more than 1.5 million people, generating considerable economic benefits, although these have not been quantified on a national scale.

Very little is known about the small-scale fisheries, even though it is practised on more than 75 percent of waterbodies. Small-scale fishing is divided between being a commercial activity that has recently emerged and subsistence fishing – which has also undergone significant recent changes. Floodplain fishing has been practised since precolonial times and is vital for certain communities such as the Tembe-Thonga of northern KwaZulu-Natal (floodplain of the Pongola River) and the Makuleke on the Limpopo River. Fishing techniques used to be extremely diversified, targeting all the fish species present during hydrological cycles. These communities have had to adapt to changing conditions, first when a dam was built for irrigation purposes, and second when the Kruger National Park was extended. As a result, these communities typically now only fish occasionally using modern techniques such as gillnets. Elsewhere, fishing is practised by a growing number of people, including in communities with no fishing tradition in order to diversify their livelihood strategies. This is observed in many reservoirs and fishing may be limited to subsistence purposes or involve more commercially oriented activities. In the latter case, because of the use of efficient fishing gears such as gillnets, there are also recurring tensions with recreational fishing. A new policy on inland capture fisheries, drawn up in 2021 and based on the Ecosystem Approach to Fisheries, aims to clarify the status of the various users of inland fisheries and to guide the development of new regulations in favour of the most fisheries-dependent communities.

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Eswatini

Eswatini is a small land-locked country located on three river basins, the main one being the Lusutfu River (also known as the Great Usuthu, or Maputo River), whose main tributaries are the Pongola River, the Komati River (Incomati) and the Mbuluzi River. These three rivers flow into the Indian Ocean in southern Mozambique. The country has no natural lakes, floodplains or marshes. However, several reservoirs are formed by dams, notably on the Lusutfu river (Nyetane, Lubovane, Van Eck, Luphohlo, Sivunga) and its tributary the Pongola (Jozini dam located mainly in South Africa), on the Komati (Maguga, Sand River) and on the Mbuluzi (Mnjoli and Hawane). Other small dams are scattered throughout the country for livestock farming and human consumption. The total surface area of these reservoirs is estimated at around 100 km², but only three are larger than 10 km² (SAE, 2014), which implies a production potential of around 300 tonnes per year at a yield of 80 kg per hectare (Lymer *et al.*, 2016). Eswatini has only reported fish landings to FAO on three occasions since 1950, the last time in 1988 with 90 tonnes. Since then, FAO has estimated the captures and the most current estimate is 65 tonnes (2021).

Biodiversity is relatively high, with around 50 native species plus 8 introduced species (trout, sunfish and carp) while a fish and fisheries survey conducted by the Fisheries Administration in 2002/2003 identified approximately 60 species of fish throughout the country. There is no endemism, but at least 2 species native to the Komati basin are in danger of extinction. The composition of the catches is not indicated (FAO, 2023) but the main fish species that are exploited are tilapias and catfish. Species targeted for sport fishing include the largemouth bass (*Micropterus salmoides*), rainbow trout (*Oncorhynchus mykiss*) and tiger fish (*Hydrocynus vittatus*). The South African Department of Water and Sanitation (DWS) hosts the Inkomati-Usuthu Catchment Management Agency (IUCMA) which manage only the South African part of the basin, despite the existence of several rivers shared with Eswatini.

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Lesotho

Lesotho is a small, mountainous land-locked country with three main rivers: the Senqu, Makhaleng and Mohokare, all part of the Orange River Basin. The total length of the rivers is 2 160 km, with a drainage area of 31 000 km². All the rivers are mountain streams with no floodplains. There are no natural lakes, but there are several hydroelectric dams, the largest of which are at Katse (36 km²) and Mohale (22 km²). The surface area of the water bodies associated with these dams is estimated at 80 km², including a large number of very small reservoirs with no real potential for fisheries development. Potential annual fish productivity can be estimated at 460 tonnes on the basis of an 80 kg per hectare productivity estimate for the large reservoirs and 60–120 tonnes for the rivers (Lymer *et al.*, 2016). Biodiversity is very low, with only seven native species (including cyprinids, bagrids and cichlids) and an additional eight species introduced for aquaculture and to enhance capture and recreational fisheries, including rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), common carp (*Cyprinus carpio*), largemouth bass (*Micropterus salmoides*) and bluegill sunfish (*Lepomis macrochirus*) (FAO, 2008).

There is no tradition of fishing, and what fishing there is conducted is mainly for subsistence purposes, with the exception of a small commercial gillnet fishery carried out on the largest reservoirs by a few professional fishers. In 2020, Lesotho launched a study to develop a management plan for small-scale commercial fishing on the dams under the jurisdiction of the Lesotho Highlands Development Authority. Lesotho has reported inland fisheries catches every year since 2000, but data for 2021 have been estimated by FAO at 55 tonnes, 27 percent of which is common carp and 18 percent clariid catfish, with the remainder unidentified but likely to be native species. The extent of development of cage aquaculture on the reservoirs is still anecdotal, unlike trout farming on rivers where production reached 2 600 tonnes in 2020.

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Botswana

Botswana lies between the Okavango, Zambezi, Orange and Limpopo river basins. The Okavango is formed by the Cubango and Cuito rivers, which originate in the Angolan highlands, cross Namibia and flow into the inland delta to the north of Botswana. The other rivers mark the borders with Namibia (Nossob), South Africa (Molopo and Limpopo) and Zimbabwe (Shashe). Lake Ngami is an endorheic lake seasonally filled by the Taughe River, an effluent of the Okavango River system flowing out of the western side of the Okavango Delta, and is one of the fragmented remnants of the ancient Lake Makgadikgadi. There are 71 known fish species.

The main large river and associated waterbody is the Okavango River and its endorheic delta. This fishery was estimated to have 35 000 residents fishing 40 days per year. Another estimate is 56 000 residents fishing 60 days, yielding 1 045 tonnes annually(Tvedten *et al.*, 1994). Within the delta and its outlets there are estimated to be around 3 000 people fishing as part of their livelihood strategies. The men and women of the Dxeriku, Hambukushu and Wayeyi specialize in fishing. The gears used are highly diversified and catch practically all the species present, including the smallest sizes. Commercial fishing is carried out by around 40 full-time fishers and there is recreational fishing upstream in the delta, targeting *Hydrocynus* sp. The variability in catches stems mainly from the production from the commercial fisheries. Annual production from subsistence fishing are less well documented but are probably in the range of 1 000 to 2 000 tonnes, depending on climatic conditions. In the Okavango Delta fishing makes a major contribution to food security, as women practice subsistence fishing using baskets and mosquito nets, but there is no evidence of overexploitation. Some of the catches from the Zambezi fisheries in Zambia and Namibia are marketed in Botswana.

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7.2 ASIA

Subregion	Inland capture fisheries catch (tonnes in 2021)	Percentage global inland capture fisheries catch	Population (2021)	Per capita inland fish production (kg/cap/year)
Southeast Asia	2 174 876	19.14	675 796 064	3.22
Southern Asia	3 381 268	29.76	1 860 908 126	1.82
China	1 197 835	10.54	1 489 975 659	0.80
Eastern Asia	28 802	0.25	202 414 578	0.14
Western Asia	181 006	1.59	268 331 155	0.67
Central Asia	115 624	1.02	136 206 766	0.85
TOTAL	**7 079 411**	**62.30**	**4 633 632 348**	**1.25**

7.2.1 Southeast Asia

Country/territory	Inland capture fisheries catch (tonnes in 2021)	Percentage of global inland fish catch	Population (2021)	Per capita inland fish production (kg/cap/year)
Myanmar	786 110	6.92	53 798 084	14.61
Cambodia	383 050	3.37	16 589 023	23.09
Viet Nam	149 504	1.32	97 468 029	1.53
Thailand	112 604	0.99	71 601 103	1.57
Lao People's Democratic Republic	71 000	0.62	7 425 057	9.56
Malaysia	5 562	0.05	33 573 874	0.17
Archipelagic				
Indonesia	465 989	4.10	273 753 191	1.70
Philippines	201 056	1.77	113 880 328	1.77
Brunei Darussalam	0	0.00	445 373	–
Timor-Leste	0	0.00	1 320 942	–
Singapore	0	0.00	5 941 060	–

The Southeast Asian subregion consists of two principal areas, continental and archipelagic. The continental part of Southeast Asia comprises Cambodia, Lao People's Democratic Republic, Myanmar, Singapore, Thailand, Viet Nam and Peninsular Malaysia. Its major river basins include the Mekong, Salween and Irrawaddy, Chao Phraya, and Hong (Red) River. The subregion has extensive aquatic environments linked to these rivers that include lowland lakes, ponds and reservoirs, upland streams, and highly productive floodplains as well as coastal lagoons and deltas. Productivity is highest in Myanmar where catches are equivalent to almost 7 percent of total global inland fish production.

The archipelagic areas of Southeast Asia comprise the large and small islands of Borneo (Brunei Darussalam, Sabah Malaysia, Sarawak Malaysia, Kalimantan Indonesia), the archipelagos of the Philippines, Indonesia and Timor-Leste. The significant river basins include Kapuas, Mahakam, Batang Kuantan, Batang Hari, and Bengawan Solo. There are some large lakes (such as Laguna de Bay, Taal, Toba as well as Lanao) and the large wetlands and peatlands of Sumatra, Java and Kalimantan.

Inland fisheries are important across the Southeast Asian subregion and a wide range of species are caught and consumed or otherwise utilized. As a result, per capita consumption is correspondingly high. Rural households typically fish as part of diversified livelihoods. In rural areas these are typically agriculture-based livelihoods and many of the landscapes in which fisheries take place are therefore agricultural landscapes and many have been modified. Fisheries have also been modified through enhancement measures, most notably stocking and enhanced fisheries are widespread in both artificial and natural waterbodies.

In continental Southeast Asia in particular, consumption of inland fish from capture fisheries is high, with Nam *et al.* (2015) estimating annual per capita consumption in the Lower Mekong Basin Countries (Cambodia, Thailand, Lao People's Democratic Republic and Viet Nam) to be around 33 kg. Across the subregion however, inland capture fisheries are affected by changes associated with rapid economic development and resulting from the expansion of irrigated agriculture, hydropower development, climate change and growing human populations (e.g. MRC, 2019).

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Myanmar

Myanmar is bordered by the Bay of Bengal, the Andaman Sea and the countries of Bangladesh, India, China, Lao People's Democratic Republic, and Thailand. The country has extensive water resources: The largest river in Myanmar is the Ayeyarwady River (Irrawaddy River) which is 2 150 km long. Although the Ayeyarwady has only half the length and half the basin area of the Mekong, the two rivers have similar annual discharges. Other major rivers are the Chindwin River, a tributary of the Ayeyarwady River, Salween River and the Sittaung River. It is estimated that Myanmar contains 8.1–8.2 million ha of surface water, the bulk of which is associated with the country's major rivers, estuaries and lakes (FAO and NACA, 2003). It is also estimated that 1.2–1.3 million ha of Myanmar's freshwater resources are located in permanent wetlands, with the remaining area (7 million ha) being seasonal wetlands, including floodplains (FAO and NACA, 2003). The topography of the country, coupled with the flood pulse system, means that some 80 percent of flows occur during the monsoon.

A total of 449 fish species have been identified from rivers and lake of Myanmar. These consist of 365 native species and 54 endemic fish, as well as 12 introduced species. The fisheries based on these fish are reported to provide at least 60 percent of Myanmar's animal protein consumption and make important contributions to economies and culture (Soe *et al.*, 2020).

Two-thirds of the population live in rural areas and while Myanmar has both marine and inland fisheries, more people are involved in inland fisheries (full-time and part-time) than marine fisheries (1.6 million compared to 1.4 million). These figures are considered likely to underestimate participation as the statistics do not account for households that engage in fishing as a subsistence activity (Soe *et al.*, 2020). The diversity of environments, species and fishers is reflected in a wide range of gears including gillnets, surrounding nets (including fences), cast nets, lift nets, hook and line, and traps. While a lot of fishing is conducted from the shore, non-motorized wooden vessels are often used for fishing in more open-water environments (Soe *et al.*, 2020).

Fishing can occur year-round but the most productive period is between June and September during the rainy season. Prior to 1999, Myanmar's inland fishery production reported to FAO was relatively low, varying between 140 000 and 160 000 tonnes. Re-estimation of the contribution of floodplain fisheries, particularly the *inn* fisheries (large fishing concessions based on traps that capture floodplain fish during recession of water at the end of the monsoon season) and the "leasable" fisheries (e.g. fixed bagnet fisheries based in the Ayeyarwady Delta) has led to increased catch estimates. Management measures applied in the *inn* fisheries such as enhancement through stocking also contribute to increased fisheries productivity. Reported production from Myanmar in 2021 was 786 110 tonnes, equivalent to almost 7 percent of global inland fish catch.

Rural fish supply chains typically depend on capture fisheries, including subsistence fisheries and involve small quantities of fish (e.g. Belton *et al.*, 2015). Fish is often sold fresh but, during times of higher fish abundance, fish will also be processed and processed. Fish, including dried and fermented fish, can be particularly important at certain times of the year as well as in upland areas. It is reported that even in coastal areas people prefer to consume freshwater fish (Thilsted and Bose 2014). The majority of fish caught is consumed by the fishing household. It was reported by Belton *et al.* (2015) that in 2010 approximately 14 percent of monthly household food expenditure was spent on fish and fish products, second only to expenditure on rice (19 percent). Average annual per capita consumption estimates range from 15 kg to 61 kg (Soe *et al.*, 2020).

There are a number of threats to inland aquatic environments and fisheries in Myanmar. Amongst those identified are environmental impacts including pollution from mines, quarries and industry as well as hydropower. In coastal areas saltwater intrusion is affecting water quality.

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Cambodia

Cambodia has a wide range of aquatic environments, including rivers, lakes, reservoirs, floodplains and flooded forests. The majority of these environments are dependent on floodwaters, with around 70 percent of the annual water coming from upstream countries. The majority of this water flows through the Mekong River, of which around 500 km is in Cambodia, before entering the Mekong Delta. About 86 percent of Cambodian territory is within the Mekong River Basin, including the catchments of the Bassac River, the Tonle Sap River and the Tonle Sap Lake (ADB, 2019). Other permanent and seasonal aquatic environments, including artificial canals or reservoirs, ponds and paddy fields are also important for inland fisheries. The Tonle Sap Lake in Cambodia is the largest freshwater lake in Southeast Asia and is responsible for around two-thirds of the fish production. Productivity of waterbodies is largely driven by the flood pulse and the reflects the productivity of the wider Mekong River system. Cambodia's inland fisheries are among the largest and most significant in the world. In these naturally fluctuating environments, dry-season refuges for fish play an important role, the most notable being permanent floodplain lakes, including the Tonle Sap Lake, the deep pools of the Mekong and its tributaries upstream of Kratie.

Cambodian inland fisheries are notable for the high diversity of species in the catches. Nam, Ngor and Degen (2014) estimated that there were around 500 species of fishes and other aquatic animals in the catches, placing the country amongst the top ten in terms of freshwater fish diversity. The diversity of fishing gears reflects the diversity of species with over 150 types of fishing gears used (Deap, Degen and van Zalinge, 2003). Recent surveys (FiA, 2023), indicate the most important gears, based on their contribution to the reported catch, are gillnets (45 percent), horizontal cylinder traps (18 percent), cast nets (11 percent) and hand capture (8 percent). Official inland fisheries catch statistics report annual catches to be over 400 000 tonnes per year, worth some USD 300 million (FiA, 2023). This includes the catch of other aquatic animals (OAAs) such as shrimps, crabs, snails, frogs, insects, snakes and turtles that contribute around 15 percent of catches and that can be particularly important in paddy field fisheries. This is consistent with the 383 050 tonnes of fish reported to FAO for 2021. The majority of the catches come from subsistence and commercial fisheries, the latter including the stationary trawl (*dai*) fishery at the mouth of the Tonle Sap. In addition, there are also some limited recreational fishing. Capture fisheries are largely based on natural productivity, although there are some enhancement activities in smaller waterbodies, including stocking and the creation of small dry-season refuges. Sometimes the fish refuges are also stocked. There are minimal stocking activities in large waterbodies.

Traditional processing plays an important role in the food systems and culture of Cambodia. Processing also provides a means to ensure the availability of seasonally abundant fish throughout the year. Many of the processed fish products, including the dried-salted fish, smoked fish, fish balls and fermented fish products such as *prahok*, *pha ork* and *nem* (LeGrand, Borarin and Young, 2020) are based on traditional techniques. In the case of the *dai* fishery at the mouth of the Tonle Sap, a highly productive stationary trawl fishery supplies large numbers of small-scale processors who travel to buy fish during the short harvesting period. The increase in aquaculture has provided additional sources of fish for some processing activities and enabled some processors to continue traditionally seasonal operations year-round. Most processed products are consumed domestically, with only a small proportion of higher-valued products exported mainly to regional markets, including in Viet Nam, Thailand and the Republic of Korea (iDE and UNIDO, 2021).

It has been estimated that 90 percent of people depend upon small-scale and subsistence fishing for their food security (Hap, Seng and Chuenpagdee, 2006). In many cases, fisheries are combined with other livelihoods activities, often agriculture, and fishing needs to be considered in this way as part of diversified livelihood strategies. The diversity of fisheries, their role in livelihoods and cultures and high levels of participation combine to produce some of the highest annual per capita fish consumption, with Nam *et al.* (2015) estimating wild fish consumption in Cambodia at 53.6 kg.

The importance of inland fisheries and the diversity of fisheries and fishing practices that exist at the local level is reflected in management approaches. Regionally, Cambodia is a member of the South East Asia Fisheries Development Centre (SEAFDEC) and the Mekong River Commission (MRC). At the national level, local management is an important focus. Nationally, local management activities are important and Sok and Yu (2021) describe how co-management has been a feature of many inland fisheries that has been institutionalised through the regime of the community fisheries (CFi). The CFi are the focus for developing local management plans. Also important at the local level are Community fish refuge ponds (CFRs) that provide dry season refuge or sanctuaries for brood fish in seasonally inundated paddy fields (MRC, 2022). These are derived from traditional practices associated with floodplain areas and rice cultivation and have become central to inland fish enhancement promoted by the government and others.

Elsewhere, a focus on gear restrictions is accompanied by the establishment of fish sanctuaries and protected areas at different scales. One such focus are the 167 deep pools in the Mekong River. These are recognized as critical habitats. Consequently fish sanctuaries and conservation areas have been established in parts of the mainstream Mekong and some CFi have established community fish conservation zones (MRC, 2022). Similar conservation areas have been created in the Tonle Sap, including in some of the productive fishing areas previously under the commercial fishing concessions.

Pressures on inland fisheries include the results of increasing urbanization, irrigated rice cultivation and other land use change. With the fisheries heavily dependent on the flood cycle, the effects of changing water flow and water quality can also affect the fisheries.

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Viet Nam

Viet Nam with its narrow profile has few major rivers (including the Hong [Red] River), and Mekong Delta. Much of the water resources in the country originate outside of the country and flow through it to the sea, with a high degree of seasonality. In addition to the rivers and deltas there are also some lakes and large reservoirs that contribute to fish production. There are other freshwater resources in Viet Nam outside of the Mekong Delta (such as Lake Ho-Tay and Lake Ba Be reservoirs and 1 967 reservoirs with a storage capacity of at least 0.2 km^3, as well as Hue Lagoon and northern upland streams and paddy fields) that also have inland fishing activity.

Viet Nam is reported to have 632 species of freshwater fish, including 587 native species and 17 introduced species. The nature of the aquatic environments, with several short rivers and proximity to the sea, means that species composition includes migratory species and can also vary between dry and wet seasons, with a mix of marine and inland species in catches (Nguyen *et al.*, 2023). Gears used include cast nets, gillnets and seine nets as well as hook and line, long lines and traps. The overall trend in inland fishery production in Viet Nam has risen to around 200 000 tonnes in the early 2000s but has reduced to around 150 000 tonnes, with the current reported catch being 149 504 tonnes (2021). The reported statistics are likely to underestimate total catches as they may be covering only part of the inland fishery (Coates, 2002) and significant other sources of production at household level may be unrecorded. The presence of marine species in inland waters and the increase in aquaculture production and availability of cultured species can create challenges in identifying and quantifying the production from inland capture fisheries.

Fisheries fulfil different roles in household livelihood strategies. Full-time fishers will catch fish year-round from river, canal, paddy fields and floodplain waterbodies, and will supplement income from fishing with wage labour (traditionally agricultural work) and the collection of wild vegetables. While the majority of the catch is sold (typically to traders but also directly to consumers), some will be retained for household consumption. Fish seed will also be collected and sold for stocking and grow on in aquaculture. Fisheries can also be a part-time activity or combined with other activities, in which case fish will primarily be caught as a contribution to household food supply with surplus sold. Nam *et al.* (2015) estimated annual per capita wild fish consumption in Viet Nam to be around 16 kg, although contributions to fish consumption are also made by production from aquaculture (Nam *et al.*, 2015).

Changes in land use, including the expansion and intensification of rice cultivation – including production of a third crop of rice in the delta region – as well as the expansion of aquaculture and upstream hydrological changes, combine to affect fish abundance and fisheries (e.g. Vu, Hortle and Nguyen, 2021). These kinds of changes are also believed to have contributed to the decline in importance of the fisheries in the once productive Hong (Red) River.

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Thailand

Thailand has 22 river basins and 353 sub-basins, with a total area of inland waters of approximately 3 750 km^2, including several large river basins (Mekong River and its several tributaries, Chao Praya River basin, Ta Chin River basin). Other significant inland water resources include Songkhla Lake Basin, several large reservoirs built for irrigation and hydropower, as well as swamps and wetlands and a huge rice-growing area (Ratanachamnong and Sriputtinibondh, 2022).

Catches from inland fisheries have increased over time and to around 200 000 tonnes but the present catch reported to FAO of 112 604 tonnes (2021) represents a decrease on these figures. It is therefore likely that this figure is an underestimate of total catches and production. The Mekong River Commission (MRC) estimated the inland capture production (including aquaculture) from the Mekong Basin area of Thailand to be over 900 000 tonnes (Hortle, 2007). Production includes various migratory species, as well as species associated with floodplains including climbing perch (*Anabas testudineus*), snakehead (*Channa* spp.) as well as non-indigenous tilapia and carp species. Stocking of large- and medium-sized reservoirs occurs in Thailand using tilapia as well as Indian and Chinese carps, with production from these waterbodies making up a large part of reported national production.

As with other countries in the subregion, the diversity of fish and fisheries environments mean that a diversity of fishing gears including traps, cast nets, gill nets and hook and line are used. Fishing itself can often be combined with other livelihood activities or, as in the case of fishing days, be central to cultural events. Studies conducted in the Mekong region suggest that fish catches are consumed and sold both as fresh and processed products. Processed fish products include smoked and sun-dried fish, fish balls and fish sausage, and fermented fish. Distribution of fish includes marketing directly and through traders, as well as the customary practices of bartering and sharing catches with families, as well as with nearby villages (Mahasarakarm, 2007). Both fresh and processed fish are used in a variety of traditional dishes. Annual per capita fish consumption is high at around 36 kg (Nam *et al.*, 2015).

Fisheries management includes gear, closed seasons and area restrictions as well as the use of enhancement and conservation measures at different scales. Fish stocking programs have a long history and continue to be popular. This includes the ad hoc stocking of small waterbodies as well as larger-scale stocking programs subsidized by the government. Species used in stocking programmes include indigenous species such as silver barb (*Barbonymus gonionotus*) and freshwater prawn as well as non-indigenous species (Chinese and Indian major carps and tilapia).

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The Lao People's Democratic Republic

The Lao People's Democratic Republic is a land-locked country that is bordered on the east by Viet Nam, Cambodia to the south, Thailand to the west and south, and Myanmar and China to the north. In relation to water resources, the country is located almost entirely within the Mekong Basin, and has a large number of tributary rivers, and associated floodplains and a few reservoirs. Almost 90 percent of the water resources drain into the Mekong River, contributing about 35 percent of the Mekong River's discharge.

In the Lao People's Democratic Republic more than 481 fish species have been identified, including 22 non-indigenous species (Phonvisay 2013). More than 10 non-indigenous fish species have been introduced into the Lao People's Democratic Republic through various sources, including common carp (*Cyprinus carpio*); Chinese carps including silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idella*) and bighead carp (*Hypophthalmichthys nobilis*); Nile tilapia (*Oreochromis niloticus*); and the Indian major carps including rohu (*Labeo rohita*), mrigal (*Cirrhinus mrigala*) and catla (*Catla catla*). These species are widely used in stocking and enhancement initiatives.

Based on occasional official reports, inland capture fishery production in the Lao People's Democratic Republic has increased steadily since 2003, and the current estimate of 71 000 tonnes remains substantially lower than the estimate of 208 503 tonnes that was derived from the MRC fishery programme valuations (Hortle, 2007). Participation in fisheries is high and fishing is often combined with other livelihood activities, often agriculture and the harvesting of wild plants and animals. Fishing principally contributes to household food, with fish also sold to generate income. The role of women in fisheries includes not only the processing and preparation of fish but also the fishing itself – their fishing activities often take place close to the house and in smaller and often more marginal environments such as ditches, streams and paddy fields. While the majority of fishing is an individual activity, there are also examples of collective fishing. This includes in the larger river barrier gears but also in floodplain waterbodies, where a team of fishers will lease waterbodies and harvest them at the end of the recession period. These fishers may be from the locality but may also be from outside and lease waterbodies in different locations.

The people of the Lao People's Democratic Republic, especially in the rural communities, are highly dependent upon the country's fish and other aquatic animals as their most reliable sources of animal protein intake, and it can be particularly important as a nutritional safety net during times of poor or failing rice crop harvests. Nam *et al.* (2015) estimated annual per capita wild fish consumption in the Lao People's Democratic Republic at 36.2 kg.

Local communities have an important role in the management of fisheries in the Lao People's Democratic Republic and the government has included the promotion of community fisheries and stock enhancement within strategic agricultural development policies and plans. The devolution of some authority for management has provided opportunities for experimentation at the local level and resulted in the adoption of the different management strategies and benefit arrangements, (Saphakdy *et al.*, 2009; Garaway *et al.*, 2006). Management measures that are widely used include closed areas and seasons, gear restrictions and stock enhancement through both ad hoc and formal stocking programmes (often in the larger reservoirs). As in Cambodia, dry season refuges and the maintenance and restoration of habitats and habitat connectivity are often part of management strategies.

Fisheries in the Lao People's Democratic Republic are, however, under considerable pressure due to population growth, demand for fish, and the increasing commercialization of fish production and supply. The development and expansion of hydropower and irrigated agriculture, especially for rain-fed and floodplain habitats, is considered a key threat to fisheries.

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Malaysia

The inland fisheries of Peninsular Malaysia are concentrated in the major rivers, although fishing also takes place in most small rivers and waterbodies. Peninsular Malaysia has no major natural lakes, but does have large reservoirs. Freshwater fish in Malaysia includes around 621 native species, of which 4 are endemic as well as 16 introduced species. The total reported capture fisheries production (Peninsular and Borneo) was 5 562 tonnes.

Inland fisheries contribute significantly to the national economy and rural households. While fishing is important, most fishers also have other sources of income. Reports generally indicate that impacts on water quality as a result of agricultural plantation runoff, deforestation and mining have variously had a serious impact on inland fisheries productivity (Khoo *et al.,* 1987).

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Indonesia

Indonesia has considerable water resources in the form of some large river basins particularly in Kalimantan (Mahakam, Kapuas). The country has the largest area of lakes and floodplains in the Southeast Asia subregion, as well as smaller rivers volcanic lakes, smaller waterbodies and paddy field systems (in Sumatra, Java and Sulawesi).

Indonesia has a diversity of freshwater fish species, which more than 1 200 species of which there are around 630 endemic species and 28 non-indigenous species, providing the highest species density of freshwater fish globally (Hubert *et al.*, 2015). Fishing takes place in a wide range of aquatic environments, including rivers, lakes, reservoirs, paddy fields and irrigation canals, peatlands and estuaries, as well as brackishwater lagoons. Gears used include gillnets, barrier gears, traps, longline and hook and line (e.g. Muthmainnah *et al.,* 2016). The choice of gear depends on season, water level and species targeted and a sequence of fishing gears may be operated according to water level fluctuation (Ditya *et al.*, 2022). Small boats are also used in more open-water environments. In peatland areas, artificial ponds (*beje*) are used to trap fish during the seasonal movements between November and March. Fish are retained in these ponds and harvested later in the year. Eels (*Anguilla* spp.) are a particular target species and are harvested as glass eels for sale to aquaculture operators. The resulting products are exported to foreign markets including Japan, the Republic of Korea, and China (Muthmainnah *et al.*, 2020).

The inland capture fishery production of Indonesia has risen from 336 141 tonnes in 1994 to 465 989 tonnes in 2021. Fisheries in inland waters for many communities are important for food security and income as well as for cultural and religious identity and for recreation (Ditya *et al.*, 2022). Fish are often consumed or sold fresh and are also made into processed products including dried, salted and smoked fish, fish balls and fish skins. Eels are principally sold live to traders and the traders may provide the gear and equipment to the fishers for eel collection. Women are often involved in these activities as well as in administrative aspects (Muthmainnah *et al.*, 2020).

One notable management arrangement is the leasing of floodplain waterbodies. Perennial waterbodies within the floodplains are auctioned by the local government. The leaseholder then has the right to manage and harvest the waterbody and determine gears to be used, stocking and harvesting and they can hire fishers for the harvesting of the waterbody.

Aquatic environments across Indonesia are subject to change and the building of dams, highways, mines, as well as other changes in land use and agriculture (including intensification and increased palm oil production), have led to the fragmentation and degradation of these environments (e.g. Haryani, 2022; Hubert *et al.*, 2015). Fish habitats and their connectivity are affected by these changes as well as from increased fishing pressure, commercialization of some fisheries and the increase in aquaculture, including cage culture in lakes that is often associated with non-indigenous species.

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The Philippines

The archipelago of the Philippines has few major river basins and floodplains (Mindanao River, Agusan River) reflecting the geography of the country. Guerrero (2022) reports there to be 406 328 ha of inland waters in the Philippines, including lakes (61.5 percent of the total), marshes and swamps (26 percent), rivers (7.6 percent), and reservoirs (4.7 percent). Inland fisheries are predominantly located in lakes (including Bay, Lake Taal, Lanala, Lake Mainit) and reservoirs. These can often be multi-purpose, used for fish production (both capture fisheries and aquaculture), domestic water supply, navigation, and irrigation.

Freshwater fish in the Philippines includes about 358 species, of which there are 120 endemics and 59 introduced species, including snakehead (*Channa striata*), common carp (*Cyprinus carpio*) and Mozambique and Nile tilapia (*Oreochromis mossambicus* and *O. niloticus*, respectively). Fish introductions have been for aquaculture and fisheries but also for the aquarium trade (e.g. Sarmiento, Ventolero and Santos, 2019). Some non-indigenous species are also reported to be processed into fishmeal, dried fish skin, and handicrafts (Muthmainnah *et al.*, 2019). Overall, recent studies by Guerrero (2022) have indicated that the most commonly caught fish in commercial catches were tilapia (50 percent of the total), carp (16 percent) and snakehead (11 percent).

As an archipelago, fisheries in Philippines include both marine and inland fisheries and there is also significant aquaculture production. This can make it difficult to separate out the production, particularly as the delineation of inland fisheries includes some brackishwater areas such as lagoons, river mouths and bays. Overall production from inland fisheries in 2021 was 201 056 tonnes. The introduction of floating fish cages in the 1990s, such as in Lake Tana, have increased overall fish but reduced the catches from the wild capture fisheries, impacting some of the small-scale fishers.

The major issues threatening the sustainability of freshwater fishes have been identified as fishing pressure, water pollution (including from aquaculture), invasive fishes, and environmental degradation (Guerrero, 2022).

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Brunei Darussalam

Brunei Darussalam is located on the northwestern coast of the island of Borneo. The fisheries are mainly concentrated in the rivers and the estuaries located in the northeast of the country. There are reported to be 104 species of freshwater fish in Brunei Darussalam, including 46 endemic species. Inland fisheries production between 2015 and 2021 has varied between 8 and 42 tonnes and was almost 18 tonnes in 2021, with the majority (10.67 tonnes) from Brunei-Muara district (Jalaban Perikanan, 2021).

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Timor-Leste

Timor-Leste covers a total of 15 410 km^2 of the eastern end of the Indonesian archipelago. The majority of fishing is focused on the marine fisheries and inland fisheries are small-scale and subsistence. Tilapia (*Oreochromis niloticus*), common carp (*Cyprinus carpio*) and catfish (*Clarias batrachus*) have all been introduced to promote inland aquaculture (Sendall *et al.*, 2016). Demand for freshwater fish is limited, with marine species being more popular and it has been suggested that the local culture also influences the low levels of fish consumption (Angarita *et al.*, 2019).

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Singapore

Singapore is a city-state with no reported inland fish catches.

7.2.2 Southern Asia

Country/territory	Inland capture fisheries catch (tonnes in 2021)	Percentage of global inland fish catch	Population (2021)	Per capita inland fish production (kg/cap/year)
India	1 847 000	16.25	1 407 563 842	1.31
Bangladesh	1 301 244	11.45	169 356 251	7.68
Pakistan	149 852	1.32	231 402 117	0.65
Sri Lanka	62 157	0.55	21 773 441	2.85
Nepal	21 000	0.18	30 034 989	0.70
Bhutan	15	0.00	777 486	0.02

India

There are 14 major and 44 medium-sized river systems in India, along with a large number of smaller systems. Their combined length is about 195 210 km. The topography of the country includes high mountain areas, lowland floodplains and coastal deltas and lagoons. The river basins contain floodplain lakes and wetlands, which are known variously as *mauns*, *chaurs*, *jheels* and *beels* that can be especially important in areas such as Assam, Manipur, West Bengal, Bihar and eastern Uttar Pradesh. The total estimated area of natural wetlands is 5 310 000 ha and additional wetlands, including reservoirs, canals and paddy fields, add another 2 270 000 ha to this figure. This is a total area of 75 800 km^2 that represents some 5.8 percent of India's geographical area (FAO, 2023; Bassi *et al.,* 2014). These wetlands are arguably the most important environments for fish production, with river fisheries contributing relatively little to the total inland fishery production of India (see also Kelkar and Arthur, 2021). It is also important to acknowledge that fish production is not just a feature of rural landscapes and that fish production from urban and peri-urban areas is also important, although the nature of the fisheries may be different (Kadfak, 2019).

Freshwater fish diversity reflects the diversity of habitats with over 1 000 species. The fish include those in the fast-flowing cooler waters of the northern parts of India, such as the snowtrout (*Schizothorax richardsonii* and *Schizothorax* spp.) and mahseer (*Tor* spp.), as well as the large rivers and floodplains where carp and catfish species can be important (FAO, 2024). Introduced fish species, including tilapia (*Oreochromis* spp.), have been stocked to enhance fisheries and are important in some fisheries. Fishers use a wide range of active and static fishing gears. Gear use depends upon a range of factors including the nature of the fishery environment, target species, habitat and season. Many gears have been developed based on knowledge of target species behaviour, including habitat use, migration, feeding and spawning. These may be used to target fish and other aquatic organisms at all stages of their life cycles, including juveniles and larvae, often using fine mesh nets. These can be used to supply capture-based aquaculture. Other factors may be social or economic and relate to the types of gears that are permitted or access to financing and credit. Gears include both those used by individuals (including gillnets, cast nets and hook and line) as well as larger gears (including seine nets) that require teams of fishers to operate them (FAO, 2024; Kelkar and Arthur, 2021). While men often catch and women process and sell fish, in many cases women also regularly catch fish as well as collect crabs, prawns and prawn seed (e.g. Mitra *et al.*, 2017).

Based on reports in 2019, total freshwater fish production varies across the states and Union Territories of India. States such as Andra Pradesh (2.8 million tonnes) and West Bengal (1.6 million tonnes) are highly productive, contributing 32 percent and 17 percent of total freshwater fish production. Other states such as Uttar Pradesh (600 000 tonnes), Odisha (500 000 tonnes) and Assam (327 000 tonnes) also make significant contributions (Government of India, 2019). There are also states with fewer water resources, such as Rajasthan and Himchal Pradesh where the contribution to freshwater fish production is far lower. FAO estimates that total inland fish production in India was 1.85 million tonnes in 2021, showing a general increasing trend over the past 25 years from a production of 608 378 tonnes in 1995.

India also has some inland recreational fisheries, although many are less well documented and most of the focus has been on the cold water fisheries. Embke *et al.* (2022) report that participation is only around 13 000 people, although some recreational fishing may be classified as subsistence where the retention rates are high. Total retained catches from the recreational fisheries were further estimated to be around 33 tonnes, around 50 percent of the total recreational catches. In addition to the recreational fisheries there is increasing production of ornamental fish, mainly for export, principally in the areas of the Western Ghats, Central and Northeast India, and the Himalayan foothills and Terai River stretches (e.g. Raghavan *et al.*, 2013).

The Government of India estimates that more than 23 million people across the country depend on inland fisheries (FAO, 2024). Overall, the figure is likely to be a significant underestimate (e.g. Fluet-Chouinard, Funge-Smith and McIntyre, 2018) but the estimation of dependence remains difficult – as inland capture fisheries are dispersed and seasonally or interannually, the same people may or may not be actively fishing or fishing in the same places (Santha, 2010). Inland capture fisheries in India are especially important in terms of food, providing 23 percent of all freshwater fish production to some of the poorest members of the population (FAO, 2024). Fish are sold fresh, dried and fermented (Mitra *et al.*, 2017), and a large proportion of this fish is locally or regionally consumed. There are regional trade networks, for example in Northeast India, where the Jagiroad Market in Assam is an important trade hub for dried fish (Kelkar and Arthur, 2021). The contribution to food security and nutrition of inland fish also needs to be understood in the context of the massive rural populations of India and the quality of their diets, which do not have considerable amounts of animal protein. Many of the Indian states are land-locked, thus although they are part of a single country, they are remote from the sea and marine-sourced products are either hard to access or too expensive to purchase for the majority of their rural populations (Uttar Pradesh, Bihar, Jharkhand, Assam, Arunachal, Chattisgarh, Rajasthan, Madhya Pradesh, Punjab, Chandigargh, Meghalaya, Manipur, and Mizoram). There are also states that have access to freshwater as well as marine fisheries, and where inland fisheries are still important such as Andhra Pradesh, Gujarat, Karnataka, Orissa, West Bengal, Tamil Nadu, Maharastra and Kerala.

Stocking, or fisheries enhancement measures, are also a common feature of inland fisheries in India and effective at increasing production (FAO, 2024; Sugunan, 1995). This includes use of wild seed and fry (capture-based aquaculture) or use of hatchery-produced seed and fry (culture-based fisheries) to supplement naturally occurring wild stocks. The spread of freshwater aquaculture and culture-based fisheries is also associated with the introduction of non-indigenous fish species to inland waters across India (Singh and Lakra, 2011). While capture fisheries are widespread and make important contributions to livelihoods, the emphasis by state and national governments has been on the development of culture-based fisheries and aquaculture.

Hydrological alteration, dam construction, and fishing pressure are all identified as driving changes in fish abundance, diversity and community structure. Invasion by aquatic plants has been identified as a threat to cold-water fisheries systems (Sandilyan *et al.*, 2018). Elsewhere, while enhancement can increase the productivity of inland fisheries, it is important that these practices don’t drive intensive fishing or restrict the free movement of fish to the detriment of the wild fish populations or lead to the enclosure of waterbodies and reduction in access by poorer and otherwise marginalised groups (FAO, 2024; Arthur *et al.*, 2023).

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Bangladesh

Bangladesh is a low-lying country situated in the delta formed by the outlet of the combined rivers Ganges Brahmaputra and Meghna. Wetlands of many different types are a dominant feature of the geography. Rahman (1989) mentions 10 300 km^2 of rivers, canals and estuaries, 1 142 km^2 of natural depressions (*beels* and *haors*), 1 619 km^2 of ponds and tanks, 55 km^2 of oxbow lakes, Kaptai Lake (the Karnafuli reservoir) comprising 688 km^2, 28 000 km^2 of floodplains and 873 km^2 of brackishwater farms. Inland fisheries include the capture fisheries that occur within river and estuaries, beels, floodplains and paddy fields, Sundarbans and Kaptai Lake. Elsewhere there are also enhanced and culture-based fisheries and aquaculture that occur in ponds, seasonal floodplain waterbodies and reservoirs, as well as fish farms, and crab culture (both pen and cage) in more open waters.

Fish diversity in Bangladesh is estimated to be around 265 species (Rahman, 1989). Given the extensive practices of fisheries enhancement and fish culture, species such as the indigenous Indian major carps including catla (*Catla catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*) together with minor carps (*Labeo gonius* and *Labeo bata*) are important. This is combined with non-indigenous species such as silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idella*), and common carp (*Cyprinus carpio*). With growing interest in live fish (Shamsuzzaman *et al.*, 2020), there is also interest in native species including catfish (e.g. *Clarias batrachus* and *Heteropneustes fossilis*), climbing perch (*Anabas testudineus*), and snakeheads (including *Channa punctatus, C. striatus* and *C. marulius*).

About 1.2 million people are engaged full time and another 10.2 million are engaged part time in capture fisheries for their livelihoods (Ministry of Fisheries and Livestock, 1998). Most of these people appear to depend on inland fisheries, as 60 to 70 million people own less than 0.2 ha of land and live in floodplains (Shankar, Halls and Barr, 2004). A variety of gears are used individually or collectively, including gillnets, seine nets, set bag nets, lift nets, scoop nets and traps.

Bangladesh is one of the world's largest producers of inland fish and has reported its inland catches almost without exception since 1950. The country has been experiencing increasing catches since 2012. In 2021, the landed volume was 1 301 244 tonnes. About 12 percent of the country's total fish production comes from hilsa (*Tenualosa ilisha*), and this species has historically made the single highest contribution to the country's total fish production (Toufique, 2015). About 65 percent of Bangladesh's total catch of Hilsa currently originates from the marine environment (Shamsuzzaman *et al.*, 2020). The high proportion of hilsa in catches and the increase in intensity of fish culture combine to make it difficult to accurately determine the productivity and catches from inland fisheries, as the species are often the same.

Stocking typically involves a mix of species including the Indian major carps, introduced Chinese carps as well as some small indigenous species. The expansion of fisheries enhancement and intensification of enhancement and culture activities are most likely a result of the government's support for these activities.

Fish, represents the second most valuable agricultural crop in Bangladesh and play a crucial role in the livelihoods and employment of millions of people (DoF, 2019). The majority of fish is used fresh, although there is some drying, salting and smoking of some fish. Live fish production has tripled since 2000. Overall both live fish and indigenous carp species have high market demand (Shamsuzzaman *et al.*, 2020). Frequency of fish consumption, and the diversity of fish products consumed is generally very high. Recreational fishing has also been identified as contributing to inland fisheries and Embke *et al.* (2022) suggest that there may be 976 200 people participating (0.6 percent of the population). Retained catches in the recreational fisheries are estimated to be around 50 percent, representing additional catches of 1 210 tonnes.

There is support for fisheries enhancement and increasing the productivity of inland fisheries. This can be related in some cases to policies that involve the leasing of waterbodies for fish production. Elsewhere, the management of hilsa is a priority given the contribution to overall fish production and cultural significance of the fish. Since 2003, the Government of Bangladesh has put in place several protection and conservation measures, including the closure of some areas to fishing, restrictions on fishing gear, a closed season, and regulations for fishing vessels. Fishers have also been given incentives during the closed season in the form of food and alternative income generation (Islam, Mohammed and Ali, 2016).

Inland capture fisheries are affected by changes in water and land use (including flood control, drainage and irrigation and changes in agriculture practices) that have led to the loss of habitat connectivity and pollution with chemicals, pesticides and fertilizers. Changes in river flow, flooding and sedimentation due to the construction and operation of dams have affected stocks. Reduction in the productivity of waterbodies has been offset through mitigation measures such as stocking and increased fish culture (Shamsuzzaman *et al.*, 2017). Although this, in some cases, has the potential to increase fish production, there are serious concerns regarding the distribution of benefits (Valbo-Jørgensen and Thompson, 2007). Despite the community-based focus of much of fisheries management, secure access for fisher communities can still be influenced by those who are not direct participants in fishing activities. (Firoz Khan, Mustafa and Niamul Naser, 2016).

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Pakistan

Inland capture fisheries are dominated by the Indus River Basin, which has a total area of 1.12 million km^2 (Qamer *et al.*, 2009) with a 9 700 km^2 floodplain. In the Sindh Province alone there are more than 100 natural lakes of different sizes covering an area of about 1 000 km^2. Among them, lakes Halijee (18 km^2), Kinjhar (120 km^2) and Manchar (160 km^2) are quite important for fish production. Apart from these large lakes, a cluster of small lakes collectively called Bakar Lake extends over 400 km^2. The natural lakes in Punjab cover about 70 km^2. Six large reservoirs have been created in the past four decades through the construction of dams and barrages across rivers, which provide about 2 500 km^2 for fish production. The largest reservoir is the 400 km^2 Chashma on the Indus itself, the other large reservoirs are the Tarbela and Mangla (respectively 271 km^2 and 267 km^2). In addition, there are several smaller reservoirs – the irrigation system of Pakistan is one of the largest in the world, serving 144 000 km^2 of irrigated land with 58 500 km main canals and 1.6 million km^2 ditches (Akhtar, 2003; FAO, 2009).

The fish fauna of the Indus system in its northern part is coldwater type, whereas the greater middle and southern parts of the system are warmwater. Akhtar (2003) mentions that there are about 30 commercial species, mainly in the southern parts, including Indian major carps, snakeheads, catfishes, sheatfish, featherback and others as well as non-indigenous species including tilapias, Chinese carps, common carp (*Cyprinus carpio*) and trout. Hilsa (*Tenualosa ilisha*) used to be an important species, however, the construction of barrages has prevented it from reaching its spawning sites in the Indus (George, 1992). A similar situation has occurred with the large mahseer (*Tor* sp.) according to Akhtar (2003).

In terms of overall fish production, inland fisheries are estimated to contribute 36 percent to the total volume of catches (TDAP, 2021). Pakistan reported landings of 149 842 tonnes from inland fisheries in 2021 and has generally exhibited continuous growth since 2003. The large artificial waterbodies remain the major source of fish production and about 25 percent comes from the six major reservoirs, with catches from natural lakes remaining generally of secondary importance. Coldwater streams and rivers have low production, although they may be important for local subsistence fishing and have considerable potential for recreational fisheries (Akhtar, 2003). While there is little information on the status of recreational fisheries, Embke *et al.* (2022) estimate that annual participation is fairly significant, suggesting around 1 373 218 people.

In 2014, there were an estimated 211 609 inland fishers (some of these working only part time). This means that more than 50 percent of all fishers in the country are employed in inland fisheries (FAO, 2017). People in Pakistan are generally not significant consumers of fish, but fish does provide an important food component in some areas and the preference is mainly for fresh fish. Fishing in Pakistan accounts for less than 1 percent of the GDP, but it still plays a crucial role for particular groups and regions, including Balochistan and Sindh (TDAP, 2021).

Issues affecting inland fisheries in Pakistan include flow regulations and deforestation that have led to habitat degradation and pollution with pesticides (e.g. Schmidt, 2014) as well as discharge of raw sewage near Karachi, and wetlands have been lost because of land reclamation (Schmidt, 2014). Although reservoirs and irrigation infrastructure have considerable fisheries potential, fishers are not considered to be important user group and therefore these reservoirs are not managed in such a way as to benefit fishers (Akhtar, 2003; Schmidt, 2014). Fishing rights are traditionally auctioned and although certain management measures are in place, there is little enforcement of the management regulations and information related to catches is poor (Akhtar, 2003). Short leases leave little incentive to apply good management practices, although stocking is sometimes undertaken (Akhtar, 2003).

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Sri Lanka

While there are few large rivers and floodplains in Sri Lanka, the country has a historic system of water storage with some major reservoirs being more than 2 000 years old (Amarasinghe, Pushpalatha and Wijenayake, 2022). Although fisheries in these reservoirs represents a secondary use, medium-sized Sri Lankan reservoirs and small irrigation tanks in particular are highly productive and contribute to the productive potential of the country. There are a large number of these waterbodies (over 12 000), many concentrated in the dry zone of the country (receiving 125–190 cm annual rainfall). The total reservoir extent of the country is around 206 000 ha (Jayasinghe and Amarasinghe, 2018).

There are reported to be a total of 113 species of freshwater fish in Sri Lanka. These include 76 species of indigenous freshwater fish (including 33 endemic species) and more than 30 species of non-indigenous fish. In the inland fisheries, it is the non-indigenous species that have increased in importance with the introduction of non-indigenous tilapia (*Oreochromis* sp.) in the 1950s. Stocking is widespread and in seasonal irrigation tanks that drain or dry out completely on an annual basis, restocking is practiced (culture-based fisheries) and this is currently being promoted under government- and community-based programmes (Amarasinghe, 2013). In larger reservoirs, the rehabilitation of state-owned fish hatcheries has led the stocking programmes to focus more on Chinese and Indian major carps. Annual fish yields have increased up to 208 kg per hectare and the contribution to catches of tilapia has declines with catla (*Catla catla*), rohu (*Labeo rohita*) and common carp (*Cyprinus carpio*) providing the majority of the landings (Pushpalatha and Chandrasoma, 2009). Stocking in reservoirs has also expanded to include freshwater prawn, *Machrobrachium rosenbergii* (Amarasinghe, Pushpalatha and Wijenayake, 2022).

Gillnets remain one of the main gears used in the fisheries with some use of traps that have been designed to target *M. rosenbergii* (Amarasinghe, Pushpalatha and Wijenayake, 2022). Amarasinghe, Pushpalatha and Wijenayake (2022) also report that in the past there has been the use of beach seine gears in reservoirs and fishers driving fish into gillnets by beating water with wooden poles or weighted ropes. This suggests that fishing is both individual and also engaged in collectively.

Reported production in 2021 was 62 157 tonnes. Production benefits from the nature of the aquatic environments that have been created and the widespread stocking of waterbodies. There is little information on recreational fisheries, but Gunasekera (n.d.) reports that (based on customs goods declaration forms) 52 species of fish were collected from freshwater habitats and exported from Sri Lanka as part of an ornamental fish fishery.

Inland fish remain important to rural food security in Sri Lanka. Consumption studies reported by Murray and Little (2022) suggest that fresh inland fish was consumed by 60 percent of households in the dry zone provinces at least once per fortnight and by 82 percent at least once per month. Preference for inland fish compared to similarly priced substitutes was reported to be due primarily to freshness at point of sale, highlighting the role of accessibility.

Management (and stocking) has, with the exception of a short period in the early 1990s, been supported by the Government of Sri Lanka. This has included stocking, providing fishers with fibreglass canoes and gillnets, and organising fisher cooperative societies (Amarasinghe, Pushpalatha and Wijenayake, 2022). Use of mechanized boats and any kind of shore seine nets are forbidden in perennial reservoirs and the use of gillnets is regulated through minimum-permissible mesh sizes.

The primary uses of reservoirs in Sri Lanka are for irrigated agriculture and hydroelectric power generation. Inland fisheries remain a secondary use of reservoirs. This can lead to potential conflicts of interest between different user groups due to these differing interests.

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Nepal

Nepal consists of approximately 17 percent flat land located in the southern end of the country commonly known as *terai*, and the remaining 83 percent is occupied by hills and mountains in the northern part. The climate ranges from subtropical (< 1 000 metres above sea level) to alpine/arctic at high altitude (> 5 000 metres above sea level). Nepal possesses a large number of rivers fed with perennial supplies of water from melting snow from the Himalayas. It also has a considerable amount of smaller lakes as well as a large number of reservoirs. Fishing also takes place in irrigated paddy fields and marginal swamp areas, (410 000 ha). There are approximately 1 500 ha of artificial reservoirs.

Nepal is home to around 230 native freshwater fish species (Rajbanshi, 2012). Aquaculture in ponds and lakes includes the use of Indian major carps and Chinese carps, as well as Nile tilapia (*Oreochromis niloticus*) and common carp (*Cyprinus carpio*). Annually it is estimated that around 28 percent of domestic fish production comes from capture fisheries and 72 percent from aquaculture (Kunwar, 2018). Despite this, capture fisheries provide employment for over 400 000 people, around 60 percent of whom are female. Inland capture fisheries in Nepal are exclusively small scale, with fishers using traditional gear mainly for subsistence fishing. Participation and employment in capture fisheries are also greater than aquaculture (Pandit and Rizal, 2022).

FAO currently records 21 000 tonnes of fish produced from capture fisheries in 2021. In the early 1990s, there was relatively little fish in the Nepalese diet, but recently the amount of fish protein in diets is increasing. This suggests that the increased fish production, availability, affordability, and purchasing capacity and awareness might have led to the increased consumption. Various aquatic products other than fish are consumed in different parts of the country. Including pila (*Pila globosa*), bivalve (*Lammelidens marginelis*), crabs, shrimp, frogs (*Nanorana liebigii, Nanorana blanfordii*), turtle, and Makhan (*Euryale ferox*) (Gurung, 2016).

Capture fisheries are identified as playing important roles in the livelihoods of people around the lakes (Husen, Gurung & Nepal, 2019). Chilled fresh fish are generally preferred by consumers and supplied through domestic trade. Fluet-Chouinard, Funge-Smith and McIntyre (2018) suggest that there is a degree of unrecorded trade with neighbouring India and that annual per capita freshwater fish consumption is around 1.7 kg.

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Bhutan

Bhutan has five major river systems from west to east (Amo, Wang, Chang [Sankosh], Tongsa and Manas) with the total length of rivers and their tributaries estimated to be about 7 200 km. The country is mountainous and has over 590 natural lakes of various sizes, the majority of them being small and located above an altitude of 2 200 m. The estimated total area of these lakes is about 4 250 ha. There is one artificial reservoir in Bhutan (Chukha) with an area of 150 ha. The inland aquatic environments of

Bhutan have over 100 species of freshwater fish, including several endemic species. During the 1980s, seven species of carp were introduced to promote polyculture in the warmer parts of southern Bhutan (Khanal, 2020). These included: catla (*Catla catla*), rohu (*Labeo rohita*) mrigal (*Cirrhinus mrigala*), silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Hypophthalmichthys nobilis*), grass carp (*Ctenopharyngodon idella*) and common carp (*Cyprinus carpio*).

Fish for food in Bhutan has traditionally come from the wild riverine and lake fisheries of the country and via imports from neighbouring India. Commercial fishing is illegal although communities with customary rights to designated water bodies are allowed to fish, with catches from inland fisheries reported to FAO amounting to 15 tonnes (2021). Domestically produced fish is mostly sold as fresh but sometimes salted or smoked, including in the preparation of smoked snowtrout known as nya doesem (Khanal, 2020). Average annual per capita fish consumption for the period 2014–2018 was estimated to be 5.29 kg (Khanal, 2020). The combination of restrictions on fishing, imports from India, and aquaculture production make it difficult to accurately estimate production and consumption from capture fisheries Most fish in markets is imported fish from India. Average annual imports of fish for the period 2014–2018 has been estimated to be almost 4 000 tonnes. This comprises a mixture of fresh and dried fish, including both freshwater and marine species (Department of Revenue and Customs, 2014). There is some recreational fishing in Bhutan for trout, as well as the potential to develop recreational angling for trout and mahseer.

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7.2.3 China

Country/territory	Inland capture fisheries catch (tonnes in 2021)	Percentage of global inland fish catch	Population (2021)	Per capita inland fish production (kg/cap/year)
China	1 197 682	10.54	1 457 934 562	0.82
Taiwan Province of China	153	0.00	23 859 912	0.01
China, Hong Kong SAR	0	0.00	7 494 578	0.00
China, Macao SAR	0	0.00	686 607	0.00

Note: This review does not include the culture-based fisheries and rice–fish production of China, which are considerable, but which are more correctly accounted for under aquaculture production.

China has both a diverse topography and extensive water resources estimated to be around 27 million ha (FAO, 2023), including over 20 000 rivers with drainage catchments of 100 km^2 or more. Of these, 228 have drainage basins exceeding 1 000 km^2 (Ministry of Water Resources and Power, 2012). The main resources are based on several large river systems, including the Yangtze River (Chang Jiang), Tarim, Yellow River (Huang He), Pearl River (Xun Jiang) as well as the Bei and Hsi rivers The Yangtze River and rivers to the south of it carry 82 percent of the total runoff of Chinese rivers. China also has numerous natural lakes and waterbodies, as well as paddy fields. Lakes account for about 30 percent of the total area of inland waters in China (FAO, 2023) and China has more than 22 104 dams over the height of 15 metres and there are estimated to be more than 98 566 reservoirs of varying types and size (FAO, 2023).

There are 1 133 species of fish in China's inland waters, including more than 1 000 freshwater fish species (the majority cyprinids), more than 20 migratory fish species and more than 100 estuarine fish species (FAO, 2023). There has been a history of translocations and introductions of non-native species into waterbodies throughout the country (Kang *et al.*, 2017). FAO (2023) reports at least 439 non-native, freshwater fish species which have been introduced into China. The origins of these non-native freshwater fish species are South America (35.5 percent), followed by Asia (23.0 percent) and Africa (21.4 percent). A wide variety of gears are used including gillnets, seines, traps, hook and line, and barrier gears. Fishers have also used animals, including otters and cormorants to catch fish (FAO, 2023).

Catch has been relatively stable since 2007 and is currently 1 197 682 tonnes (2021). However, the overall stability does not indicate the gains and losses in individual fisheries and systems. Four provinces, namely Jiangsu, Anhui, Jiangxi and Hubei, have the highest catches, accounting for more than half of the total inland fisheries catches, followed by catches from Shandong, Hunan, Guangdong, Guangxi, Hebei, Zhejiang, Fujian, and Heilongjiang. The catches from all these provinces account for about 80 percent of the total national inland capture fisheries production (Zhao, Gozlan and Zhang, 2015). These are all located in mainland China and additionally, Taiwan Province of China reported 153 tonnes of inland capture production (2021), while China, Macao SAR and China, Hong Kong SAR do not report any inland capture production.

Most inland wild capture fishery production is concentrated in the major rivers and lakes, whereas most reservoir fisheries are dominated by enhanced fisheries (FAO, 2023). Most inland capture fisheries are small scale and spatially dispersed and not all activities and catches are reported. The situation for recreational fishing is similar, making it difficult to obtain accurate inland capture fisheries production information. Interventions in inland waters, particularly in reservoirs, have included stock enhancement, repeated stocking and even fertilization. The intensification of fisheries also coincided with China's development of irrigation and hydropower, expanding the number of reservoirs and other waterbodies suitable for enhanced fisheries and aquaculture. For example, the country's dams account for about 46 percent of the total number of dams over 15 metres height globally (FAO, 2023). This has had a significant positive effect on the productivity of these waterbodies and production. However, Inland capture fishery statistics also do not always clearly distinguish between landings of wild fish and fish from enhanced or culture-based fisheries (FAO, 2023).

With increasing economic development, the role of inland capture fisheries has been changing. While aquaculture provides the majority of freshwater fish supply, high-quality aquatic products from natural waters are still highly sought after by consumers, and inland capture fisheries remain the primary activity in some areas (FAO, 2023).

Traditionally, catches were consumed or traded fresh with some preserved using drying and pickling methods. There has been an increase in trade in fresh fish and greater use of chilled preservation technologies (FAO, 2023). According to statistics, in 2019, the annual per capita consumption of aquatic products in China was 13.6 kg (including fish from inland fisheries). However, national averages can obscure the regional variation that is a feature of inland fisheries in China. As well as being important for food, inland fisheries are also important for their cultural significance and there are a number of fishing festivals that recognize this.

In January 2014, the Ministry of Environmental Protection issued technical guidance for the delineation of the ecological protection based on the concept of the "Three Red Lines". This requires effort to be directed at improvement of water use and the restoration of water quality. However, this policy does not explicitly address the restoration of aquatic ecosystems and associated biodiversity or the restoration of river flows. However, China has established 535 national aquatic resource protection areas to conserve more than 300 aquatic species. The protected areas encompass more than 150 000 km^2 and are mainly for the protection of fish, especially freshwater fish (FAO, 2023). Other seasonal closures operate across major watersheds. One of the most notable interventions has been the fishing ban along the Yangtze River that prohibits productive use of fish. This was initiated in 2002, expanded in 2015 and then in 2020 resulted in a ten year ban on fishing the year in the Yangtze's main streams and important tributaries (FAO, 2023). This is a rolling closure and has recently also included the closure of the Taihu Lake fishery.

In recent years, the state and local governments have attached great importance to recreational fishery and have issued a series of policies to promote the development of recreational fisheries in inland aquatic environments (FAO, 2023). Statistics reported in FAO (2023) indicate that there are 110 000 recreational fishery operators and 683 000 recreational fishers. This is recognized to be an underestimate and recent estimates in Embke *et al.* (2022) suggest that there could be as many as 126 million participants.

A combination of factors affect China's inland fisheries (FAO, 2023). These include the effects of water resource development on flows, connectivity and water quality as well as fishing pressure and the results of the introduction of non-indigenous species. While aquaculture has contributed to increasing overall freshwater fish production, it has also created issues in terms of water pollution and targeting of broodstock fish that have affected inland capture fisheries (Yu and Chen cited in Zhao, Gozlan and Zhang, 2015). Regulations have also had an impact and, since the implementation of the increasingly strict fishing ban policy from 2016 to 2017, the fishing population – particularly traditional fishers – has gradually decreased.

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7.2.4 Eastern Asia

Country/territory	Inland capture fisheries catch (tonnes in 2021)	Percentage of global inland fish catch	Population (2021)	Per capita inland fish production (kg/cap/year)
Japan	18 252	0.16	124 612 530	0.15
Republic of Korea	5 500	0.05	51 830 139	0.11
Democratic People's Republic of Korea	5 050	0.04	25 971 909	0.19

Japan

The primary fishing locations in Japan are the lakes and rivers, although fishing also occurs on a smaller scale in estuaries, paddy fields, canals and ditches and ponds. Dai *et al.* (2024) identified 55 species of freshwater fish in Japanese lakes. Non-indigenous species include largemouth bass (*Micropterus salmoides*), channel catfish (*Ictalurus punctatus*), rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), brook trout (*Salvelinus fontinalis*), and snakehead (*Channa argus*). Several of these were introduced for sport fishing, while channel catfish were originally introduced for aquaculture and were able to successfully establish in some lakes after escaping from aquaculture facilities (Matsuzaki and Kadoya, 2015).

Many types of gears are used including nets, traps, and hook and line. Katano, Hakoyama and Matsuzaki (2015) describe the use of specialized gears, including the use of trained cormorants to collect fish and the use of aggregating devices including stone piles and live female decoys to attract salmon and dace (*Pseudaspius hakonensis*). Although data on inland fisheries are limited in Japan (Matsuzaki and Kadoya, 2015), the catches are much smaller than those from marine fisheries. Catches from inland fisheries are dominated by salmonids and ayu sweetfish (*Plecoglossus altivelis*), together with eel, pond smelt (*Hypomesus nipponensis*) and carp species (Katano, Hakoyama and Matsuzaki, 2015). Japanese inland fishery production decreased from 94 282 tonnes in 1996, to the current much lower level of 18 252 tonnes in 2021. This is attributed to a combination of factors including disease and invasive species.

Fish are most often consumed fresh. Eels in particular have an important role in Japanese cuisine and culture. While there are little data available, eel have been declining and the focus of conservation efforts. As with eel fisheries elsewhere, capture of glass eel for ongrowing in aquaculture facilities has become central to eel production (Sakurai and Shibusawa, 2021).

Fisheries are often managed at the local level through cooperatives based on a licence issued by the governor of the prefecture (Katano, Hakoyama and Matsuzaki, 2015). Enhancement of inland water through stocking occurs for many fisheries, including for restoration and for recreational fisheries. The Hokkaido Island chum salmon (*Onchorynchus keta*) marine fishery is the highest volume chum fishery in the world but relies almost exclusively on hatchery production for the smolts. Recreational fishing is popular and Embke *et al.* (2022) estimated that there were around 4 million people participating in recreational fisheries in Japan (around 3 percent of the population). Total annual recreational catches have been estimated at around 17 000 tonnes and retained recreational catches amount to some 10 000 to 12 000 tonnes (Embke *et al.*, 2022; Cooke *et al.,* 2017).

Inland fisheries continue to be affected by the degradation of the inland aquatic environments and predation by introduced non-indigenous species. Efforts have been made to restore aquatic environments and fish stocks, and migratory fish including salmon and eel have been used to raise awareness due to their cultural importance.

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The Republic of Korea

The total area of inland waters is approximately 5 700 km² (National Geographic Information Institute of the Republic of Korea, cited in Park, 2010). The ten major rivers have a combined length of 3 413 km, with the longest river, the Makdong, being 1 348 km long. The five largest river basins have a combined total of 27 484 km of streams (Kwater cited in Yoon *et al.,* 2015). However, almost all rivers and streams have now been dammed or regulated and the country has numerous reservoirs – within the five major basins there are 33 718 weirs (Yoon *et al.*, 2015).

The Republic of Korea has reported on their inland fisheries to FAO every year since 1950. In 2021 landings were reported at 5 500 tonnes (FAO, 2023). The most important species are Japanese corbicula clam (*Corbicula japonica*) and common carp (*Cyprinus carpio*). However, almost half of the production is not identified at species or genus level (FAO, 2023). Only 103 tonnes of salmonids that historically were very important were landed in 2015 (FAO, 2023; Park and Hong, 2013).

Fish and seafood have always been an important part of the Korean diet and, although this has mainly relied on marine products, crucian carp and black bass were introduced in the 1970s to feed the population (Park, 2010). However, not only did the Korean population never get used to the taste of many of the introduced species, but also it was realized that several species had negative ecological impacts and were therefore declared invasive. Enhancement programmes thus turned towards indigenous species (Park, 2010). Today the demand for freshwater species as food is largely met by aquaculture, whereas stocked and naturally reproducing fish are mostly targeted by the growing recreational fisheries (Park, 2010; Hart, 2016). There are 30 000 recreational bass fishers in the Republic of Korea (Hart, 2008).

Water pollution, overfishing, habitat destruction and mismanagement of fisheries are thought to have resulted in the decrease in commercial capture fisheries (Park, 2010). Also, water management practices appear to have had a seriously negative impact on migratory freshwater fish (Yoon *et al.*, 2015), and consequently there are now attempts to install fish ladders around many weirs (Yoon *et al.*, 2015) in addition to the expansion of the stocking programme of chum salmon (Park and Hong, 2013).

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The Democratic People's Republic of Korea

The country's aquatic ecosystems comprise wetlands around tidal flats including lagoons, river estuaries, lakes, alpine wetlands, reservoirs and paddy fields (UNEP, 2003). FAO (2010) mentions a total of 1 300 km^2 of waterbodies. The Democratic People's Republic of Korea (2005) has identified 100 natural lakes and 1 700 reservoirs.

Most of the country's rivers are short and their basins small. The major river basins are shared with neighbouring countries and in several cases form a natural border. Most of the rivers rise in the mountain ranges of the north and east of the country and run west to the Yellow Sea. There are five river basin groups: the Yalu River flowing southwest from the Changbai mountain range to the Korea Bay; the Tumen River which flows east from the Changbai mountain range to the Sea of Japan; the Taedong River flowing west to the Korea Bay near Pyongyang; and the east-coast and west-coast river watersheds comprising many small streams rising in the northern and eastern mountain ranges. There are reported to be 111 species of freshwater, 59 brackishwater and 15 anadromous fish.

Reporting by the Democratic People's Republic of Korea on inland fisheries to FAO has been very irregular, and FAO has estimated catches since the last report in 2001 when 4 928 tonnes were landed (current catches are reported to be 5 050 tonnes). There is no indication of the composition of the catch in FishStat. However, historically chum salmon (*Onchorynchus keta*) can be an important species during their spawning migration runs (Park and Hong, 2013).

The environmental conditions in the river basins are reported to be deteriorating because of pollution from industry and agriculture (UNEP, 2003).

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7.2.5 Western Asia

Country/territory	Inland capture fisheries catch (tonnes in 2021)	Percentage of global inland fish catch	Population (2021)	Per capita inland fish production (kg/cap/year)
Iran (Islamic Republic of)	107 628	0.95	87 923 432	1.22
Iraq	36 358	0.32	43 533 592	0.84
Türkiye	33 140	0.29	84 775 404	0.39
Syrian Arab Republic	2 530	0.02	21 324 367	0.12
Israel	925	0.01	8 900 059	0.10
Jordan	410	0.00	11 148 278	0.04
Lebanon	15	0.00	5 592 631	0.00
Palestine	0	0.00	5 133 392	0.00

This subregion consists of countries that have mainly arid land and low rainfall. There are two important rivers, the Tigris and Euphrates as well as part of the Caspian Sea that are important for inland fisheries. This explains the distribution of inland fisheries production within the subregion. Catches in the Western Asia subregion are heavily dependent on cyprinids and clupeids.

The Islamic Republic of Iran

Iran has two major inland basins in the north and south and several smaller basins in the central and eastern parts of the country. The distribution of inland fisheries reflects this with a northern fishery (the Caspian Sea); and an inland fishery. Gilan and Mazandaran provinces on the Caspian Sea in particular are an important centre for inland fisheries production. This is largely because of the high rainfall resulting in the presence of a considerable number of permanent freshwater bodies. There are more than 588 reservoirs, many rivers (the largest is the Karun), and several lagoons and lakes.

Iran is estimated to have over 200 species of freshwater and brackishwater fish. These are mainly cyprinids but also include sturgeon, loaches and around 10 species of gobiids (Keivany *et al.*, 2015). The most important species in the Caspian Sea include the Caspian Sea sprat, which includes common kilka (*Clupeonella cultriventris*), Big eyed kilka (*Clupeonella grimmi*) and anchovy kilka (*Clupeonella engrauliformis*), along with bony fish such as mullets (*Liza* sp.) and common carp (*Cyprinus Carpio*) and sturgeon (of which there are five species). Sturgeon and other semi-migratory fish enter rivers and lagoons connected with the Caspian Sea, for spawning and feeding. Sturgeon has been the basis for an important fishery and Iran has been the biggest exporter of caviar and other sturgeon products. However, sturgeon fisheries have been reducing due to fishing pressure and environmental change (Harioglu and Farhadi, 2017).

The presence of marsh-type aquatic vegetation in some lagoons and in the Gorgan River discharge area is of considerable importance for fish. Gilan Province has about 10 000 ha of inland waters, of which more than 90 percent is estimated to be available for the inland fishery. Mazandaran has some 13 000 ha, of which 40 percent is with permanent water, the rest drying out during the summer. River regulation and intensive fishery have also led to a decline in common carp stocks of the lower reaches of Iranian rivers and in some lagoons of the Caspian Sea Basin (FAO, 1987).

Since 1996, fisheries production statistics have been collected annually by the Iran Fisheries Organization. Inland fish catches are largely driven by the catches from the Caspian Sea in the Islamic Republic of Iran and these peaked in 1999 (146 000 tonnes). They collapsed to less than half by 2003, and have been recovering since, reaching 107 628 tonnes in 2021. The decline of the Iranian fishery corresponded to a general decline in clupeid abundance (mostly *Clupeonella*) in the Caspian Sea fishery.

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Iraq

The Tigris-Euphrates riverine system is the main source of inland fresh water in Iraq. This system has extensive lake and marsh resources and floods seasonally. Inland freshwater bodies cover between 600 000 and 700 000 ha, made up of natural lakes (39 percent), dams and reservoirs (13.3 percent), rivers and their branches (3.7 percent), and marshes (44 percent). It is reported that there are 24 freshwater fish species recorded in Iraq (Harioğlu, Mustafa and Batool, 2023).

Inland fisheries are present in the Tigris and Euphrates rivers and in the reservoirs associated with the dams at Mosul, Dokan, Darbandikhan and Habaniya. Harioğlu, Mustafa and Batool (2023) report that there are approximately 15 340 fishing boats in Iraq. The majority (85 percent) are not motorized. Similar proportions are described in the southern marshes, where a recent study found that only 25 percent of fishing boats (2 140 boats) were motorized. Various gears are used in the fisheries, including included trawl nets, gill nets, seine nets, cast nets, and hook and line.

The mean annual inland fisheries production for Iraq for 1981–1997 was 18 800 tonnes, compared to an estimated 8 000 tonnes in 2001. Previous estimates of annual sustainable production from inland waters have been put at 30 000 tonnes (FAO, 2014) and current production is reported to be 36 358 tonnes. Catches were fairly stable in Iraq until the southern marshes were drained, but the fisheries have apparently recovered after the partial refilling of these wetlands. The inland fisheries are principally based on carps (*Cyprinus* spp.) and the indigenous barbs species (*Barbus* spp.). A study in the southern marshes found a total of 15 species in five families. Common carp (*Cyprinus carpio*) dominated the overall catch (29 percent), followed by *Planiliza abu* (16 percent) and tilapia (15 percent). Tilapia species have become established in Iraqi waters, expanding rapidly to became an important part of the catches, particularly in southern Iraq (Abood and Mohamed, 2020). There are some estuarine species, such as mullet in the lower reaches and these diadromous species are among the more valuable species in the catches (Nasir and Khalid, 2017). There is some stocking using cyprinid species to increase fish production (Abood and Mohamed, 2020). Fish are typically consumed fresh in the local area. Consumption of fish (both inland and marine) has historically been low, with an annual average per capita consumption of 4.3 kg in 1979, but this has gradually increased to10 kg in 2020 (Harioğlu, Mustafa and Batool, 2023).

The establishment and operation of hydropower dams located in the headwaters of the Tigris and Euphrates Rivers and their tributaries in Türkiye, Syria, and Iraq, have affected the fisheries in Iraq. As well as diverting water, this has affected the quantity and quality of water entering the Shatt Al-Arab River and marshes areas, as well as allowing saline water from the Arabian Gulf extend up to 100 km into Shatt Al-Arab.

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Türkiye

Türkiye's inland resources are varied in terms of water quality, trophic status, altitude, climate, ecosystem diversity and species diversity. The total area of inland waters is 17 000 km^2. Türkiye possesses 6 000 km^2 of lakes and reservoirs on which 3 149 licensed fishing boats were engaged in fishing activities in 2009. Lake Van, Atatürk and Keban dam reservoirs are the major fishing grounds in eastern Türkiye with significant contributions to inland capture fisheries. The freshwater biodiversity is high, with some 340 species, 78 of which are endemic, partly due to its location at the junction of three zoogeographic regions (Atalay, Kirankaya and Ekmekçi, 2017; Tarkan, Marr and Ekmekçi, 2015). Despite this diversity, the fisheries are focused mainly on four species: tarek (*Alburnus tarichi*), which is caught only in Lake Van and its tributaries; common carp (*Cyprinus carpio*); the non-indigenous gibel carp (*Carassius gibelio*); and sand smelt (*Atherina boyeri*), a translocated marine fish are widespread (Atalay, Kirankaya and Ekmekçi, 2017). Other species that are caught include mullet (*Mugil* sp.) and eel (*Anguilla anguilla*), in addition to finfish, frogs and snails.

Productivity (catch per unit area) varies between 9.4 and 27.2 kg per hectare depending on the size of the reservoir (Tüfek cited in Rad and Rad, 2012). The Demirköprü Dam Lake, located on the Gediz River in western Türkiye, provides an important carp fishery and they are targeted using multifilament gillnets (Dereli *et al.*, 2018). Elsewhere, gillnets, trammel nets and seine nets are used. Few recent figures are available but in 2006, there were 7 670 licensed fishers working on inland waters (Mitchell, Vanberg and Sipponen, 2010). Studies have also indicated that in some cases fishers ceased fishing as a result of the impact of COVID-19 on market opportunities (Dartay, 2023). Perhaps as a result of decreased activity, the number of annual fatalities within inland fisheries has reduced from 17 in 2013 to just 3 in 2020 (Soykan, 2023). Most of the inland capture fisheries catch is landed by cooperatives in Mediterranean, Eastern and Central Anatolia regions (Rad and Rad, 2012). Recreational fisheries are also important with an estimated 574 000 people (0.7 percent of the population) participating. Recreational catches have been estimated at 1 331 tonnes, of which 49 percent is retained for consumption, contributing to fish supply (Embke *et al.*, 2022).

The inland catch of Türkiye was 54 500 tonnes in 1999 and has been slowly declining to the current level of 33 140 tonnes in 2021. Despite declining catches, demand for carp remains high, reflected in relatively high market prices. Indeed, Atalay, Kirankaya and Ekmekçi, (2017) report that while freshwater fish make up only about 10 percent of total fish landings in Türkiye, they tend to have a higher economic value than marine fish. Gibel carp and sand smelt, despite making up a large proportion of landings, are not consumed locally but are exported (Atalay, Kirankaya and Ekmekçi, 2017). There is evidence of the increasing economic importance of aquaculture contributing to the diminished role for inland capture fisheries (Rad and Rad, 2012). Average per capita fish consumption in Türkiye is relatively low, although the contribution of inland fisheries to this total can vary. A study by Abdikoğlu, Azabağaoğlu and Unakitan (2020) in Tekirdag Province on the shore of the Sea of Marmara reported that while annual per capita fish consumption was around 14 kg, and around 98 percent of people reported eating fish, inland fisheries only contributed 0.5 kg of this number. Elsewhere, in Van province, Terin (2019) found that local consumption was higher than the national average and linked to local inland fisheries.

A range of issues impact inland fisheries including water quality and water management problems, sand mining, flood, erosion, pollution, habitat degradation, draining of wetlands, conflicts between water users, illegal fishing, overfishing, and non-indigenous species (Yerli, 2015). The introduction of non-indigenous species, including the gibel carp, are also identified as having the potential to adversely affect indigenous fish through competition for food and space.

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The Syrian Arab Republic

The Syrian Arab Republic has a total area of 185 180 km². There are 16 main rivers and tributaries in the country, of which 6 are main international rivers, including the largest river – the Euphrates (Al Furat). Three other rivers form part of the borders including the Yarmouk in the southwest which forms the border with Jordan before flowing into the Jordan river; the El-Kabir which forms the border with Lebanon; and the Tigris, which forms the border between the Syrian Arab Republic and Türkiye in the northeast. The eastern region, covering 41.8 percent of the total area, features extensive irrigation networks, especially on the Euphrates and Al Khabour rivers.

Freshwater fishes of Syria are reported to comprise 108 species, of which 11 species are non-indigenous, and 6 are considered endemic to Syria (Saad *et al.*, 2023). Springs (and spring-fed streams) are important habitats for freshwater fish as they are often the only permanent waters and therefore play critical roles as fish refuges (e.g. Garcia *et al.*, 2015).

Syrian inland fisheries take place in reservoirs and waterbodies throughout the Tigris-Euphrates basin in northern and northeastern Syria. Inland capture fisheries play a minor role in the Syrian economy, partly due to the limited extent and low natural productivity of fisheries environments. However, there is some evidence from the number of new entrants that fisheries can provide opportunistic coping mechanism within livelihoods. Current estimates of annual production (2021) are a total of 2 530 tonnes. However, reporting on fishing activity, catches, species, fish markets and prices has become infrequent. Availability of fish for consumption has become related to proximity. Thus, availability of fish from inland waters has decreased in Damascus, but availability has increased in other cities that are closer to one or more inland fishing areas.

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Israel

Israel has a total area of 22 070 km², with inland waterbodies occupying 430 km² (FAO, 2015). The transboundary Jordan River flows south into the Dead Sea Lake. Lake Kinneret (also known as the Sea of Galilee or Lake Tiberias) is part of the Jordan River system and, at approximately 170 km², is the sole freshwater lake in Israel and main freshwater reservoir for the country. There are about 10 rivers which run broadly east to west across the coastal area, flowing into the Mediterranean Sea. Species compositions differ with coastal rivers supporting catadromous eel (*Anguilla anguilla*) and mullets, as well as cichlid and clariid species and the cyprinodont *Aphanius mento* (Goren and Ortal, 1999).

The Jordan River system has the richest native fish diversity, dominated by cyprinid and cichlid species (at 10 and 7 species respectively), while Lake Kinneret has the richest overall fish diversity with 19 species (Goren and Ortal, 1999). About 15 fish species have been introduced to the inland waters of Israel. This includes the translocation and stocking of mugilid fish in Lake Kinneret and stocking with mango tilapia (*Sarotherodon galilaeus*) and silver carp (*Hypophthalmichthys molitrix*). Other introductions have followed that of mosquitofish (*Gambusia affinis*) to control mosquitoes and the escape from aquaculture of cichlids as well as non-indigenous trout, and sturgeon into the Jordan River (Goren and Ortal, 1999).

Commercial inland fisheries (using purse seine and gillnets) occur in Lake Kinneret. In 2005, three purse seiners and about 68 small boats (< 11 m) with gill and/or trammel nets operated in Lake Kinneret (FAO, 2007). In 2005, the commercial catch in Lake Kinneret was 1 396 tonnes (representing 5.3 percent of total fish catch) with this considered to be fully exploited. Yields of stocked species were correlated to stocking densities (Gophen, 2018). Other fishery management measures imposed have capped capacity (fishing licences) and reduced fishing effort (three-month fishing ban) (Mitchell, Vanberg and Sipponen, 2010). From 1994 to 2006 fisheries management measures were also used to manipulate lake food webs in order to improve water quality and increase the condition of commercial fish stocks. This was achieved by decreasing the number of lanvun (*Mirogrex terraesanctae*) through removals of between 300 and 900 tonnes annually between 1994 and 2006.

The total catch was reported in 2021 to be 925 tonnes. The principal species are cichlids, including (*Sarotherodon galilaeus* and *Oreochromis aureus*). Other important species include carps, barbs and mullets. The main inland recreational fisheries are for carps and cichlid species in the Upper Jordan River and for non-indigenous salmonids in the Dan, Hermon and Senir river tributaries. Recreational fishing is prohibited in the inland-water nature reserves that are the principal measure for fish conservation (Goren and Ortal, 1999). Annual per capita fish consumption averaged about 22 kg in 2016. While imports account for the largest share of total domestic supply of fish for human consumption, domestic fish production – including inland capture fisheries and aquaculture – still make important contributions.

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Jordan

Jordan has a total area of about 88 780 km^2, and lies to the east of the Jordan River There are no natural lakes and most of the rivers in the country are seasonal with large seasonal and annual variation. Most of the streams and large springs are primarily associated with the Jordan River system. A few belong to the water system of the Dead Sea. The Jordan River system was estimated in 1967 to have approximately 470 ha of water surface (FAO, 1967). The country has ten reservoirs on the Jordan River system with a total storage capacity of 326 million m^3. Irrigated agriculture in Jordan is the largest user of water, consuming 60 percent of the total.

A total of 15 endemic freshwater fish species have been identified in the inland waters of Jordan (Hamidan, 2004). A number of non-native species have been introduced into the inland waters of Jordan primarily for aquaculture, but some have also been released into open waters. These include common carp (*Cyprinus carpio*) and *Oreochromis aureus*, but other species include: *Acanthobrama lissneri*, *Clarias gariepinus*, *Coptodon zillii, Oreochromis niloticus* and *Mugil cephalus*. *Oreochromis aureus* is considered to have had the highest impact on local endemic freshwater fishes, (e.g. *Aphanius sirhani* and *Garra ghorensis, Aphanius dispar richardsoni*, mainly because of competition for breeding sites and predation of eggs and young stages (Khoury *et al.*, 2012). Commercially important fish species include the Bolti (*O. aureus*) and common carp (Al-Weher, 2008).

Inland fisheries in Jordan are limited, with annual production reported to FAO (2021) of 410 tonnes. The principal fisheries are in the mainstream of the river Jordan and the country's reservoirs. Ziglab irrigation reservoir was stocked with carp and tilapia fingerlings starting in 1966 (FAO, 1973). *Clarias gariepinus* is the most common species in the King Talal, Sharhabeel Dam (also known as the Ziglab Dam), and in the Karameh and Wadi Al Arab dams. All these fish populations may have originated from the Jordan River Basin (Khoury *et al.*, 2012). Water bodies are limited and there is demand for water for urban, agricultural and industrial uses. Furthermore, many existing water bodies are also affected by increasing levels of salinity, pollution and eutrophication as a consequence of these uses.

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Lebanon

Lebanon has a total area of around 10 452 km² and a population of around 4 million. The country is topographically diverse, featuring two mountainous ridges extending broadly parallel and separated by the Bekaa Valley. The country receives an annual rainfall of between 700 and 1 500 mm. This supports a large hydrological network of wetlands, rivers and lakes that include 12 rivers and two main reservoirs, including the Quaroun Reservoir. Around one-quarter of Lebanon's area is shared as transboundary river basins, including the El Kebir river that forms the northern boundary with the Syrian Arab Republic as well as tributaries for the Orontes and Jordan rivers (Shaban, 2019). There are 27 species of freshwater fish identified in Fishbase (Froese and Pauly, 2024), including introduced carp and trout species. Inland aquaculture is mainly focused on the non-indigenous rainbow trout (*Onchorynchus mykiss*).

The most notable inland fishery in 2005 was the small fishery reported to utilize 18 vessels fishing around the inner Qaraoun reservoir on the Litani River in the Bekaa Valley. The majority of vessels were wooden (*flouka*), some of which had inboard engines while others were unpowered. The vessels traditionally landed their catch along the lakeshore near their respective villages with fish sold fresh and unprocessed (Majdalani, 2005). All vessels used trammel nets and operated all year round. The target species were carp and catfish and reported catch reached a peak in 2003 at 285 tonnes. Recently the fishery has been affected by pollution and fish disease outbreaks that prompted a ban in 2018 on fishing in the reservoir. Inland fish production in Lebanon was estimated to be 15 tonnes in 2021. There are no reported inland recreational fisheries in Lebanon (e.g. Embke *et al.*, 2022). Per capita consumption of fish has been estimated at 8.9 kg, which is mainly (90 percent) marine fish sourced largely through imports (Pinello and Majdalani, 2018).

Bekaa, Zahleh and surrounding districts at Mount Lebanon, rely on groundwater resources for approximately 90 percent of their needs for agriculture and domestic use. This is in line with other countries where waterbodies are limited and there is demand for water for urban, agricultural and industrial uses, with water availability and quality in general being affected (Falah, Yemendzhiev and Nenov, 2020).

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Palestine

There has been no inland fisheries catch reported to FAO.

7.2.6 Central Asia

Country/territory	Inland capture fisheries catch (tonnes in 2021)	Percentage of global inland fish catch	Population (2021)	Per capita inland fish production (kg/cap/year)
Uzbekistan	53 000	0.47	34 081 449	1.56
Kazakhstan	41 457	0.36	19 196 465	2.16
Turkmenistan	15 042	0.13	6 341 855	2.37
Tajikistan	2 350	0.02	9 750 064	0.24
Afghanistan	1 500	0.01	40 099 462	0.04
Azerbaijan	1 464	0.01	10 312 992	0.14
Armenia	770	0.01	2 790 974	0.28
Georgia	20	0.00	3 757 980	0.01
Kyrgyzstan	20	0.00	6 527 743	0.00
Mongolia	0	0.00	3 347 782	0.00

Uzbekistan

The Aral Sea and the Amu Darya River Basin have historically been the most important regions for inland fisheries in Uzbekistan. Annual fish production peaked at about 25 000 tonnes in 1958. Subsequently, the construction of an extensive irrigation network saw water abstraction and salinity increase, the Aral Sea shrink and Uzbek catches from the Sea itself cease in 1983. The centre of fishing operations shifted to a group of about 20 lakes (970 km^2) in the Amu Darya Delta, and the Aydar-Arnasay lake system

(3 700 km^2) midway along the course of the Syr Darya River. These systems are complemented by a number of lakes (2 330 km^2) spread across the country, and 39 multipurpose reservoirs (3 310 km^2), of which the most important in fisheries terms are the Tudakul, Shorkul and Mezhdurechye reservoirs. Most of the country's 600 rivers, save those in the mountains, are exploited for irrigation purposes, with riverine fishing activities both limited and concentrated on the Amu Darya, Syr Darya, Zarafshan and Kashkadarya. The irrigation canal network is extensive, and extends to about 150 000 km, but generates little fishing activity (Karimov *et al.*, 2009).

Since the demise of the Aral Sea fishery, and up to 2011, inland capture fishery production has not exceeded 6 000 tonnes. Since then it has been increasing and currently production is reported to be 53 000 tonnes (2021). Uzbekistan is the only Central Asian state where current fisheries capture exceeds that prior to independence and progress in recent years has been rapid and sustained (Graham, Pueppke and Uderbayev, 2017). After the breakdown of the commercial fishing in the Uzbek part of the Aral Sea in 1983, the Aydar-Arnasay lake system became the most important fishery lake in Uzbekistan with an annual catch of more than 4 600 tonnes (in 1988). However, the fish catch in this lake system experienced a sharp decline (down to 728 tonnes in 2006) due to the increased inflow of polluted drainage water from the large Golodnaya Steppe (Hunger Steppe) irrigation scheme though has been steadily recovering since 2007 (Groll *et al.*, 2016).

Although Karimov *et al.* (2009) report that the poaching of fish is widespread, this appears to be less of a problem in Uzbekistan where a combination of small waterbody size and a system of long-term regulatory leasing have combined to curb commercial poaching. Since 2003, waterbodies are leased out to fishery enterprises on a rental agreement basis. Fish capture in reservoirs and lakes is carried out by fishery enterprises that conclude contractual rental agreements with local administrations for periods of ten years or more. These enterprises catch fish on a quota-free basis, but are required to take measures to conserve species and to maintain the productivity of waterbodies. One beneficiary of this was Akva Tdakul whose culture-based programme on the reservoir of the same name saw output rise from 170 tonnes to over 1 000 tonnes in the space of four years.

Recreational fishing in Uzbekistan is largely unregulated, although two national fishing and hunting societies exist. All citizens are entitled to fish in any waterbody across the republic that is not subject to protected area status or has been leased out to fishing enterprises or fish farms. Embke *et al.* (2022) report that the number of people participating in recreational fisheries in Uzbekistan as 213 885 with catches of around 112 tonnes, of which around 44 percent is retained. Karimov *et al.* (2009) suggest fishing is not considered to be of major importance for household food security, suggested by the apparently low annual per capita fish consumption of 0.5 kg.

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Kazakhstan

The larger part of the Caspian Sea (371 000 km^2) and part of the Aral Sea (historically 67 000 km^2) lie within Kazakhstan, as do an estimated 48 000 lakes (3 041 of which have a surface area greater than one square kilometre), although a number of them dry up in the hot summer period. The most important lakes are Lake Balkhash (17 000 km^2); Alakol, or more properly the Alakol lake system (3 700 km^2), consisting of four large lakes (Sasykkol, Koshkarol, Alakol and Zhalanashkol); and Lake Tengiz (1 382 km^2). As a result of agricultural irrigation programmes in the 1960s where water flowing to the endorheic Aral Sea was diverted, evaporation exceeded inflow and the Aral Sea decreased significantly in both depth and area, with serious consequences for the fishery (Graham *et al.*, 2022). Artificial waterbodies include 475 reservoirs, the most prominent being the Bukhtarma, Kapchagay and Shardara reservoirs, all of which have important fisheries (Graham *et al.*, 2022). The major reservoirs are in the south, where there are 75 reservoirs in total with a combined volume of 955 km^3 and a surface area of over 10 000 km^2. The majority of large reservoirs are multipurpose, providing hydropower and irrigation facilities, and their surface area and depth consequently fluctuates over the course of the year. There are also more than 96 000 km of irrigation canals (Timirkhanov, *et al.*, 2010). The country also possesses more than 8 500 permanently or seasonally flowing rivers, though only 155 are more than 100 km in length and only 7 flow for more than 1 000 km (Graham *et al.*, 2022). There are four significant rivers from the standpoint of capture fisheries: the Irtysh, Syr Darya, Ili and Ural (Graham *et al.,* 2022).

Since 2001, when production hit a historic low of 22 960 tonnes, production has risen to a reported 41 457 tonnes in 2021, with just over half sourced from the Ural-Caspian Basin. However, current production is well below historic levels, which were as high as 112 000 tonnes (1965). This decline is attributed to the collapse of the Aral Sea fishery, poor water management in the reservoir system, and decreased production in the Balkash and Alakol lake systems and the Caspian Sea. In the latter case, concerns have also been raised about the likely impact of the introduction in the early 2000s of the comb jelly (*Mnemiopsis leidyi*) on catches of the planktivorous kilka/sprat (*Clupeonella* spp.), the mainstay of Caspian landings in recent years (Mitrofanov and Mamilov, 2015). Additional factors influencing the decline of fish species in the Caspian Sea were pollution from oil wells, wastewater and mining (Abbasov *et al.*, 2023). Since then, fisheries have recovered slightly mainly due to better water management, including in the Aral Sea. However, pollution continues to affect inland water bodies causing environmental degradation especially in the Caspian Sea, resulting also in high levels of heavy metals in harvested fish (Graham *et al.*, 2022). Another challenge is transboundary water abstraction given that Kazakhstan borders five countries, each with its own priorities for water resources, thereby reducing water flows into Kazakhstan.

Most authors acknowledge that the reported statistics do not reflect production and that there is under-reporting. Mitrofanov and Mamilov (2015) attribute this to the current state strategy of selling, under the auspices of the Kazakh Fisheries Research Institute (KazNIRKH), quotas on the basis of “one waterbody – one quota – one lot”, thus monopolizing the fish catch in each waterbody. Excluded fishers therefore have little alternative but to fish illegally. It is estimated that unreported catches could represent two to ten times that of legal, reported harvests (Kulikov, Assylbekova and Isbekov, 2021; Strukova *et al.*, 2016; Timirkhanov *et al.*, 2010). Recreational fisheries include “subsistence” recreational fishing that is conducted in all waterbodies of Kazakhstan where fish exist. This household fishing also contributes to fish production and contributes to food security. However, there are currently no data available regarding the total number of recreational fishers in the country of the contribution to household food security.

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Turkmenistan

Turkmenistan is a country dominated by the Karakum desert (284 900 km^2), which is one of the world's largest sand deserts. Of particular importance for inland fisheries is the 611 km coastline on the Caspian Sea, along which Turkmenbashi is the country's only industrial deepwater fishing port. Elsewhere, Lake Kara-Bogaz (18 000 km^2) is the largest lake in Turkmenistan, a shallow lagoon separated from the Caspian Sea by a narrow strip of land. Its high salinity (35 percent, compared to surface salinity of up to 1.4 percent in the Caspian) places it on a par with the Dead Sea, and makes it uninhabitable to fish populations. Lake Sarygamysh (800 km^2), shared with Kazakhstan, is the only other inland lake of note, and nine reservoirs offer limited fishing possibilities. The major rivers are the Amu Darya (which flows along the country's northeastern border before entering the Aral Sea), the Tejen and the Murgab (which originate in Afghanistan), and the Atrek (which originates in the Islamic Republic of Iran). No significant rivers originate in Turkmenistan. The Karakum canal (1 400 km in length) draws its waters from the Amu Darya, and is the centrepiece of an extensive network of irrigation canals that stretches for just over 37 000 km.

The country's major fishery has historically been the Caspian kilka/sprat fishery, accounting for more than 98 percent of national landings. Production has dropped sharply from a peak of more than 50 000 tonnes during the Soviet era following the closure of the Soviet fishing cooperatives, and is now estimated at 14 700 tonnes (2021), well below 40 percent of its pre-independence level (Graham, Pueppke and Uderbayev, 2017). In 2014, three new fishing vessels (each with a gross registered tonnage of 400) were introduced into the kilka fishery, although their impact on catches is not yet evident. Annual sturgeon catches throughout the Caspian declined from more than 25 000 tonnes in the 1970s to 470 tonnes in 2000, and sturgeon fishing in the Caspian Sea is now forbidden.

Fisheries access is controlled through the 1998 Provision on Protection of Fish Stocks and Regulation of Fishing in Territorial and Inland Waters. Not all catches are documented, with UNECE (2012) reporting that the amount of fish landed was at least 10 to 13 times more than the officially permitted fishing quotas. There is little available information regarding recreational fishing. The Society for Hunters and Fishermen is the official body for recreational fishers and polices its own waterbodies, however no indications as to the size of its membership are available.

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Tajikistan

Tajikistan has some of the largest rivers of Central Asia, including the Amu Darya and Syr Darya, amongst the 300 large and small rivers in the country. In addition, there are about 1 300 lakes, including Lake Karakul (380 km^2) and Lake Sarez (75.8 km^2), providing a total area of 705 km^2, although the majority (78 percent) are located over 3 500 metres above sea level in the Pamir/Gorno-Badakhshan region. The combined discharge from the rivers makes up to 12 percent of the volume of river flows in Central Asia and it provides about 55 percent of the water flowing into the Aral Sea Basin. The water of rivers are used for hydropower and irrigation. The associated irrigation canal network is about 33 250 km in length, with extensive use of unlined earthen canals. Glacial meltwater is partly captured by eight major multipurpose reservoirs, the biggest being Nurek (98 km^2) in the central part of the country, and Kayrakkum (52 km^2) in the northern part of the country.

In addition to the relative inaccessibility of many water bodies, their low fertility limits fisheries productivity. Historically, fish production in Tajikistan has therefore been based on small-scale cyprinid pond culture with limited commercial capture fishing development taking place (from the 1930s onwards) in the lakes of the Pamir, central and southwestern regions. Capture fisheries production was boosted following the completion and stocking of the Kayrakkum reservoir in 1956, and Khaitov *et al.* (2013) report catches of 400 to 500 tonnes per annum (principally carp and bream) over the 1960–1989 period. Capture production at Nurek (completed 1980) was never as successful because of low levels of phytoplankton and zooplankton. It was suggested that the lower productivity might provide opportunities for the use of the reservoir for recreational rather than commercial fisheries and trout aquaculture (Khaitov *et al.*, 2013).

In 1990, fish production from a combination of capture and culture totalled 3 857 tonnes. Since 2008 there has been a recovery in capture production, with FAO reporting inland capture production rising from 380 tonnes in 2008 to 2 350 tonnes in 2021, though production is still a small proportion of overall production in Central Asia. Along with the decline in production, employment in fishing also fell, from 6 000 in the early 1990s to about 1 500 a decade later.

There is little documentation of recreational fisheries although the Association of Hunters and Fishers of the Republic of Tajikistan (AHFRT) was established in May 1956 and in conjunction with a number of fishing clubs issues licences for recreational fishing in the country. Most recreational fishers are not members of these associations however, and are entitled to fish in any waterbody that is not in private hands or assigned to a fishing club. The AHFRT estimate that between 50 and 60 tonnes are landed by recreational fishers annually, with at least 10 percent of this total being sold in local markets (Khaitov *et al.,* 2013).

Energy generation and irrigated agriculture remain priorities for water resources management in Tajikistan. Together with the limited productivity of the waters, this can affect the potential for capture fisheries, although downstream impacts of dams on fish habitat and fisheries have not been fully assessed (Campins, Saura and Pons, 2016).

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Afghanistan

There are five major river basins in Afghanistan: the Kabul (drainage area 54 000 km^2), the Helmand (190 000 km^2), the Hari Rod and Murghab (each approximately 40 000 km^2), and the Amu Darya (91 000 km^2). Most of the rivers flowing into these basins are perennial, with peak flows in the spring months as the snows in the Hindu Kush mountains melt, but reducing to small rivulets devoid of fish during the dry summer months. The Kabul River (which is a tributary of the Indus) is the only river reaching the sea, the majority ending in brackishwater swamps or within the arid areas of the country. The country has few lakes, which are also small in size (Zarkol on the Tajik border, Shiveh in Badakshan, Istadehye Moqor near Ghazni, and the six lakes in the Band-e Amir National Park). The country boasts 23 dams, although there is no information on the size of the accompanying reservoirs – nor of their suitability for fishing activity (Petr, 1999).

The country has a total of 121 species with 85 native species (Çiçek *et al.*, 2023; Coad, 2015). Çiçek *et al.*, 2023 report that the majority of species are cyprinids (36 species; 30 percent of the total species), followed by Nemacheilidae (22 species), Leuciscidae (12 species), Danionidae (8 species), and Sisoridae (6 species). Productivity however is low, and FAO has estimated inland capture fishery production since 1970. The current estimate of 1 500 tonnes (2021) represents an approximation of the likely level of fish production from unmonitored fisheries in Afghanistan. While it is not currently possible to establish annual fish consumption, productivity and distribution of waterbodies suggest that Afghanistan fish consumption rates are low.

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Azerbaijan

Azerbaijan has more than 450 natural lakes covering 394 km^2, although only Lake Sarysu (65.7 km^2) and Lake Aggol (56.2 km^2) are over 20 km^2 in size. The country has a Caspian Sea coastline of 713 km and 3 218 of its 8 359 rivers, including the two longest (the Araz and the Kura), drain directly into the Sea. Mingachevir (605 km^2) and Shamkir (116 km^2) are the largest of the country's more than 60 reservoirs (covering a total area of over 1 000 km^2) and the country also has an estimated 65 900 km of irrigation canals.

Commercial fishing activities are concentrated on the Caspian Sea (predominantly kilka - *Clupeonella* spp.), the Mingachevir and Shamkir reservoirs, and the Kura River (European carp, *Cyprinus carpio*; shemaya, *Chalcalburnus chalcoides*; eastern bream, *Abramis brama*; pike-perch, *Sander lucioperca*), with a small commercial fishery also existing on Lake Sarysu. Azerbaijan was estimated to have about 20 000 recreational fishers, most of whom are members of one of the branches of the Society of Hunters and Fishers. Recreational fishing is governed by the Regulations of Sport and Amateur Fishing. These allow fishers to catch up to 5 kg of non-predatory species daily (there is no daily catch limit for predatory species). Salmonov *et al.* (2013) suggest recreational fishing is primarily for personal consumption, and takes place chiefly along the Caspian Sea and some of the inland lakes.

Commercial fisheries in Azerbaijan produced over 55 000 tonnes of fish from inland waters in 1988 (96 percent kilka). However, unfavourable hydrological conditions in the 1990s and the accidental introduction and rapid proliferation of the comb jelly (*Mnemiopsis leidyi*) saw a steady drop in exploitable biomass. Stock collapse due to the combination of environmental change and fishing pressure led kilka landings to fall below 150 tonnes in 2015, putting the kilka catch on a par with the landings of Caspian shad, mullet and Caspian kutum. Reported reservoir and river capture production also halved to 220 tonnes over the period 2003 to 2010. More recently, in 2021, FAO reported total inland capture fisheries production at 1 464 tonnes. This figure is much lower than the reported production from the State Statistical Committee of the Republic of Azerbaijan, which indicated that the national fish production was 59 513 tonnes in 2021. This fish production figure is reasonably close to the predicted production derived from the survey-production model (53 103 tonnes) (Fluet-Chouinard, Funge-Smith and McIntyre, 2018).

Salmonov *et al.* (2013) suggest reported catches are likely to be underestimated on two counts. First, the contribution of retained recreational catches is likely to be much larger than the 100 tonnes per annum reported by the Society of Hunters and Fishers. Second, as data on Caspian catch levels are based on information submitted by commercial fishing companies or individuals at the time they receive their quota, rather than on the volumes landed in the coastal ports.

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Armenia

Lake Sevan (1 256 km^2), the largest lake in the Caucasus region, is located in Armenia. The lake is the site of the main inland fishery in Armenia, which historically provided some 90 percent of the finfish and 80 percent of the national crayfish catch. Another 17 lakes (covering seven km^2) and 18 reservoirs (10.5 km^2) are of less importance in the fisheries context. Although there are an estimated 9 480 rivers in the country, less than four percent are longer than 10 km and many dry up in the summer months, limiting their fisheries potential. Riverine fisheries are negligible. There are also 310 km of irrigation canals in the country (Savvaitova and Petr, 1999).

Since the Sevan-Hrazdan hydropower cascade was completed in the 1930s, water extraction has seen Lake Sevan's volume reduced by some 44 percent, and the water level drop by over 19 metres. Attempts to raise water levels using the Arpa-Sevan (1980s) and Vorotan-Arpa (2004) tunnels have been partly successful, and between 2001 and 2013 the lake level rose by 3.9 metres and its volume by 5.5 billion cubic metres. Water abstraction, combined with fishing pressure, had led to the collapse of the endemic Sevan trout (*Salmo ischchan*), khramulya (*Varicorhinus capoeta*) and barbel (*Barbus lacerta goktchaicus*) fisheries by the mid-1970s. Ladoga and pelagic whitefish (*Coregonus lavaretus*), introduced to the lake in the 1920s, ensured landings remained between 1 000 and 2 000 tonnes over the period 1935–1991. However, unrestrained fishing in the post-Soviet period saw the lake's whitefish population decline from 30 000 tonnes in the early 1990s to just 2000 tonnes in 2019 (Gabrielyan, Khosrovyan and Schultze, 2022), and fishing bans were regularly introduced on the lake after 2002 (Yu, Cessti and Lee, 2015). FAO reports current trout and whitefish production as 27 tonnes out of a total inland fishery production of 770 tonnes (2021). The bulk of Armenia's reported inland capture fisheries production is accounted for by Danube crayfish, which has increased from 360 tonnes in 2012 to 697 tonnes in 2021.

Although Lake Sevan is the only waterbody in the country where fishing is regulated, Fishing in other natural and artificial public waterbodies and rivers is unregulated. Due to the declines in the inland fisheries in Armenia, there have been programmes to enhance the fisheries in Armenia through releasing trout into the lake. These programmes have also led to Sevan trout being introduced in Ukraine, Kyrgyzstan and Karelia in the Russian Federation (Savvaitova and Petr, 1999).

It is widely believed that most of the poorer segments of rural population fish regularly for their own consumption and about 20 percent do this regularly (effectively around 590 000 people). Hovhannisyan *et al.* (2011) estimate that annual per capita consumption of fish increased sharply from 0.3 kg to 1.8 kg between 2005 and 2008. If national production and net exports are aggregated, annual per capita consumption of fish and fishery products was just over 2 kg in 2008.

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Georgia

Georgia has 25 075 rivers, two-thirds of which drain into the Black Sea, and one-third into the Caspian Sea. The main Georgian rivers are the Alazami (391 km), the Mtkvari (351 km), the Rioni (333 km) and the Enguri (206 km). However, 99 percent of the country's rivers are less than 25 km in length. The country also possesses 860 lakes covering 170 km^2, although the two largest, Lake Paravani (37.5 km^2) and Lake Kartsakhi (26.3 km^2) have maximum depths of less than four metres. Thirty-seven reservoirs cover 258.3 km^2, the largest being Mtvari (112.3km^2), Khrami (27.7 km^2), Sioni (12.8 km^2), Tkibuli (12.1 km^2) and Shaori (10.2 km^2). Although 134 of these waterbodies are used for fisheries purposes, van Anrooy, Mena Millar and Spreij (2006) report that the productivity of most of the lakes and reservoirs is poor because of low water temperatures, wide fluctuations in water levels, prolonged coverage of the surface with ice, limited natural reproduction of the main commercial species, and an absence of restocking in recent decades.

Commercial capture (marine and inland) fisheries in the republic date to 1930 when the joint-stock company Saktevzi was established. Production grew from approximately 2 000 tonnes in the early 1930s to reach 113 889 tonnes in 1980, with inland fisheries production contributing just two percent of the total. FAO report capture production data for Georgia of just 20 tonnes in 2021, although van Anrooy, Mena Millar and Spreij (2006) estimated total inland capture fisheries catch to be about 400 tonnes in 2004. This higher figure is supported by the consumption survey model estimate of 492 tonnes for 2011 (Fluet-Chouinard, Funge-Smith and McIntyre, 2018). Khavtasi *et al.* (2010) suggest that recreational fishers may be responsible for landing several hundred tonnes a year, with fish retained for household consumptions. This may help explain the discrepancy between reported inland catches and the household consumption model estimate.

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Kyrgyzstan

The total area of surface water resources in Kyrgyzstan is about 719 654 ha and there are 1 923 lakes in the country. Issuk-Kul Lake is the world's second–largest mountain lake with a water area of 6 247 km^2. More than 84 percent the lakes are at altitudes of between 3 000 and 4 000 metres, limiting their accessibility. This includes some of the larger lakes, such as Son-Kul (270 km^2) and Chatyr-Kul (161 km^2). Productivity of the fisheries of these water bodies is further restricted by their low fertility. In addition to the lakes, more than 30 000 rivers and streams flow across the country, the longest being the Naryn (535 km, which flows into the Syr Darya after passing through the Fergana Valley), the Chatkal (205 km), and the Chui (221 km). Thirteen multipurpose reservoirs covering around 378 km^2 were created to regulate flows in five transnational rivers (the Chui, Naryn, Talas, Ak-Bura, and Kara-Darya). The largest of these is the Toktogul reservoir constructed on the Naryn river (284 km^2) and the Kirov reservoir (26.5 km^2) on the Talas River. Linked to the reservoirs is an irrigation network that includes 12 835 km of canals, the majority (82 percent) of which are earthen.

There is only a relatively small number of commercially valuable native fish species. Consequently, many of the large lakes and reservoirs were stocked with fish species from watersheds elsewhere in the Russian Federation and Central Asia while Kyrgyzstan was part of the Soviet Union, increasing the number of fish species to over 70. Depending on the productivity of the waterbody, the resulting potential for fish production in large lake and reservoir is estimated to be between 0.5 and 7.5 kg per hectare.

Despite the low productivity and relative inaccessibility, during the Soviet era average annual commercial fish catches were regularly reported to be over 1 400 MT per annum. The focus of the commercial fisheries were the larger waterbodies, including Lakes Issyk-Kul, Son-Kul, and Kara-Suu and the large reservoirs, including Toktogul, Kirov, Orto-Tokoi, and Bazar-Korgon. The primary target species were Sevan trout (*Salmo ischchan*), whitefish (*Coregonus lavaretus*), peled (*Coregonus peled*), common carp (*Cyprinus carpio*), bream (*Abramis brama*), tench (*Tinca tinca*), pike perch (*Stizostedion lucioperca*), grass carp (*Ctenopharyngodon idella*), silver carp (*Hypophthalmichthys molitrix*), chebak (*Leuciscus schmidti*), chebachek (*Leuciscus bergi*), and marinka (*Schizothorax intermedius*). In the post-independence period the commercial fisheries have declined, and by 2000, annual commercial catches had reduced to 50 tonnes, and to 20 tonnes in 2021. Despite the contraction in production there are currently more than 80 small-scale fishing entities that still operate.

Recreational fishing is widespread and takes place in ponds, reservoirs, streams and rivers. The recreational fisheries target around 15 fish species, including Amudarya trout (*Salmo trutta oxianus*) and Osman (*Diptychus dybowskii*). People are able to purchase a permit or valid for a three-day period and includes daily bag limits and gear restrictions (number of rods). According to the Department of Fisheries in 2022 there were an estimated 100 000 fishers participating in recreational fishing, although only 4 151 permits were issued. Annual per capita fish consumption in Kyrgyzstan is relatively low at about 3 or 4 kg (Ilibezova *et al.*, 2014). The same authors calculate that the share of fish and fish products is less than 10 percent of total household expenditure on meat and fish.

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Mongolia

Mongolia is the fifth-largest country in the world, covering 1.5 million km^2. With an average altitude of 1 580 metres above sea level it is also one of the highest countries in the world. The country has 3 060 natural lakes with a surface area larger than 0.1 km^2. The largest lake is Lake Uvs (3 518 km^2), but, like the majority of Mongolian lakes, it is relatively shallow (average depth is around 10 metres). The second-largest, Lake Khuvsgul (2 770 km^2), is more than ten times deeper, and holds 74 percent of the country's total freshwater resources. Other notable lakes include Khar-Us (1 496 km^2), Lake Khyargas (1 481.1 km^2), Lake Buir (615 km^2) and Lake Khar (565 km^2). Many of smaller lakes dry up once or twice every decade, resulting in the periodic near complete loss of all aquatic life as fish, aquatic plants and animals are stranded on the drying lake-bottoms.

In addition to the lakes, there are 4 113 rivers extending across 67 000 km. The major rivers are the Orkhon (1 124 km); the Selenge (1 024 km), which carries around 30 percent of the country's total river flow; the Kherlen (1 090 km); the Zavkan (808 km); the Tuul (704 km); and the Hovd (593 km). The country also possesses a number of small reservoirs created for irrigation purposes through the construction of 27 earthen dams.

Commercial fisheries in Mongolia date from the 1950s and were centred upon Lakes Buir, Ugii (25 km^2) and Dood Tsagaan (10.5 km^2). Mean annual catches of more than 725 tonnes were recorded in the late 1950s, as fisheries management focused upon enhancement through the introduction of fish species, principally the Baikal omul (*Coregonus autumnalis*), and peled (*Coregonus peled*) into selected waterbodies. High levels of fishing pressure saw annual catches decline to under 200 tonnes by the late 1980s. In the early 1990s, fishing was prohibited on both Lake Ugii and Dood Tsagaan because of such concerns (Dulmaa, 1999; Ganbaatar, 2003). FAO data suggest current reported capture fisheries production in the country is approximately 49 tonnes, although FAO has estimated the annual fish production potential of the Mongolian lakes and rivers to be in the range of 650 to 750 tonnes.

Recreational fisheries are a feature of the inland fisheries of Mongolia. Taimen (*Hucho taimen*), the world's largest salmonid, are a particular target of recreational anglers (commercial harvesting of taimen being illegal) and fishers are permitted to catch taimen upon purchase of a licence from the Mongolian Government based on a game-management plan in game reserve areas. There are estimated to be around 3 250 recreational fishers in Mongolia based on data in Embke *et al.* (2022) and there were 600 individual licences for taimen approved in 2023. These licences were allocated to the rivers Delgermurun, Tengis and Shishkhed, Eg, Uur, and Onon in accordance with the game-management plan approved by the Ministry of Environment and Tourism. Local community-based organizations (fishing clubs or *nukhurlul*) and other enterprises are responsible for the management of the game reserve area and implementing the management plan for recreational fishing.

Fish and fish products play are believed to play only a minor role in Mongolian household food and nutritional strategies. Dulmaa (1999) reports that the Ministry of Health recommended annual per capita fish consumption levels of 3–6 kg in rural areas, and 4–24 kg in urban areas. In 2013 the annual per capita supply of fish products was just 0.68 kg.

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7.3 RUSSIAN FEDERATION

Country/territory	Inland capture fisheries catch (tonnes in 2021)	Percentage of global inland fish catch	Population (2021)	Per capita inland fish production (kg/cap/year)
Russian Federation	271 795	2.39	145 102 755	1.87

The Russian Federation subregion is large, spanning both Asia and Europe, and has extensive inland water resources. The inland waters of the Russian Federation include 22.5 million ha of lakes, 5.3 million ha of reservoirs and 523 000 km of rivers (Yadykina *et al.*, 2024), around 200 000 km of which are significant as spawning and nursery areas (Mamontov *et al.* cited in Dgebuadze, 2015). Eight of the 50 largest river basins in the world are located wholly or partly in the Russian Federation. However, many of Russia's freshwater bodies are situated in places that are difficult to access, and therefore, only an estimated 40 percent of them are used for fisheries (Dgebuadze, 2016). The Russian Federation can be divided into eight administrative fishery regions or basins (Yanovskaya, 2024), that include rivers, reservoirs and lakes. Lakes Baikal and Teletskoe as well as the water basin of Lake UbsuNur are included in the UNESCO World Heritage List.

The Fiftieth National Report of the Ministry of Natural Resources and Ecology of the Russian Federation (MNRE, 2015) indicated that there are 343 species of freshwater fish and 9 species of lamprey (including diadromous species) in inland waters of the Russian Federation. Diversity varies in the rivers, ranging from 28 species in the Kolyma River to 128 species in the Amur River Basin. Species diversity within Lake Baikal (the deepest lake in the world) is particularly high, with 2 630 species and subspecies of animals and plants, of which more than 2 000 are endemic. It is also reported that about 60 percent of the Russian Federation's freshwater fish species are of commercial interest and almost all of them are targeted by recreational fisheries.

Inland capture fisheries have always been important, with earlier catches for the Russian Federation as part of the Union of Soviet Socialist Republics (USSR) at about 124 000 tonnes in 1980 (Berka, 1989), with an additional inferred catch from recreational and informal fishing of 67 000 tonnes (Berka, 1989). Current reported catches in 2021 total 271 795 tonnes. This is similar to the total of 269 084 tonnes reported by Yanovskaya (2024), where the contributions by basin were: Northern fishery basin at 5 295 tonnes, Far Eastern fishery basin at 52 297 tonnes, Western fishery basin with 16 269 tonnes, Volga-Caspian fishery basin at 101 887 tonnes, Azov-Black Sea fishery basin with13 157 tonnes, West Siberian fishery basin at 68 466 tonnes, East Siberian fishery basin with 6 678 tonnes, and finally Baikal fishery basin at 4 945 tonnes. In terms of volume, the fishery of the Caspian Sea is one of the most important for the Russian Federation. Crucially, these production figures do not also include recreational fishing (also referred to as "amateur fishing"), which is extensive and considered to produce a significant level of retained catch (Embke *et al.*, 2022). It is estimated that total unreported and retained catches could be in the order of 20–100 percent more than the officially reported catch for the country (Dgebuadze, 2015).

Fishing effort is concentrated on the most valuable and available fish species found in the mainstream rivers and reservoirs located near populated areas. The riverine catch is dominated by whitefish (*Coregonus* spp.), pike and burbot. Makoedov and Kozhemyako (2007) state that roach, omul and bream make up to 80 percent of the harvest, however this information dates from the mid-2000s.

In the centre of the country, Lake Baikal has a surface area of approximately 31 500 km^2. Only a shallow part of the lake has commercial significance, as it is here that fishing is conducted mainly for Baikal omul (*Coregonus migratorius*). The total catch of omul in Lake Baikal in 2013 amounted to 1 900 tonnes, remaining at the level of 2012 (1 870 tonnes). Catches are reported to have declined, mainly as a result of the unfavourable situation in the fishing of certain fishing areas although the status of stocks of other species of fish (bream, pike, catfish and perch among others) in the lake is considered to be quite stable.

Fisheries in the east, in the Siberian basins, are largely based on salmon – particularly on the Pacific coast – and the fishing often takes place in quite remote areas. The salmon catches of the Russian Federation are reported to be 470 900 tonnes (Glubokovsky *et al.* cited in Dgebuadze, 2015), but are reported in the marine catch of the Russian Federation.

The role of inland fisheries and their contributions to livelihoods is also diverse. There are estimated to be around 40 500 commercial fishers employed by fisheries enterprises in 2018, of which 13 percent were full-time and 87 percent part-time or seasonal (Samoylenko *et al.*, 2024). Recreational fisheries are variously estimated to involve between 15 million (Dgebuadze, 2015) and 40 million people (Embke *et al.*, 2022), the latter figure equivalent to around 28 percent of the population. Fishing tourism as an activity has also been growing since around the year 2000 and demand for fishing tours continues to increase.

Elsewhere, traditional fisheries are also important and the livelihoods and economic activities of some of the population remain similar to those practised several hundred years ago. In some areas, livelihood strategies are based on reindeer husbandry, and fisheries continue to be of universal importance as part of these strategies, along with hunting and gathering wild plans (Yadykina *et al.*, 2024). Subsistence fishing takes place mainly in estuaries, lagoons and rivers (for anadromous fish).

For commercial fisheries, regulation is through agreements with the state. These can include quota systems where total allowable catches have been established and, in other cases, through other forms of agreement including leasing and auctioning the harvest rights (Samoylenko *et al.*, 2024). Recreational fishing is prohibited in waterbodies reserved for commercial fish farming, including pond aquaculture and in irrigation systems (Samoylenko *et al.*, 2024). Traditional fishing by indigenous peoples is carried out in accordance with the fishing rules for individual basins, including allocations made from within the established quotas where these exist. Indigenous peoples involved in fishing are legally bound to use the catch only for local consumption and are not allowed to sell their catch.

Many inland fisheries are affected by other activities that affect water availability and quality (Yanovskaya, 2024). The most significant impact on biodiversity within rivers has been caused by large-scale hydropower dam construction since the mid-1930s. Elsewhere, salinity affects the biological productivity of the Caspian Sea and varies across the waterbody by 0.1–0.2 percent near the estuaries of the Volga and the Ural rivers, up to 10–12 percent in areas close to the Middle Caspian. The Caspian is also affected by dams and the construction of the Volgograd dam was particularly damaging, which prevented several sturgeon species (including the beluga) access to most of their spawning grounds. The stocking programmes by the riparian states have not been able to compensate for this loss (Secor *et al.,* 2000). Most Russian reservoirs continue to have declining stocks of the most valuable fishery species (sturgeon and freshwater salmonid), attributed to illegal, unreported and unregulated fishing in addition to long-term impacts on hydrology and environmental water quality, habitat alteration (obstruction of migration routes and reduction in the area of spawning grounds) as well as competition with non-indigenous species (Dgebuadze, 2015; Berka, 1989).

The entry of wastewater from most agriculture, domestic and industrial sources into waterbodies contributes to pollution, as well as eutrophication of individual waterbodies (primarily reservoirs). There have been efforts to increase production and mitigate the impacts of other activities in waterbodies throughout the Russian Federation using enhancement measures. These include creating habitats (such as spawning nests for Chinese carp) and the introduction of Chinese carp and bream (*Abramis brama*) to reservoirs. Dgebuadze (2015) reports that non-indigenous species comprise more than 15 percent of species in most Russian river basins. Rivers have also been subject to active stocking of hatchery-reared salmon (Berka, 1989).

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7.4 EUROPE

Subregion	Inland capture fisheries catch (tonnes in 2021)	% global inland capture fisheries catch	Population (2021)	Per capita inland fish production (kg/cap/year)
Eastern Europe	59 223	0.52	156 405 446	0.38
Northern Europe	36 214	0.32	33 619 956	1.08
Western Europe	22 183	0.20	267 860 558	0.08
Southern Europe	15 503	0.14	141 522 786	0.11
TOTAL	**133 122**	**1.17**	**599 408 746**	**0.41**

7.4.1 Eastern Europe

Country/territory	Inland capture fisheries catch (tonnes in 2021)	Percentage of global inland fish catch	Population (2021)	Per capita inland fish production (kg/cap/year)
Ukraine	24 124	0.21	43 531 422	0.55
Poland	18 785	0.17	38 307 726	0.49
Hungary	4 601	0.04	9 709 786	0.47
Czechia	3 314	0.03	10 510 751	0.32
Romania	3 224	0.03	19 328 560	0.17
Serbia	2 354	0.02	7 296 769	0.32
Slovakia	1 815	0.02	5 447 622	0.33
Belarus	611	0.01	9 578 167	0.06
Slovenia	161	0.00	2 119 410	0.08
Montenegro	145	0.00	627 859	0.23
Bulgaria	89	0.00	6 885 868	0.01
Republic of Moldova	0	0.00	3 061 506	0.00

Eastern Europe has significant river and lake resources centred on the extensive Danube Basin, its tributaries and delta, as well as the Dnieper and Dniester rivers. The reservoirs of Ukraine and the extensive lake district of Poland are important resources as these two countries dominate the production of this region.

Inland fisheries have been an important source of food in many eastern European countries, especially during the period when governments invested in stocking and promotion of inland fisheries as part of the centrally planned economies. This support declined following the breakup of the Union of Socialist Soviet Republics and this was reflected in the reported catches until about 1998. The production of Ukraine increased after 1998, with the country's dominant position driving the regional trend, although the catch of other countries has remained largely stable throughout.

Based on data for 2021, Ukraine contributed about 41 percent of the catch for the subregion and Poland about 32 percent, with Hungary contributing a further 8 percent. The rest of the catch was shared between the other countries with catches ranging between 89 tonnes and 3 314 tonnes. The region's catches consist mainly of cyprinid species (especially common carp). However, a wide range of species are stocked in lakes and reservoirs to support the remaining commercial fisheries and growing participation in recreational fisheries.

There are reports of high levels of participation in recreational fishing, or fishing for the family in the Eastern European subregion (see Chapter 2 in this publication). This suggests that there may be considerably more fish consumed as part of household diets than is revealed in the reported catch statistics. Indeed, commercial fishing has been declining in Eastern Europe with no commercial fishing allowed in Hungary, Czechia, Slovakia, Republic of Moldova and Bulgaria (except the Danube region).

Ukraine

The total area of all inland freshwater waterbodies in Ukraine is about 24 000 km^2: 73 000 rivers and streams (about 250 000 km total length), about 20 000 lakes and estuaries, 1 160 reservoirs and 28 700 artificial ponds, 1 190 km of large canals, and another 1 032 km of sluices. The largest rivers are the Danube, the Dnieper and the Southern Bug, and the largest dam is the Dnieper Cascade with a total area of 6 920 km^2. Most Ukrainian lakes are in the drainage basins of the Danube, Dnieper, Pripyat, South Donets. Fish biodiversity is estimated to be 30 to 35 species, mostly non-indigenous and indigenous cyprinids, perches, pike, catfish and clupeids (Movchan, 2015). Flow regulations of the main rivers have degraded the conditions for natural reproduction and feeding of many fishes, and blocked migration routes. In the past there have been attempts to mitigate these losses through stocking programmes mainly using non-indigenous species; currently some 20 non-indigenous species have been introduced, of which 9 have become established (Movchan, 2015).

According to FAO statistics, inland fisheries catches in Ukraine reached 24 123 tonnes in 2021. No recent data were found on how catches are distributed geographically although data for the period 1997 to 2003 suggest that reservoirs on the Dneiper and the Lower Dneiper River were historically the most productive. In that period catches from inland fisheries made up about 20 percent of all capture fisheries production in the country. Ukraine has traditionally had high levels of participation in inland recreational fisheries and Embke *et al.* (2022) estimated that nearly 11 percent of the population participated. There was also a significant catch by recreational fisheries, although many catches remained unreported.

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Poland

Poland has 5 810 km^2 of inland surface waters, of which the Vistula and Oder rivers are the most important watercourses (GUS, 2022). There are 2 800 km^2 of lakes where most of the commercial fishing takes place, and over 750 professional fishers are involved in capture fisheries. Including post-harvest employment, inland fishing employs about 1 590 people (IRŚ-PIB, 2023, 2022). Important species for the commercial fisheries include indigenous cyprinids (including common bream, roach, white bream, and tench among others), other important species were vendace, pike, perch, pike-perch and European eel. The volume of eel catches has significantly decreased, but overall still remains important.

Recreational fisheries are also significant and in Poland, there are between 1.5 million to 2 million recreational fishers (Embke *et al.*, 2022; Czarkowski, Wolos and Kapusta, 2021; Wołos *et al.*, 2016; Czerwiński, 2016). Overall, recreational catches are higher than professional ones and it is estimated that in 2020 the catches from recreational fishing exceeded 9 000 tonnes. However, statistical data, covering an area of approximately 3 650 km^2, indicated that recreational fishers caught less than 3 000 tonnes (2 904 tonnes in 2020 and 2 775 tonnes in 2021), which is 1.5 times higher than professional landings (IRŚ-PIB *et al.*, 2023, 2022). Data on recreational catches are collected from smaller area compared to professional catches and subject to considerable delay.

The average annual per capita consumption of fish and seafood was 14.2 kg in 2021. Among freshwater and anadromous fish, the most important fish consumed are salmon (0.8 kg per capita), trout (0.6 kg) and carp (0.5 kg). Embke *et al.* (2022) estimate that 45 percent of the inland fish catch is retained for consumption. Overall, however, much of the inland fish consumed comes from aquaculture, partly from import (IERiGR-PIB and Hryszko, 2022). Wild fish caught in inland waters (such as vendace, eel, pike, pike-perch, and perch) is often a rare and exclusive commodity.

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Hungary

The total surface area of water suitable for inland fisheries in Hungary is 1 400 km^2. In this respect, the Danube and the Tiesza, its main tributaries, are the two most important rivers. Several large lakes are also important, namely Lake Balaton (596 km^2), Lake Fertö (75 km^2) and Lake Velence (7.5 km^2) and the Lake Tisza reservoir (64 km^2) (Specziar and Erös, 2016). According to the current Hungarian law governing fisheries and aquaculture (Act CII. of 2013 of the Hungarian Parliament on fisheries management and fish protection), no commercial fishing has been permitted in the country since 1 January 2016. Apart from recreational use (angling), inland capture fisheries are restricted to selective capture for ecological reasons, research, and occasional demonstration of traditional fishing methods. The total landing from these types of fisheries is negligible, reported by Kiss-Horváth, Kosáros and Lengyel (2022) as 181 tonnes in 2021.

Angling is by far the most common type of recreational fishing in Hungary. According to the Hungarian National Federation of Anglers (*Magyar Országos Horgász Szövetség* – MOHOSZ), the number of registered anglers exceeded 750 000 in 2023. This compares with a figure of around 550 000 provided by Embke *et al.* (2022). Anglers have spent a cumulative total of over 7 million fishing days on the rivers and lakes with 473 547 national and 17 945 tourist angling licences bought. The total landing by anglers was 4 375 tonnes in 2021 of which common carp had the highest share, representing around 20 percent of all catches. It is estimated that around 40 percent of the recreational catch is retained and consumed. The productivity of several stocks, including common carp is dependent on regular and continued stocking (e.g. Specziar and Erös, 2016).

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Czechia

Since Czechia is without access to the sea, inland fisheries constitute 100 percent of annual production. There are more than 24 000 ponds and reservoirs in the Czechia, with a total area of almost 52 000 ha, of which more than 41 000 ha are used for fish farming. In Czechia, there are more than 2 000 fishing grounds with an area of approximately 42 000 ha. Recreational fishing is practised by 330 000 registered members of the two largest users of fishing grounds: the Czech Anglers Union and the Moravian Anglers Union.

Recreational fishers in Czechia caught a total of 3 314 tonnes of fish in 2021, with the catch dominated by common carp (*Cyprinus carpio*). Most anglers (around 90 percent) are active anglers who fish at least once per year. Catch composition varies depending on the aquatic environment (Lyach, 2023).

Common carp form the bulk of the catch on the medium-sized rivers (78 percent), followed by Bream (10 percent) and piscivorous fishes (including Northern pike, Zander, and European catfish, which collectively make up around 10 percent of catches). On small streams, rainbow trout dominate the angler catches (80 percent by biomass), followed by brown trout (10 percent) and European chub (8 percent). It is estimated that around two-thirds of the recreational catch is consumed (Embke *et al.*, 2022).

Catches of have been relatively stable in recent years, with possible annual fluctuations due to unfavourable climate or pressure from piscivorous predators. It has been noted that the damage caused by piscivorous predators has been increasing in recent years (especially damage caused by river otters and cormorants). Their predation has a particular impact on salmonid species as well as affecting aquaculture production facilities. The development and operation of hydroelectric power plants is also negatively affecting fish migration (catadromous, anadromous and potamodromous). Other barriers on watercourses are having a particular impact on the critically endangered river eel.

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Romania

Romania is estimated to have an area of almost 500 000 ha of area covered with standing water and 66 000 km of flowing water from the lowland, hilly, and mountainous areas. The commercial inland fisheries area is formed by the Danube River (1 074 km) together with all its branches (almost 576 km), partially by the Prut River (only 100 km), alongside 290 000 ha represented by the aquatic complex lakes of the Danube Delta as well as 17 000 ha of reservoirs (artificial lakes) on the courses of the rivers Prut, Siret and Olt (Zugravu and Rahoveanu, 2011). Inland fisheries in Romania were affected by the transition to a market economy. Highest-recorded production was achieved in 1987 with 26 690 tonnes, but there was an almost continuous decline until about 2010 when 2 457 tonnes were landed. Since then there has been a slight increase, with catches hovering around 3 300 tonnes in recent years (2018–2023). Catches from the Danube Delta Biosphere Reserve (DDBR) represent over 80 percent of the total catch.

Most freshwater fish exploited by inland fisheries are caught to supply local traditional demand. The highest catch is represented by Prussian carp with 41 percent of the total followed by Danube shad with 11 percent. The Danube shad varies greatly from season to season depending on migration, the highest catch in recent years (635 tonnes) was recorded in 2019 which represented 17 percent of the total catch. Native cyprinids, with the exception of Prussian carp (*Carassius gibelio*), represent 33 percent of the total catch (the most common being freshwater bream at 9 percent, common carp at 7 percent and roach at 5 percent). Predatory species represent 12 percent of the catch, with European catfish having the largest share at 5 percent. (National Agency for Fishing and Aquaculture, n.d.).However, there are probably significant amounts of unrecorded landings, and there are no statistics of the increasingly important recreational fisheries, although there are 200 000 registered anglers.

Some 3 550 fishers were active in inland waters in 2022, using 1 900 registered vessels. The fishers use boats that are less than 6 metres in length with small outboard motors and utilize traditional fishing methods that have been practised for decades and sometimes centuries. Until the 1950s inland fisheries was the main economic activity along the Danube and its delta, today it is the main economic activity only in the delta region where 1 200 people work in inland fisheries. Besides these fishers, the local population of the DDBR has the right to fish for subsistence (family) purposes. In this respect, inland fisheries continue to be important for traditional fishers as a full-time occupation and also as a subsistence activity for people with insufficient income from other sources (Zugravu and Rahoveanu, 2011).

Average annual per capita fish consumption dropped from more than 8 kg in 1989 to a low of about 2 kg between 1993 and 1999, but has since recovered – reaching around 8 kg in 2020 (EUMOFA, 2024). However, although the country was able to meet the national demand almost entirely during the planned economy, the country is now relying on imported fish for about 85 percent of the supply (EUMOFA, 2024). Since the 1950s, the policy of controlling the floods and converting the floodplains into arable land by damming the Danube has not had the expected positive impacts on agriculture, with fish catches declining severely as a response. Additionally, the two Iron Gate hydroelectric dams have blocked the upstream migration of fishes, especially sturgeons.

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Serbia

Serbia is a land-locked country with no marine fisheries. The rivers that flow through the Republic of Serbia, including the Danube, the Sava and the Tisza, flow into the Aegean and Adriatic seas and the Black Sea Basin. The Black Sea drainage basin covers 92 percent of the territory of the Serbia. The fishing waters of Serbia are divided into 17 fishing districts managed by fishing district managers that are empowered by the Law on Protection and Sustainable Use of the Fish Stocks.

Commercial fishing is carried out on the Danube, Sava, and Tisza rivers. Although these are the largest rivers flowing through Serbia, their geographic contribution in relation to the entire territory is limited to one-third of the country's territory. Fishing vessels operating on the inland waters are small size vessels (less than six metres in length) and they use mostly gillnets, seines, traps and longlines, the latter may have up to 100 hooks. The total number of registered commercial fishers has declined slightly from 523 fishers in 2013 to 404 fishers in 2022 (Statistical Office of the Republic of Serbia, 2023).

Recreational fishing remains a very popular activity on Serbian rivers, streams, ponds and lakes. The number of recreational fishers in the period 2013–2022 from 72 989 fishers in 2013 to 88 734 fishers in 2022. In total, inland capture fisheries take place in 66 000 km of rivers and streams and about 150 artificial lakes and reservoirs, as well as 30 000 km of canals in the northern part of the country.

Recreational fishing can be conducted in all Serbian waters and permits are valid for the whole territory, except for protected areas in which it may also be allowed (8.2 percent of Serbian territory is under protection). Recreational catches were estimated at 1 664 tonnes, of which 39 percent was retained for consumption (Embke *et al.*, 2022). Serbian waters are characterized by a high diversity of fish species. There are around 110 freshwater species of which 20 percent are allochthones and 10 percent are non-indigenous. The most popular species in the recreational fisheries are common carp (*Cyprinus carpio*), wels catfish (*Silurus glanis*), pike-perch (*Sander lucioperca*), pike (*Esox lucius*) and bream (*Abramis brama*) as well as other cyprinids. One of the priorities for fisheries management is the conservation of sturgeon species (of which there are six species) in the Danube River and its tributaries in accordance with national and regional strategic documents and agreements.

Changes in the number of active commercial fishers and recreational fishers affect the landings. Overall there has been an increase in recreational fishing and a simultaneous decrease in landings of commercial fishers. In 2021, professional fishers and recreational fishers landed 927 tonnes and 1 426 tonnes respectively (Statistical Office of the Republic of Serbia, 2023).

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Slovakia

Slovakia is drained by rivers forming part of the Danube basin, which drains an area of 47 087 km^2. In addition, there are 8 164 km of canals for drainage, irrigation and navigation (Novomeská and Kovač, 2016. The country also features many relatively small, mainly artificial, waterbodies (ponds and reservoirs) with a total area of 938 km^2 (Novomeská and Kovač, 2016). Fishing is only recreational, with 120 000 registered fishers. Commercial fisheries essentially ceased when the country became independent (Novomeská and Kovač, 2016). Total recreational catches were estimated at 1 800 tonnes, of which only 37 percent was retained and consumed (Embke *et al.*, 2022).

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Belarus

Belarus has 53 rivers that are more than 100 km long, with a total length of 9 500 km. The biggest are the Dniepr, Prypiat, Zapadnaya and Neman rivers. There are 10 000 lakes in the country of which 90 percent are oxbows of the Dniepr and Prypiat rivers. Twenty-two lakes are larger than 10 km^2, of which the largest are the Naroch, Chervonoe, Vygonovsoe, Lukomlskoe, Nescherdo and Drisviaty lakes. In addition, there are 144 reservoirs with volume greater than 1 km^3.

Annual catches have varied between 553 tonnes and 1 122 tonnes since 2000. In 2021, 611 tonnes were landed. Most of the catch is cyprinids – the most important among them bream (*Abramis brama*), which makes up 30 percent of total catches – alongside other important species such as goldfish and roach (FAO, 2023). In contrast, Semenchenko, Rizevski and Ermolaeva (2015), report that total catches reached 8 961 tonnes in 2010, of which roughly 30 percent came from the large lakes and 5 percent from reservoirs. It is not clear what is behind this discrepancy, however, it appears that catches by recreational fishers, which added up to more than 8 000 tonnes in 2010 (Semenchenko, Rizevski and Ermolaeva, 2015), are not reported to FAO. Participation in recreational fishing is high, with around 10 percent of the population fishing in inland waters (Embke *et al.*, 2022).

The fishery is managed through stocking programmes and licensing. According to Semenchenko, Rizevski and Ermolaeva (2015), many lakes and rivers appear to be affected by fishing pressure as the total fisheries potential is approximately 5 000 tonnes. Other negative impacts result from invasive species, dam construction and spawning habitat degradation.

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Slovenia

Inland fish catch in Slovenia in 2021 was reported as 161 tonnes. The highest reported catches were in 1994 with 339 tonnes. In spite of the low volume of the catch, the level of detail is impressive with more than 90 percent of the landings reported at the species level. The dominant species is common carp at 45 percent, followed by rainbow trout at 14 percent (FAO, 2023). There were more than 14 000 recreational fishers in the country in 2004 (IUCN, 2004), and this has risen to an estimated 21 000 in recent years (Embke *et al.*, 2022). Recreational catches have been estimated at 199 tonnes, of which 41 percent is retained for consumption (Embke *et al.*, 2022).

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Montenegro

The annual catch in Montenegro was 145 tonnes of fish in 2021. The catch comprises mostly carp (*Cyprinus carpio*). The aggregated catches has remained fairly stable, however there is no definitive view as to stock status. There are 400 licensed fishers with 200 small-scale fishing vessels. Skadar Lake is the largest lake in Montenegro, and there is a high demand for its products at local markets. Most of the fish (mainly smoked carp) is sold informally, but around 270 tonnes of fish is sold annually to a fish canning factory that has a fishing concession on Lake Skadar (MAFWM, 2006). Recreational fish catches are estimated to amount to nine tonnes, of which about 56 percent is retained for consumption (Embke *et al.*, 2022).

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Bulgaria

Natural waterbodies in Bulgaria are limited, consisting of 570 ha of lakes and a total length of rivers of 20 231 km (150 km^2), including 471 km of the Danube River (NAFA, 2007; Mitchell, Vanberg and Sipponen, 2010). Bulgaria has 5 107 dams with a total water surface area of 637 km^2. A review of fish species diversity in five rivers in the northwest of Bulgaria (Voinishka, Vidbol, Archar, Tsibritsa and Ogosta) in 2005 found a total of 27 fish species belonging to seven families (Trichkova *et al.*, 2009). Of these, 24 species were indigenous to the Danube Basin.

Since August 2012, commercial fishing is allowed only on the Danube River, due to an amendment in the national legislation. Inland fish catches were reported as 86 tonnes in 2021, just 3 percent of what was landed less than three decades ago in 1999 when the highest catch of 2 475 tonnes was recorded

(FAO, 2023). A decade ago inland fisheries constituted 10.3 percent of the commercial landings, with17 percent of this coming from the Danube River and the remainder from reservoirs.

Although production levels from inland fisheries are relatively low, they play an important role at the local level in less developed areas bordering the Danube River as a source of income and employment. The fisheries for key species appear to have declined including common carp, Prussian carp, silver carp and bighead carp. During 2012, the landings of these four species were 1 239 tonnes (FAO, 2023). In 2017, 375 full-time and 1 776 part-time fishers (all male) were reported. Recreational fishing (which can only be carried out with a permit) is popular in Bulgaria with an estimated 70 000 participants (about 1 percent of the population) and catches of 1 470 tonnes – of which 41 percent is retained (Embke *et al.*, 2022). The main threats to fish populations are regulation by weirs and dikes in the lower reaches, water pollution, excessive fishing and poaching, and the construction of micro-hydropower stations along the river courses (Trichkova *et al.*, 2009).

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Republic of Moldova

The Republic of Moldova is framed by two large rivers and a few medium-sized ones, and it is crossed by several thousand other smaller rivers and water flows. Both the topography and water resources of the country are ideal for the construction of small water reservoirs and fish ponds. This is why the total artificial water surface in the country is so large. In total there are 41 707 ha of water reservoirs and ponds, of which 20 507 ha (49.2 percent) are used as fish farms. With reference to the practice of aquaculture, in 2021 domestic fish production was 13 900 tonnes and in 2022 14 200 tonnes.

No commercial fishing activity is practiced in the Republic of Moldova since 2016, when a moratorium on commercial fishing was introduced. As there is no commercial fishery, no record of catches are kept. The moratorium on commercial fishing in natural water basins is believed to have produced some positive results and in 2021, ichthyological investigations conducted in the Lower Dniester ecosystem identified 16 cases of the species *Caspiosoma caspium*. This was the first recording of this species after 50 years of absence and significant as the species is included in *The Red Book of the Republic of Moldova*. According to its taxonomic affiliation, it is unique in the Republic of Moldova from the genus *Caspiosoma*, belonging to the class Actinopterygii, order Perciformes, and family Gobiidae. It was believed that the species could only be found in the Cuciurgan Reservoir, being identified only once in 1969 in the number of a single specimen.

There is a small recreational fishery in inland waters with around 3 400 participants which catch around 70 tonnes annually, of which nearly 40 percent is retained (Embke *et al.*, 2022).

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7.4.2 Northern Europe

Country/ territory	Inland capture fisheries catch (tonnes in 2021)	Percentage of global inland fish catch	Population (2021)	Per capita inland fish production (kg/cap/year)
Finland	23 574	0.21	5 535 992	4.26
Sweden	8 098	0.07	10 467 097	0.77
Estonia	2 795	0.02	1 328 701	2.10
Lithuania	984	0.01	2 786 651	0.35
Norway	226	0.00	5 403 021	0.04
Latvia	214	0.00	1 873 919	0.11
Denmark	207	0.00	5 854 240	0.04
Iceland	116	0.00	370 335	0.31

The main water resources of Northern Europe are found around the extensive glacial lake networks that pervade the subregion. There are many short, steep rivers suitable for migratory salmonids, although some of these have lost connectivity because of damming.

Finland

The catch of Northern Europe is dominated by the catch of Finland, which contributed 65 percent of the subregion catch. Finland has a very large area of inland waters, which total 31 560 km^2 or 9.3 percent of the country's total land area. The commercial inland fishery catch was 5 100 tonnes in 2021, with vendace being the most important fish species in terms of volume – accounting for 40 percent of the total catch. The commercial inland pike-perch catch increased strongly during the 2010's, with more than 80 percent of the commercial pike-perch catch being caught from inland waters at the end of the decade. In the 1990s, 90 percent of the commercial pike-perch catch was caught in marine waters. The value of the catch in 2021 was EUR 15.9 million, with vendace being the most significant inland species. Together, vendace and pike-perch accounted for 80 percent of the value of the catches in the commercial inland fisheries. The total number of commercial fishers in 2021 was around 1 750 in inland waters, of which 340 were full-time fishers.

According to the 2022 recreational fishing statistics, the number of recreational fishers has increased to 1.8 million, suggesting up to one-third of all Finnish people went fishing. The number of fishers aged between 25 and 44 years grew the most, showing an increase of more than 50 percent from 2020. The last time the number of recreational fishers was at this level was in 2008. The composition of fishers indicates that a total of 43 percent of men and 23 percent of women went fishing. Total recreational fishing catch increased to slightly more than 33 000 tonnes in 2022 from just under 31 000 tonnes that were recorded in 2020. In addition, 2 500 tonnes of recreational caught fish was released. The total catch increased the most for pike-perch and roach. The pike catch increased from 6 500 to 8 200 tonnes, the pike-perch catch from 2 700 to 4 300 tonnes, and the roach catch from 1 600 to 3 100 tonnes. In contrast, the perch catch decreased from 11 400 to 9 900 tonnes and the vendace catch from 2 600 to 1 000 tonnes. A total of 33 percent of the recreational catch was caught using gillnets, while the corresponding figure in 2020 was 36 percent. Fish traps and trap nets accounted for 10 percent of the total catch. In 2020, the corresponding figure was 18 percent. In terms of angling gear, the largest catch was recorded by using a spinning rod or by trolling, accounting for 30 percent of the total catch. Recreational fisheries can be an important source of food given the scale and level of participation and it is estimated that almost 50 percent of catches are retained for consumption (Embke *et al.*, 2022).

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Sweden

Sweden has a large area of inland waters, with more than 500 000 km of rivers and nearly 100 000 lakes larger than 10 000 m^2, covering almost 9 percent of the country's total area (SLU, 2023). There is a mixture of northern and southern species and most of the fish stocks reproduce naturally, except in some regulated lakes and rivers where some salmonid populations are stocked. In some small, enclosed waters fish are also stocked for put-and-take fishing.

Ownership of fishing rights is divided between public water and private water. Private water consists of stretches of water closest to the shoreline around the coast and islands longer than 100 m in the five largest lakes (Vänern, Vättern, Mälaren, Hjälmaren and Storsjön). For inland fisheries, all fishers are allowed to sell the catches (except for European eel and live signal crayfish). Commercial fisheries are defined as licensed fisheries and are conducted either in private water, leased private water or in public water owned by the state. In the last decade an ambition to introduce ecosystem-based fishery management (EBFM) has been realized and several of the large lakes have developed plans for fishery management together with the stakeholders. For many smaller lakes and rivers local plans have been developed by local fishery conservation area associations.

Swedish commercial inland fisheries are mainly conducted in the four largest lakes (Vänern, Vättern, Mälaren and Hjälmaren). About 175 licence holders utilize 275 vessels. The landed weight reached

1 659 tonnes with an estimated value of SEK 153 million in 2022 (Swedish Agency for Marine and Water Management, and Statistics Sweden, 2023). This is compared with 139 000 tonnes in commercial marine fisheries with an estimated value of SEK 827 million in 2022 (Swedish Agency for Marine and Water Management and Statistics Sweden, 2023). Swedish commercial inland fisheries are estimated to contribute SEK 86 million to the Swedish GDP as well as up to 170 full-time employment positions (Enhol Blomqvist and Swahnberg, 2020). There is a large variation in species targeted based on where the commercial fishing is conducted. Overall, the most important species in terms of number of licences, landed weight and landed value are pike-perch and signal crayfish. Swedish inland fisheries are considered profitable and new licence requests are high for some lakes. All the large lakes show positive revenues even though variations exist between them. The processing at all levels of fisheries products in Swedish inland fisheries is relatively high. Several projects have been carried out to increase the value of fish products and to diversify the fisheries.

Recreational fisheries are extensive and occur in nearly all inland waters. Catch data for recreational fisheries are scarce but an annual national survey for recreational fisheries in Sweden has been conducted since 2013 and shows that during 2022, a total of 1.2 million people between the ages of 16 and 80 went fishing at least once, of which 350 000 were women and 850 000 were men (Swedish Agency for Marine and Water Management and Statistics Sweden, 2023). This is similar to the earlier estimate of 1.3 million participants provided by Embke *et al.* (2022). The total number of fishing days was 8.6 million days in lakes and rivers. The retained part of all catches equalled 8 500 tonnes and released part of all catches equalled 12 500 tonnes in lakes and rivers, totalling 21 000 tonnes. The most important species for inland recreational fisheries are perch, pike, trout, pike-perch and char. There is an extensive framework of regulations for inland fisheries and a website has been produced to provide an overview of these regulations[15].

A survey from 2011 estimates that 400 000 estates in Sweden include fishing rights, most of them are households (377 000) and the rest are companies, municipalities, the Swedish church, or other institutes (Krögerström, 2021). Fishing in privately owned waters is sometimes on a commercial scale. In many lakes, fishery conservation area associations have been formed to provide fishery management on a local scale, including regulation and charging fishers money for fishing in their waters.

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15 See www.svenskafiskeregler.se

Estonia

Estonia has 420 rivers of which 10 are longer than 100 km. There are 1 200 lakes larger than one hectare, with a total area of 2 115 km^2. Most lakes are eutrophic although water quality is improving. The most important waterbody is Lake Peipsi-Pihkva, a relatively shallow and productive lake that is shared and jointly managed with the Russian Federation. Lake Peipsi-Pihkva is the fourthlargest lake in Europe (3 558 km^2). Estonia reported a catch of 2 630 tonnes in 2022, of which 2 172 tonnes was from Lake Peipsi-Pihkva. According to the Republic of Estonia Agriculture and Food Board, the catches were dominated by perch (836 tonnes), bream (622 tonnes), pike-perch (386 tonnes), and roach (191 tonnes). Management of the fishery in Lake Peipsi-Pihkva is according to an agreement with the Russian Federation, On the Estonian side the fishery uses Danish seines, and licence holders may own several boats that they rotate in use to make the most of their licences. Gillnets are also widely employed, especially when the lake is covered by ice.

A small-scale fishery in Lake Võrtsjärv for European eel relies on the stocking of eels (Mitchell, Vanberg and Sipponen, 2012). In 2022, the largest amount of European eel (49.5 tonnes) was caught in Lake Võrtsjärv in the last 29 years. The most successful fishing months were May, June and September.

Recreational fishery is important in Estonia and may involve up to 4 percent of the population (Embke *et al.*, 2022; Orru *et al.*, 2014). Recreational fishing caught 83 tonnes of fish from inland lakes. Three types of recreational fishing are distinguished depending on the fishing gear used, fishing place and fishing time. Angling (free), recreational fishing with up to three angling (paid) and fishing on the basis of a fishing card (paid).

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Lithuania

Lithuania is rich in waterbodies. Of the country's 3 000 lakes, 2 827 are larger than 0.5 ha and 2 675 are large enough to support a commercial fishery. There are also 650 reservoirs and 1 589 ponds are larger than 0.5 ha (874 km^2). The largest waterbody, and the most important for fisheries, is the brackishwater Curonian Lagoon, which is shared with the Russian Federation (413 km^2 or 26 percent belong to Lithuania) (FAO, 2005; Mitchell, Vanberg and Sipponen, 2012). There are 30 000 rivers (of which 733 are longer than 10 km), as well as numerous streamlets, brooks and canals. The largest river is the Nemunas and its basin covers about two-thirds of the country. The Kaunas Dam was built on the

Nemunas River for hydropower generation (FAO, 1997). Other basins are the Lielupe, the Venta and the Daugava, whose basins are shared with neighboring countries (FAO, 2005; Mitchell, Vanberg and Sipponen, 2012).

Lithuania regularly reports inland catches to FAO, with landings in 2021 of 984 tonnes. Landings data for recent years reveal a trend of decreasing catches from the highest catch of 5 970 tonnes in 1990. In 2021 the catch was distributed among some 12 species. The most abundant species in the catches were: freshwater bream at 522 tonnes (53 percent), roach with 159 tonnes (16 percent), Vimba bream at 71 tonnes (7 percent), pike-perch with 68 tonnes (7 percent), European perch at 39 tonnes (4 percent), European smelt with 28 tonnes (3 percent), and vendace at 27 tonnes (3 percent) (FAO, 2023).

The Curonian Lagoon is the most significant inland fishing area. It is shared with the Russian Federation and has annual productivity of over 30 kg per hectare. The lagoon accounts for about 80 percent of all inland fish, and is fished by about 75 companies. Elsewhere, ponds yield 100 to 150 tonnes per year, and rivers 150 to 170 tonnes, however rivers are important as spawning and nursery grounds for many species (Mitchell, Vanberg and Sipponen, 2012). Fishing pressure on salmon and trout especially in the Curonian lagoon is significant. In addition, aquatic habitats are severely impacted by dams, polders, and reduction of natural spawning sites (Aps, Sharp and Kutonova, 2004).

Inland fisheries constitute about 2 percent of total national fish landings and employ about 1 500 people, of which 300 are part of commercial operations operating 200 vessels. As in many other countries, recreational fishing is increasing in importance. There are estimated to be 750 000 to1 million recreational fishers in Lithuania (Embke *et al.*, 2022; Aps, Sharp and Kutonova, 2004) out of a total population of 3.3 million people. Recreational fisheries are also very important for the tourist industry and contribute to food security, with an estimated 55 percent of the catch being retained for consumption.

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Norway

Norway has about 1 000 main rivers. The longest are the Glomma River (598 km), Tana River (360 km) and Numedalslågen River (337 km). There are 300 000 lakes with the largest being Mjøsa (368 km^2), Femund (210 km^2) and Røsvatn (201 km^2). There are 11 major reservoirs, however many natural lakes have been impounded for hydropower generation which obscures the distinction between reservoirs and natural lakes (Dill, 1990).

Norwegian lakes and rivers are naturally oligotrophic with low productivity and most suitable for salmonids. For example, the Mjøsa has an annual yield of 5 kg per hectare consisting mostly of whitefish, but also of trout, pike, perch and burbot. The maximum annual sustainable yield of Arctic char in mountain lakes of central Norway has been estimated at 7 kg per hectare (Jonsson cited in Dill, 1990).

Towards the end of the 1990s Norway reported landings of 11 species, but many of these seem to have disappeared from the catches (FAO, 2023). However, Dill (1990) discusses the challenges with obtaining reliable data on inland catches and indicates that official reports are serious underestimates. In 1980 for example, the total yield of Norway's inland fisheries was estimated to be approximately 5 000 tonnes (Swang cited in Dill, 1990). Norwegian rivers also support European eel (*Anguilla anguilla*) populations, although Norway represents the northern limit of their distribution area (Durif *et al.*, 2020). Inland fisheries in Norway are dominated by recreational fisheries. It is estimated that 250 000 people participate in the fishing for non-anadromous species in inland waters. Catches from these fisheries are unreported although Embke *et al.* (2022) estimate catches of 843 tonnes, of which 48 percent is retained for consumption.

Norway has more salmon rivers than any other country and in Norway it is mandatory to report catches of anadromous salmonids. No catch reports are demanded for other species. The total inland catch reported in 2022 was 425 tonnes. The catches consist mostly of Atlantic salmon (89 percent), but also sea trout (10 percent) and Arctic char (1 percent). Of the total catch, 35 percent were released. Since the first report to FAO in 1970, salmon landings have varied between 200 tonnes and 573 tonnes. In addition to official statistics of anadromous salmonids in freshwater, some non-official figures of catches from commercial inland fisheries exist: approximately 15 tonnes of brown trout and 50 tonnes of common whitefish.

Most salmon rivers continue to be productive despite hydroelectric development. This is partly the result of mitigation measures, including the construction of 300 fishways. Eutrophication has in some cases (e.g. Lake Mjøsa), led to excessive algal development in naturally oligotrophic lakes, and there are issues with acidification of both lakes and streams (particularly in southern Norway) as a result of air pollution with sulphur and nitrogen oxides. This is affecting the reproductive stages of fish (Wright and Snekvik cited in Dill, 1990). The fish-farming industry is a major source of organic waste. The fluke (*Gyrodactylus salaris*) caused severe losses of salmon parr in the 1980s. Non-indigenous species including pink salmon and brook trout (*Salvelinus fontinalis*) are also potentially displacing native species (Dill, 1990).

Since 2006, the implementation of the European Union Water Framework Directive was intended to have a positive impact on the environmental health of freshwater aquatic ecosystems and provide a coordinated approach in monitoring procedures to assess the state of inland fisheries (Mitchell, Vanberg and Sipponen, 2012).

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Latvia

Latvia has 2 256 lakes larger than one hectare corresponding to a total surface area of 1 000 km^2. The largest lakes are Lubana (82 km^2), Razna (58 km^2) and Engure (38 km^2). There are 12 500 rivers, with a total length of 60 000 km^2, 17 of them are longer than 100 km including Daugava, Lielupe, Venta, Aiviekste, and Gauja. There are 3 052 reservoirs including three major hydroelectric reservoirs, namely Kegums, Plavinas and Riga with a total area of 102 km^2 (Riekstins 1999).

In 2021, Latvia reported landings of 214 tonnes from inland fisheries. Unfortunately, these fisheries have experienced nearly continuous decline since 2000 (FAO, 2023). However, inland fishing has never been of significant scale since the country has only once reported landings over 600 tonnes (1 555 tonnes in 1988), suggesting a possible shift in reporting or data collection after independence. For 2022, 18 species were reported among which the most important are bream (26 percent), river lamprey (14 percent), tench (13 percent), northern pike (10 percent) and pike-perch (9 percent) (FAO, 2021). Recreational fisheries are growing in importance, and while there are no public catch statistics, they rival commercial catches in scale.

Less than one-third of those employed in fisheries work in commercial inland fisheries. In 2022, there were 98 people working in inland fisheries, however, 85 percent of them fish only occasionally. The level of employment has witnessed a dramatic decrease over a short span, as nearly 3 500 people worked in inland fisheries until 2003.

Commercial fishing takes place in 202 lakes, 154 reservoirs and 4 rivers. Most of the species are cyprinids and are mostly caught in lakes (Aleksejevs, 2021). The only truly riverine species is the river lamprey, for which there is a traditional fishery and the species is considered a delicacy (Riekstins, 1999). The fishery is enhanced through restocking (Eurofish, 2023). Key fishing equipment includes gillnets, seines, and traps (Riekstins, 1999). However, recently there has been a move towards prohibiting fishing with traps and nets in many lakes and rivers, in favour of recreational fishery and angling, linked with the development of ecotourism in Latvia. There are an estimated 100 000 recreational fishers (equivalent to about 5 percent of the population). Around 48 percent of the recreational catch is retained for consumption (Embke *et al.*, 2022).

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Denmark

Danish inland waters consist of about 64 000 km of streams (of which 3 970 km are fishable), two rivers longer than 100 km and five longer than 60 km. the largest is Gudenå which is 158 km long with a basin of 2 700 km^2. There are about 120 000 lakes and ponds less than one hectare, covering an area of 580 km^2 or 1.4 percent of Denmark's area. Only 87 lakes are larger than one km^2, and 6 are larger than 10 km^2: The largest is Lake Arresø (41 km^2) and the secondlargest (17 km^2) is Lake Esrom (Dill, 1990; Rasmussen and Geertz-Hansen, 2001). In addition, there are a number of semi-inland waters: fjords, sheltered bays, estuaries, lagoons and creeks (Dill, 1990).

Virtually all streams and lakes in Denmark are influenced by human activities. Most lakes are highly eutrophic, and the fish fauna is dominated by cyprinids with few predators, such as pike and pike-perch. Most streams have been regulated and channelized while only two percent are still in their original natural condition (Brooks 1984). However, the implementation of the Water Framework Directive is slowly improving both the physical condition of rivers and the eutrophic state of lakes through various types of restoration activity (e.g. removing barriers and re-meandering in streams, performing nutrient load reduction, phosphorous capture and biomanipulation in lakes). Wildlife predation especially from cormorants inflict an increasing pressure on fish populations in both streams and lakes (e.g. Skov *et al.* 2014; Jepsen *et al.* 2018).

Commercial inland catches have been declining during. In 2022, only 11 tonnes of fish were landed. 20 years earlier the total catch was 146 tonnes. The main reason for the decline is cessation of commercial inland fisheries, in most cases due to lack of profitability. In 2022, catches were divided among 12 species, the dominant species were eels (4 347 kg), pike (3 141 kg.), bream (1 730 kg.) and pike-perch (1 434 kg.). Eel catches, including both yellow and silver eel, were down to about 4 percent of the mean annual catch in the 1980s (120 tonnes) (FAO, 2021).

Fishing rights to streams and lakes in Denmark generally belong to the owner of the adjoining land. The only exceptions are that public authorities can own fishing rights without being landowner and a still-legally valid royal privilege that has existed for over 200 years. The fishing rights to nearly all streams are privately owned. In about 25 percent of lakes fishing rights are owned by the Danish state, whereas the remainder are privately owned. About 50 percent of those owned by the state are available for recreational fishing (Dill, 1990; Rasmussen and Geertz-Hansen, 2001), while most of the privately owned lakes are not.

In 2022, commercial inland fishing areas in Denmark include 10 lakes and two locations in rivers, all performed as part-time occupation. The largest commercial fishery in Denmark (in Arresø) was terminated in 2021 by the owner (the Danish State), indicative of the substantial decline in importance of commercial fishing, and the number of commercial fishers in Danish inland waters is expected to decrease further in the future. To these, the stream and lake fishing of several hundred landowners for household use should be added.

Recreational fisheries are very popular in Denmark and streams, and to a lesser extent lakes, are already fully exploited. Approximately 500 000 people engage in recreational fishing activities and put-and-take fisheries are increasingly popular (Embke *et al.*, 2022; Rasmussen and Geertz-Hansen, 2001; Fisheries Agency, n.d.). For lakes the main obstacle to increase recreational fisheries is private landowners being reluctant to allow angler access. During the last approximately 30 years, salmon stocks in Western Jutland rivers have been rehabilitated and the recreational fishery for these is increasingly popular but subject to management measures – including a total allowable catch and personal quotas (Koed *et al.* 2020). The socio-economic value of this fishery is high and it is estimated that around two-thirds of the recreational catch may be retained and consumed (Embke *et al.*, 2022; Jordal-Jørgensen *et al.* 2014).

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Iceland

The total area of inland water in Iceland is 2 750 km^2, whose source is mainly comprised of meltwater from glaciers and snowdrifts. There are about 250 large and small rivers ranging from 60 km to 237 km in length. The longest rivers are Thjórsá (237 km), Jökulsá á Fjöllum (206 km), Ölfusá-Hvítá (185 km), and Skjálfandafljót (178 km) (Dill, 1990). Iceland has about 1 800 waterbodies (Mitchell, Vanberg and Sipponen, 2012), however they are mostly very small with only 15 larger than 10 km^2 and 68 between 1 and 10 km^2. The largest is Lake Thingvallavatn with an area of 84 km^2. Some lakes, including the second-largest (Thorisvatn), have no fish at all (Dill, 1990).

The Icelandic fish fauna is poor with only five indigenous species: Atlantic salmon (*Salmo salar*) which ascends about 80 rivers up to 100 km; sea trout/brown trout (*S. trutta*) found in its resident form in any lake with suitable spawning grounds and the anadromous variety in the southern and southwestern parts of the country; Arctic char (*Salvelinus alpinus*) occurs throughout the country in both a resident lake form (including a pelagic variety) and an anadromous form; European eel (*Anguilla anguilla*) is found in rivers; and threespine stickleback (*Gasterosteus aculeatus*) (Dill, 1990). In 2021 total inland catches amounted to 116 tonnes. The highest catch reported was 907 tonnes in 1993. In 2021, the catches were distributed between Atlantic salmon (55 tonnes, 46 percent), Sea trout (42 tonnes, 35 percent) and Arctic char (22 tonnes, 18 percent) (FAO, 2021).

The inland fisheries for salmon, trout and char have traditionally been an important source of food for the farmers, but increasingly serve as a source of income through renting fishing rights out to recreational fishers and mainly tourists. In particular, the salmon fisheries are among the best (and most expensive) in the world (Dill, 1990). Ninety percent of the total salmon catch in Iceland is caught by recreational fishers. The largest remaining net fishery for salmon occurs in the Ölfusa River where angling opportunities are limited (Mitchell, Vanberg and Sipponen, 2012). Fifteen rivers produce 1 500 to 3 500 rod-caught salmon per year and the most productive river, Laxá, produces 3 000 (around 15 tonnes). Recreational angling for trout and Arctic char is practiced in both rivers and lakes, whereas commercial fishing for these species only takes place in three lakes (in 1978 Lake Thingvallavatn had an annual catch of 75 tonnes of Arctic char). Lake Mývatn yields around 20 tonnes per year, of which about 10–15 percent is trout and the remainder are char (Jónasson cited in Dill, 1990). Winter fishing through the ice is practiced in some places (Dill, 1990). It is estimated that around 50 percent of the recreational fish catch may be retained and consumed (Embke *et al.*, 2022).

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7.4.3 Western Europe

Country/territory	Inland capture fisheries catch (tonnes in 2021)	Percentage of global inland fish catch	Population (2021)	Per capita inland fish production (kg/cap/year)
Germany	16 724	0.15	83 408 554	0.20
Switzerland	1 486	0.01	8 691 406	0.17
Netherlands (Kingdom of the)	1 368	0.01	17 501 696	0.08
France	1 155	0.01	64 531 444	0.02
United Kingdom of Great Britain and Northern Ireland	724	0.01	67 281 039	0.01
Austria	350	0.00	8 922 082	0.04
Belgium	283	0.00	11 611 419	0.02
Ireland	93	0.00	4 986 526	0.02
Andorra	0	0.00	79 034	0.00
Channel Islands	0	0.00	116 109	0.00
Faroe Islands	0	0.00	52 889	0.00
Liechtenstein	0	0.00	39 039	0.00
Luxembourg	0	0.00	639 321	0.00

The main inland fisheries in Western Europe are found in the numerous rivers, some of which are large such as the Rhine, the Rhone and the Loire Rivers, lakes and reservoirs. There are about 50 species found in Western Europe that, with only one or two exceptions, are fished (e.g. Winfield and Gerdeaux, 2016). Recreational fisheries are the main focus across most countries in Western Europe, although some commercial fisheries do operate (Winfield and Gerdeaux, 2016). The role of recreational fishing also differs, and in some countries catches may be consumed while in others there may be catch-and-return policies (these roles can also differ between species within countries). Overall inland fish production is dominated by Germany, which has significant commercial inland capture food fisheries. Other Western European countries reported catches from less than 100 tonnes (Ireland) to just under 1 500 tonnes (Switzerland). The trend in reported catch shows overall stable catches for all countries in Western Europe and declines in some migratory species. With no reported catches, Andorra, Channel Islands, Faroe Islands, Liechtenstein and Luxembourg are not described in the section below.

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Germany

The Federal Republic of Germany has a total inland water area of about 820 000 ha (Statistisches Bundesamt, 2022). In addition to lakes – mainly confined to the northern, eastern and southern parts of the country – there are numerous small waterbodies, both natural and artificial, scattered throughout the country. The German inland waters used for inland fisheries (including angling and aquaculture) is estimated to be between 520 000 and 565 000 ha. The area is also believed to have declined from around 565 430 ha in 2010 to about 521 000 ha in 2021. Commercial and recreational capture fisheries make up the majority of use with 233 000 ha used for commercial inland fisheries, approximately 23 000 ha for aquaculture and 265 000 ha solely for recreational fisheries. A large proportion of the 233 000 ha used for commercial fishing is also available for recreational fisheries.

Commercial fisheries exist in almost all large river estuaries (including Elbe, Weser, Ems, Eider, Warnow, Peene and Schlei/Trave). Commercial river fisheries are locally significant, but not extensive. Important commercial lake fisheries are in the prealpine lakes in Bavaria, Lake Constance (Bodensee), the lake region of Plön-Eutin in Schleswig-Holstein, the northeastern German lake region (Mecklenburg-Pomerania), and lakes and rivers in Brandenburg and Berlin. The commercial fishery mainly targets European eel, pike-perch, pike and perch in the north and the pre-alpine region whitefish, perch and to some extent char. A 1994 census returned a total of 587 inland fishing enterprises, which likely included only the fully commercial ones. Since then, the number of fishing enterprises has decreased considerably: Whereas in 2010 the overall number of fishing enterprises (excluding aquaculture) was 866 (394 fully commercial and 472 part-time), this number has decreased to 632 enterprises (318 fully commercial and 314 part-time) in 2021.

The inland capture fisheries trend in production since 1995 has been a picture of continuous decline, from nearly 23 000 tonnes to 16 708 tonnes (2 189 tonnes commercial, 14 519 tonnes recreational). Hence, the data show a decreasing trend in the commercial fishery from 3 010 tonnes in 2010 to 2 189 tonnes in 2021. The estimates for recreational fisheries are highly variable, however the figures also reveal that the catches from the recreational fisheries far exceed the commercial catches. Recreational fishers include both urban and rural participants (Arlinghaus and Mehner, 2004). The number of valid recreational fishing licences in 2021 was around 1.65 million, and interest in recreational fishing increased during the COVID-19 pandemic. Embke *et al.* (2022) suggest the number of participating fishers could be almost as high as 5.8 million (around 7 percent of the population) and that around 50 percent of the catch is retained.

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Switzerland

Switzerland has a total inland water surface area of about 1 740 km^2. Of this, 1 422 km^2 are lakes. The total length of rivers and streams is about 65 000 km. Commercial fishing in Switzerland takes the form of professional lake fishing, and in 2022 there were 240 professional fishers operating on Switzerland's lakes. The annual commercial catch in Swiss lakes for the period 2008–2018 averaged approximately 1 500 tonnes. Recreational fishing is widely practiced with an estimated 277 200 participants annually. Recreational catches have been estimated at 254 tonnes, of which around 46 percent (118 tonnes) is retained (Embke *et al.*, 2022).

Aquatic environments in Switzerland have been negatively affected by North American crayfish (*Faxonius limosus*, *Pacifastacus leniusculus* and *Procambarus clarkii*). Measures to control and eradicate these species have included intensive trapping, introduction of predatory fish (including pike, zander and European eel) and construction of crayfish barriers (Krieg, King and Zenkner, 2020).

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The Kingdom of the Netherlands

The inland waters of the Kingdom of the Netherlands occupy 3 574 km^2 and are comprised of Lake IJssel (2 000 km^2) and the country's marginal lakes (145 km^2), delta lakes (230 km^2), polder reservoirs (790 km^2) and rivers (212 km^2) (FAO, 2005). The most important waterbody for commercial inland fishing is the Lake Ijssel, whose commercial catch was 1 106 tonnes in 2022 and mainly consisted of pike-perch (390 tonnes), roach (223 tonnes), European eel (184 tonnes), bream (177 tonnes) and perch (75 tonnes). Other important areas include lakes Veerse, Grevelingen and Lauwer, as well as sections of rivers in the south.

The majority of value for inland fisheries is derived from the European eel fishery. Decreasing populations of eel are impacting the professional inland fishery with a decline of catches and yields. (Mitchell, Vanberg and Sipponen, 2010). The total reported catch of European eel was 563 tonnes in 2022. Recently, recreational fishing has been growing in popularity – an estimated 1.6 million people fished in inland waters at least one or more time in 2020 which has almost doubled since 2019. The main species targeted by recreational fishers are minnows and carp fish (Sportvisserij Nederland, 2022). Recreational fish catches have been estimated to be in the region of 882 tonnes. The retention of fish for consumption is relatively high for the subregion, at almost 70 percent (Embke *et al.*, 2022).

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France

France has a total area of inland waterbodies of 1 400 km^2. There are five major river systems with a total length of 270 650 km (Seine, Loire, Garonne, Rhône and Rhine), 60 000 ha of lakes and approximately 100 000 ha of small lakes, ponds and marshes. Thus, France has a wide range of freshwater bodies, which have benefited recently from a reduction in pollution. In addition, an increasing proportion of the population has interest in locally sourced food products.

Despite these favourable geographical and ecological situations and levels of demand, French inland fisheries have been in decline since the mid-1970s. Commercial inland fisheries in France represent a traditional activity that is concentrated in the estuaries of the Loire, Gironde and Adour Rivers and several alpine lakes. This accounts for about 60 percent of catch. The remaining 40 percent is from river fisheries that focus in particular on migratory species. The most important species caught are eel, lamprey, shad, whitefish and perch. In 1997 there were 2 106 professional fishers operating in French inland waters, although by 2009 this had fallen to 532 fishers and by 2016 decreased further to 387 fishers with a catch of 1 200 tonnes total (Mitchell, Vanberg and Sipponen, 2010; Changeux *et al.*, 2024). Part of the reason for the decline in the commercial fisheries is their dependence on migratory species that are themselves in decline (Changeux *et al.*, 2024).

Recreational fishing has had a slower decline due to the creation of subannual fishing cards and expansion to younger fishers. In 2016, 2 million anglers and 400 subsistence fishers were estimated to be active in the recreational fisheries with catches of 7 600 and 200 tonnes respectively. The economic worth of the fishing industry was estimated at EUR 980 million, with recreational fishing being the main contributor. Recent estimates suggest that the number of participants could be as high as 5.6 million (Embke *et al.*, 2022).

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The United Kingdom of Great Britain and Northern Ireland

The United Kingdom of Great Britain and Northern Ireland has a total inland water area of 3 218 km² comprising 2 745 km² of lakes (including reservoirs), 38 802 km of rivers, over 2 000 km of canals and 3 700 km² of estuaries. Many rivers have been subject to modification that has reduced the heterogeneity of riverine habitats which, together with water pollution and the effects of introduced and invasive species, has affected freshwater biodiversity. More recently there have been efforts to restore habitats, including through the removal of barriers and reintroduction of species, such as the beaver and, more recently, the burbot (*Lota lota*).

Most of the country's inland waters are exploited for recreational purposes, and there is little commercial exploitation of inland waters. Remaining commercial fisheries are focused on migratory species, including European eel fisheries salmonid fisheries. The most important areas for professional inland fisheries in the United Kingdom of Great Britain and Northern Ireland are Lough Neagh, Lough Erne, Lake Windermere, Lake Coniston, Severn Estuary, River Foyle Estuary, and Solway Estuary, as well as a number of estuaries off the northeastern coast of England, and off the eastern, northeastern and northern coasts of Scotland. Over 1 000 people were involved, mostly part-time, in the migratory salmonid and eel net fisheries of England and Wales (Mawle and Peirson, 2009).

Recreational fishing makes up the majority of fishing and in England and Wales, the majority of which is for coarse fish. This is the case even in areas traditionally associated with salmonid fisheries, such as the Southwest and Wales (Mawle and Peirson, 2009). Recreational fisheries range from fishing on stocks that have little management, as with the salmonid stocks of upland streams and rivers, to the more intensively managed fisheries such as lowland coarse fish fisheries (e.g. Winfield and Gerdeaux, 2016).

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Austria

In Austria, professional or commercial fisheries are located on Neusiedler See, the lakes of Salzkammergut, some Carinthian lakes and Bodensee (Lake Constance). River fisheries have ceased altogether with the exception of the Danube in Upper Austria, where fishing still provides added income in a few locations. In 2020, an estimated 225 tonnes of fish were caught, compared to 350 tonnes in 2010 (not including recreational fishing). Production is reported to be enhanced in some cases by stocking with commercially produced fish (Mitchell, Vanberg and Sipponen, 2010).

Employment for commercial inland fisheries, including aquaculture, totals about 600, but fewer than 35 professional fishers make a living from fishing. While commercial fishing is declining, recreational fishing is a popular activity in Austria with the number of anglers estimated at nearly 450 000. This activity generates an annual direct and indirect contribution to the economy of EUR 437 million (EAA, n.d.) as well as contributions to food security with almost 50 percent of the recreational catch consumed.

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Belgium

Major rivers in Belgium include the Meuse and the Schelde that drain into the North Sea. Other rivers include the Rupel, Senne, Sambre, Lesse, Ourthe, Lys and Dijle, some of which are tributaries of the major rivers. Belgium also has a number of lakes, including the Lake Bütgenbach, Lake Genval and Lake Robertville, that are mainly located in the southeast as well as many artificial waterbodies and canals.

Belgium is reported to have no commercial inland fisheries operations (Newman, 2014). The inland fishery in Belgium is therefore focused on recreational fishing, including occasionally for subsistence. Over 350 000 people are estimated to participate in recreational fishing and around 50 percent of the estimated 772 tonnes caught are retained (Embke *et al.*, 2022). Much of this fishing occurs in artificial fishing areas (private ponds, fishing grounds) as well as in the country's rivers and canals (Mitchell, Vanberg and Sipponen, 2010).

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Ireland

Ireland has a total area of 3 350 km^2 of inland waters, including freshwater lakes (1 445 km^2) and main channel rivers with a total length of about 13 840 km. Habitat enhancement projects have been initiated in a number of rivers to maintain and increase fish habitats and mitigate infrastructure development (IFI, 2022). Commercial fishing activity principally comprises commercial drift-net fishing of salmon (*Salmo salar*), which since 2007 solely occurs in designated river estuaries which exceed their respective conservation limits since the coastal mixed-stock drift-net fisheries ceased operation in 2006. Some minor commercial sea trout (*Salmo trutta*) fishing also coincides with this fishery. A single commercial brown trout (*S. trutta*) fishery operates in the state in Lough Ree. As a conservation measure, there has been no commercial fishing for European eel (*Anguilla Anguilla*) since 2009. In 2022, commercial catches comprised of almost 11 tonnes of salmon and 0.01 tonnes of sea trout. The commercial salmon harvest in 2022 was the lowest recorded since 2007 when the transition to river-specific stock management was introduced. Since 2013, when 38 tonnes of salmon were harvested, there has been a progressively declining trend in annual catches recorded in the commercial salmon fishery (IFI 2023). The brown trout commercial fishery reported a harvest of 1.9 tonnes in 2022. According to information presented by Newman (2014) employment in inland fisheries in Ireland is composed of around 625 part-time fishers.

In addition to the commercial fisheries, recreational fisheries are also important in Ireland. In 2022, a total of 17 318 licences were issued for the recreational salmon fishery which reported a harvest of almost 28 tonnes. Fifty-four percent of all salmon caught in this fishery were released. No such catch information is routinely compiled at a national level for brown or sea trout recreational fisheries in Ireland and there are no recreational eel fisheries. In addition to the salmonid fisheries, there are also recreational fisheries in the lakes, loughs, canal networks and smaller waterbodies in Ireland. Recreational anglers target a mix of species including Bream, roach, perch and rudd. Total annual participation in recreational fisheries, most of which are catch-and-release, has been estimated at over 400 000 people (Embke *et al.*, 2022). Fisheries in Ireland are managed through licensing of commercial and recreational fisheries. A statutory body (Inland Fisheries Ireland) exists to protect, manage and conserve inland fisheries.

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7.4.4 Southern Europe

Country/territory	Inland capture fisheries catch (tonnes in 2021)	Percentage of global inland fish catch	Population (2021)	Per capita inland fish production (kg/cap/year)
Spain	6 000	0.05	47 486 935	0.13
Italy	3 800	0.03	59 240 329	0.06
Albania	3 544	0.03	2 854 710	1.24
Greece	940	0.01	10 445 365	0.09
North Macedonia	514	0.00	2 103 330	0.24
Croatia	384	0.00	4 060 135	0.09
Bosnia and Herzegovina	300	0.00	3 270 943	0.09
Cyprus	20	0.00	1 244 188	0.02
Portugal	1	0.00	10 290 103	0.00
Malta	0	0.00	526 748	0.00

Southern Europe has a diverse mixture of aquatic environments including lake and river resources. Catches from the subregion have declined since the mid-1980s and as of 2021 are stabilizing at about 15 503 tonnes. The principal producer is Spain, which accounts for 39 percent of the total, followed by Italy with 29 percent, Albania with 23 percent, Greece with 6 percent. FAO has estimated the catch of Spain since 1996, and of Italy since 2011, so these figures may not be reliable and the apparent stabilization of catch in the subregion may reflect that FAO estimates are unchanging.

Spain

Spain has an area of about 506 000 km², with a inland waterbodies covering 655 000 ha (Mitchell *et al.*, 2010). There are a limited number of large natural lakes, but a significant number of reservoirs and lagoons. There are about 72 000 km of permanent rivers, including the Ebro, Tajo, Guadalquivir, Duero, Miño and Guadiana. Rivers include short, fast-flowing rivers in the north and longer rivers that flow through broad valleys in the South (Antunes, Cobo and Araújo, 2016). There is a relatively high diversity of fish species with around 60 species.

Spain's commercial inland fisheries are concentrated primarily in the rivers and estuaries. (Mitchell, Vanberg and Sipponen, 2010). Salmonid fisheries exist in the north of Spain where there is some stocking to support the fisheries. Information on recreational fisheries are limited although Embke *et al.* (2022) estimated that there were over 4.5 million people participating in inland recreational fisheries in Spain, equivalent to about 9 percent of the population. Total catches in the recreational fisheries have been estimated at 38 tonnes, of which around 44 percent is retained. Fisheries in Spain are regulated through the Autonomous Communities of Spain.

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Italy

Italy has 7 230 km² of inland waterbodies comprising of lakes (2 045 km²), reservoirs (500 km²), lagoons (1 500 km²) and principal rivers (7 782 km), the largest being the river Po which drains the Alpine region of Italy and the northern Apennines (Bianco and Ketmaier, 2015). Commercial inland fishing in Italy is limited to some lakes and reservoirs and to a few reaches of the larger rivers. The commercial inland fish catch (3 915 tonnes) during 2007–2008, was composed 20 percent of cyprinid species, 10 percent of salmonoids, 5 percent of pike and perch and 3 percent of eels (Martin, 2008).

Commercial inland fishing is concentrated in relatively small waterbodies in Lombardia and Umbria and lacks appropriate fisheries management models. It increasingly depends on direct restocking for fish recruitment. In addition, recreational fisheries are popular with just over 1 million participants reported in a recent review by Embke *et al.*, 2022 – equivalent to about 1.7 percent of the population.

These fisheries can also make contributions to food security and nutrition with over 40 percent of catches retained for consumption (Embke *et al.*, 2022). Inland waters suffer from pollution and habitat modification especially the river Po, whose tributaries cover an area populated by approximately 16 million people and approximately 45 percent of all Italian industries (Mitchell, Vanberg and Sipponen, 2010; Bianco and Ketmaier, 2015).

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Albania

Albania has more than 150 rivers and streams and seven main rivers cross the territory of the country from the east to west. There are six main river basins, these being the Drini/Buna, Mati, Ishmi, Shkumbini, Semani, and Vjosa. Natural lakes cover around 4 percent of Albanian territory or 60 percent of Albanian inland water bodies. The lakes include three large lakes and 247 small lakes. In addition to the freshwater lakes, there are also coastal lagoons that are connected to the sea through one or more channels.

Fishers, particularly those operating in the natural and artificial lakes and two coastal lagoons are organized through Fisheries Management Organizations (FMO). There are currently six FMOs, representing a total of 550 boats and 1 100 fishers. The top three commercial fish species of inland waters by catch volume are common carp (*Cyprinus carpio*), roaches nei and Crucian carp (*Carassius carassius*). Commercial catch in 2022 was estimated to be 3 388 tonnes, slightly lower than the total catch of 3 544 tonnes reported for 2021. Recreational fisheries are not considered to be significant (Mitchell, Vanberg and Sipponen, 2010), although Embke *et al.* (2022) estimate that there are 3 100 fishers who catch around 15 tonnes annually, of which over half is consumed.

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Greece

Greece has inland water resources of 3 060 km^2, with 80 percent of river flow coming from the catchment area of eight large rivers There are 39 natural lakes with a combined area of 568 km^2 and 21 artificial lakes or reservoirs occupying a total of 334 km^2. There are 378 wetlands with an area of 2 000 km^2 (Leonardos, 2016) The main lakes are located in the centre and north of Greece, and most of the estimated 70 lagoon capture fisheries are in the Messalonghi region of Central Greece. Greece has a relatively high diversity of inland water fish species, with a total of 177 species in 88 genera, 27 families and 15 orders recorded. Cyprinids represent the most dominant family with 86 species.

In 2011 there were an estimated 400 people employed in commercial fishing in inland waters (Ernst and Young, 2011). Of the main target species, six species contributed more than 90 percent of catches. The group of cyprinids including the common carp (*Cyprinus carpio*) and bleak (*Alburnus* spp.) comprised 52 percent of catches, followed by the common roach (*Rutilus rutilus*) at 19 percent and the Macedonian shad (*Alosa macedonica*), which made up almost 8 percent of catches. All other species contributed less than 3 percent each (Moutopoulos *et al.*, 2022). In 1996 approximately 57 percent of the inland catch volume came from coastal lagoons with the main species caught being seabream, seabass, eel, mullet, white bream and sole (Mitchell, Vanberg and Sipponen, 2010). These are classified as marine capture catch and not inland catch therefore are not reflected in the statistics provided by FAO. Recreational fisheries are also taking place in inland waters and there are an estimated 132 360 participating fishers.

Historically, inland fishery production rose between 1950 and the early 1960s, then declined – partly due to the effects of urbanization, migration and the drainage of lakes for agriculture. This was followed by an increase in production from 1970 to the 1980s with return of migrants and increase in fishing effort. During 1988 to 2009 fishing production declined again from about 3 903 tonnes to about 940 tonnes in 2009, due to a combination of ecosystem degradation, pollution, eutrophication, the extinction of several native species, and high fishing pressure associated with the commercial species (Moutopoulos *et al.*, 2022; Leonardos, 2016). Current catches from inland waters provided by FAO for 2021 remain at 940 tonnes.

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North Macedonia

Surface waters cover 477 km^2, that represent almost 2 percent of the territory. There are about 35 rivers as well as 53 natural and artificial lakes. The four main areas associated with inland fish and fisheries are Vardar, Crni Drim, Strumica and the area of Juzna Morava. Vardar includes the area around the River Vardar with its tributaries up to the border with Greece, including part of Lake Dojran. Within North Macedonia, the River Vardar has length of 301 km. The more important tributaries of the Vardar are the rivers Treska, Lepenec, Pcinja, Bregalnica, Crna and Bosava. Total catch from inland fisheries was 24 tonnes in 2021. There are estimated to be only about 4 260 recreational fishers fishing in inland waters who catch 18 tonnes, of which around 46 percent is retained for consumption (Embke *et al.*, 2022).

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Croatia

Croatia has 620 km^2 of inland waterbodies and 21 000 km of rivers and creeks. Commercial inland fishing in Croatia is confined to only the larger lowland rivers, including the Danube and the middle and lower stretches of the Sava River. Commercial fishing is not allowed in smaller waterbodies such as creeks, as well as in lakes, reservoirs or estuaries. The total number of commercial inland fisher licences is 36, however, some fishers will have more than one licence to enable them to fish in different locations. Common carp (*Cyprinus carpio*), other cyprinid species, catfish, pike and pike-perch are the most important species in the commercial catches.

In 2022 commercial inland catches in Croatia totalled 37.5 tonnes. The retained catch in recreational fisheries in 2022 was estimated to be 326 tonnes, so the total retained catch (both commercial and non-commercial) in 2022 totalled 363.5 tonnes. There are an estimated 42 000 recreational fishers in Croatia (just under 1 percent of the total population) who target inland fish such as common carp, grass carp and wels catfish. The number of recreational fishers has been increasing (Embke *et al.*, 2022; Treer, 2019). Competition for space and conflicts between recreational and commercial fisheries, may reduce the potential for maintaining a viable commercial inland fishery in the future (Jensen, 2021).

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Bosnia and Herzegovina

Quantitative information is unavailable on inland fisheries. Inland waterbodies occupy 470 km^2. Professional inland fisheries are carried out in the River Sava, but there are no professional fisheries in lakes, reservoirs or estuaries. There is some recreational fishing with an estimated 17 100 participants and catches of about 320 tonnes, of which an estimated 40 percent is consumed (Embke *et at*., 2022). FAO estimates total catch at 300 tonnes (2021).

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Portugal

The main aquatic environments for inland fisheries in Portugal include the Minho River, Douro, Tagus and Guadiana rivers, along with lakes and extensive reservoirs like Alqueva, the largest reservoir in Western Europe. These water bodies support an array of native species, such as the lampreys (Petromyzonidae), sturgeon (*Acipenser sturio*), European eel (*Anguilla anguilla*), Allis shad (*Alosa alosa*), Twaite shad (*A. fallax*), and brown trout (*Salmo trutta*). Additionally, exotic species introduced to enhance recreational fishing, like common carp (*Cyprinus carpio*), largemouth black bass (*Micropterus salmoides*), rainbow trout (*Oncorhynchus mykiss*), are now well-established and contribute significantly to the fishing activities (Antunes, Cobo and Arujo, 2016).

Commercial fishing within these inland waters, though smaller in scale with a production of 1 tonne in 2021 (FishStat, 2023) compared to Portugal's marine fisheries and are performed mainly in the lower stretches of the rivers. These fisheries focus on diadromous species such as eels and shad. The sea lamprey (*Petromyzon marinus*) is also caught commercially in the lower stretches of streams particularly in northern Portugal. Fishing techniques predominantly involve traditional methods such as nets and rod-and-line, targeting specific areas known for their abundant fish stocks. The production from these fisheries generally supplies local markets, playing a vital role in supporting rural economies and traditional livelihoods (Antunes, Cobo and Arujo, 2016).

Recreational fishing in Portugal's inland waters is a popular activity in the northern basins, with a participation rate of 1.2 percent participation with trout, zander (*Sander lucioperca*), barbel and black bass being targeted. Management of these fisheries is multifaceted, involving regulatory measures like fishing licenses, seasonal restrictions, and limits on catch sizes to ensure sustainable exploitation of fish populations. Environmental management efforts also include habitat restoration projects aimed at improving water quality and fish habitats, crucial for maintaining the health of river ecosystems and supporting biodiversity.

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Cyprus

Inland fisheries in Cyprus primarily in streams, the longest being the 100 km long Pedieos and numerous reservoirs, with the Asprokremmos Reservoir being one of the largest and most significant. Cyprus has some of the highest dam density in the world with more than 100 dams and 20 reservoirs constructed for agricultural purposes (Griffiths *et al.*, 2021; FAO, 2024). These fragmented bodies of water are home to both native species such as the Mediterranean killifish (*Aphanius fasciatus*) and the European Eel (*Anguilla Anguilla*) and introduced species like the rainbow trout (O*ncorhynchus mykiss*) and largemouth bass (*Micropterus salmoides*) that are the target of recreational fisheries (Griffiths *et al.*, 2021; Zogaris, 2012).

Commercial fishing within these inland waters is limited but focuses on species well-suited to reservoir environments, such as carp and trout and production is estimated to be 20 tonnes (FAO, 2023). Common fishing methods include netting and angling, primarily conducted in larger reservoirs where these species thrive. Management practices are in place to support sustainable fishing and ecological health, including habitat restoration and the regulation of fishing activities.

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Malta

There has been no inland fisheries catch reported to FAO.

7.5 THE AMERICAS

Subregion	Inland capture fisheries catch (tonnes in 2021)	% global inland capture fisheries catch	Population (2021)	Per capita inland fish production (kg/cap/year)
South America	341 936	3.01	434 250 356	0.38
Central America	165 821	1.46	177 661 928	1.08
Northern America	36 350	0.32	375 152 636	0.08
Islands of the Americas	5 078	0.04	36 653 273	0.11
TOTAL	**549 186**	**4.83**	**1 023 718 193**	**0.49**

7.5.1 South America

Country/territory	Inland capture fisheries catch (tonnes in 2021)	Percentage of global inland fish catch	Population (2021)	Per capita inland fish production (kg/cap/year)
Brazil	226 030	1.99	214 326 223	1.05
Venezuela (Bolivarian Republic of)	22 000	0.19	28 199 867	0.78
Colombia	21 068	0.19	51 516 562	0.41
Peru	18 237	0.16	33 715 471	0.54
Paraguay	17 560	0.15	6 703 799	2.62
Argentina	17 267	0.15	45 276 780	0.38
Uruguay	10 910	0.10	3 426 260	3.18
Bolivia (Plurinational State of)	7 600	0.07	12 079 472	0.63
Suriname	850	0.01	612 985	1.39

Country/territory	Inland capture fisheries catch (tonnes in 2021)	Percentage of global inland fish catch	Population (2021)	Per capita inland fish production (kg/cap/year)
Ecuador	391	0.00	17 797 737	0.02
Guyana	23	0.00	804 567	0.03
Chile	0	0.00	19 493 184	0.00
French Guiana	0	0.00	297 449	0.00

The South American subregion includes 13 countries and represents the most fluvial continent of the world, containing 22 percent of global inland waters (Lymer *et al.*, 2016). The subregion contains several major river basins that flow into the Atlantic Ocean, the majority of which are shared between several countries. These include: the Amazon (the Plurinational State of Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, and the Bolivarian Republic of Venezuela); Orinoco (Colombia and the Bolivarian Republic of Venezuela); and the Plata River and its tributaries (Argentina, the Plurinational State of Bolivia, Brazil, Paraguay and Uruguay). Other relevant basins are the Tocantins and São Francisco rivers (Brazil), the Magdalena (Colombia) and the Essequibo River (Guyana and the Bolivarian Republic of Venezuela).

The rivers of the subregion are traditionally divided into black, clear, and white water rivers, of which black and clear water rivers are nutrient-poor and have low productivity (Sioli, 1968). Some of the main rivers form important inner deltas (Orinoco and Paraná), or external ones (Amazon and Magdalena), and are characterized by a high sediment load. Rivers draining to the west and the Pacific, because of the presence of the Andes range, are generally rather short, torrential and deep mountain streams. These have high sediment loads that may lead to the formation of deltas. In the dry southern part many rivers become seasonal, and some basins are endorheic. There are a number of hydropower dams on the rivers and tributaries of the subregion, many of them located in the Paraná River basin, and associated with some of these are large reservoirs (Agostinho, Pelicice and Gomes, 2008).

Major natural lakes are found in the mountain ranges, many of which are endorheic systems. The largest is Lake Titicaca (shared between the Plurinational State of Bolivia and Peru), which with an area of 8 400 km^2, is considered the largest mountain lake in the world (Llames and Zagarese, 2009). Other lakes are found throughout the Altiplano and these are mostly of much smaller size. Many of these lakes are severely threatened by the drier and warmer climate that has been observed in recent years, including the Lake Poopó, the second-largest Bolivian lake, previously reaching an area of at least 2 492 km^2 and constituting an important fishing ground, which has now almost dried up completely (Satgé *et al.*, 2017). True lakes are very rare in the lowlands, although floodplain lakes are important features of all the major river basins.

The inland fishery catch of South America (341 936 tonnes in 2021) represents about 3 percent of the global total. Catches for the subregion are likely to be underestimated as monitoring and reporting focuses on the most significant landings from the main commercial markets (FAO, 2011). Small-scale fisheries together with the commercial fisheries catches in some major tributaries are likely underreported and may be considerable.

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Brazil

Brazil has some of the largest river basins in the world, with rivers of great flow. It is estimated that the area of inland waters occupies 158 000 km^2. According to Ruffino and Baigun (2023), the most prominent basins are the Amazon (3.9 million km^2), the Paraná (891 000 km^2), Tocantins (757 000 km^2), San Francisco (634 000 km^2), and Paraguay (369 000 km^2). In addition, Brazil has 660 hydroelectric dams (Agostinho, Gomes and Pelicice, 2007). Of these river basins, the Paraná is the most intensively dammed and comprises 70 percent of Brazilian reservoirs (Petrere *et al.*, 2007) where reservoirs of up to 4 000 km^2 have been formed.

Ruffino (2014) classified Amazon fisheries into subsistence fisheries, where the fisheries catch all types of species and are entirely food security oriented; monospecific commercial fisheries, where certain species, for example large catfish, are targeted, including for export; and multi-species commercial fisheries, which exploit migratory species, mainly characids. Although the basin has some large-scale fisheries using trawl gears (Fabré and Barthem, 2005), the majority of fishing is of the small-scale and subsistence varieties (Hallwass *et al.*, 2013). Migratory species represent 25 percent of the ichthyofauna in the Amazon Basin (Barthem and Goulding, 2007) and constitute 75 percent of commercial catches due to their high economic value (Ruffino, 2016). Large catfishes such as *Brachyplatystoma rousseauxii* can make reproductive migrations exceeding 4 000 km (Duponchelle *et al.* 2016). However, approximately 200 species of fish are caught for consumption within the Amazon Basin, reflecting the importance of multi-species fisheries (Barthem and Fabré, 2004). In the Pantanal, on the other hand, four groups of species are considered according to their commercial importance (Catella *et al.*, 2017).

Non-migratory species such as *Arapaima gigas* are notable for their importance for rural communities. These fish are caught exclusively during low waters within the lagoons of the alluvial plains (Castello, 2008). Where there are reservoirs, the dominant catches are typically composed of lacustrine species (Agostinho, Gomes and Pelicice 2017). The fishing gears used in Amazonian fisheries are varied, the most relevant being coastal trawls in the estuarine zone, gillnets and purse seines in the rivers, but also the rod and line, bow and arrow, hooks, and harpoons are the most used gears in the várzeas areas (Freitas, Batista and Inhamun, 2002).

For the country as a whole, an estimated 700 000 fishers are engaged in fishing, distributed mainly in the northern and northeastern regions of the country, with women accounting for 33 percent. Brazil's inland fishery production is estimated to be up to 260 000 tonnes, of which 57 percent corresponds to the northern sector (Amazon Basin) and 28 percent to the northeastern sector. The Amazon fisheries are the most productive in the country and comprise 42 percent of catches from the country's inland fisheries (Ruffino, 2016). In the Amazon basin, small-scale fisheries provide an occupation for around

200 000 people and a total estimated annual revenue of USD 200 million (Lopes *et al.*, 2016). Fishing is not only a rural occupation and landings in urban areas of the Central Amazon can also be important, consisting mainly of migratory characids, particularly Prochilodontidae (Batista and Petrere, 2003). Meanwhile silurids are more commonly fished in the ports of the lower basin, in the estuary (Barthem and Fabré, 2004) and in the upper Solimões (Petrere *et al.*, 2004). Commercial fishing is also recorded in the reservoirs of the Paraná Basin, with annual yields of less than 20 kg per hectare and 150 kg per hectare in the reservoirs of the northeast. These reservoirs are also supported through enhancement initiatives using non-indigenous species such as *Oreochromis* sp. (Agostinho *et al.* 2007). Across all the basins, annual fish consumption is estimated to be in the region of 575 000 tonnes (Isaac and Almeida, 2011), 40 percent of this occurring within the Amazon Basin (Ruffino, 2016). Within the Amazon basin, the average annual per capita consumption varies with location from between 42 and 144 kg in rural populations to between 31 and 55 kg for urban populations (Ruffino, 2016).

Recreational (sport) fishing is an activity of growing importance due to the economic returns it can generate, but also due to its potential impact on fish stocks as well as competition and conflict, particularly with small-scale fishers (Chiaravalloti, 2017; Freire *et al.*, 2016). Freire (2012) suggested that recreational fishing could generate USD 154 million in annual benefits and estimated the existence of 220 000 recreational fishers throughout Brazil. More recent estimates by Embke *et al.* (2022) suggest that the number of recreational fishers could be as high as 1.88 million with an estimated annual catch of 7 920 tonnes, of which 38 percent is consumed. The most important area for recreational fisheries is in the Paraguay Basin, where an estimated 46 000 fishers generate an annual turnover of USD 35–56 million (Shrestha, Seidl and Moraes, 2002). In the Paraná Basin, recreational fishing is focused on the reservoirs and main channels (Agostinho *et al.*, 2003). Fishing in the upper Paraná Basin is estimated to annually generate USD 305–570 million and employ more than 4 000 people (Freire *et al.*, 2016). Ornamental fishing can also be an important economic activity in the Amazon Basin providing livelihood opportunities for around 10 000 people (Chao, 1993) who target around 60 different species (Beltrão dos Anjos *et al.*, 2009). Between 2002 and 2005, around 100 million ornamental fish were exported representing USD 1.5 million revenue for local markets and USD 9.6 million nationally.

Fisheries management in the Amazon basin is based on catch statistics available at different landing sites, although these records have been discontinued since 2015 (FAO, 2023). There is federal legislation in Brazil, as well as legislation in some states, but regulations have important limitations to manage subsistence fishing (Isaac, Rocha and Mota, 1993). Management measures are a mix of output, input and enhancement measures, and include catch and size limits, closed seasons, gear regulation and stocking. Management takes different forms and in some parts of the Amazon Basin, successful fishing agreements have been developed to support community-based co-management of local fisheries in lakes (*varzeas*) within floodplain areas (Ruffino, 2014; Castro and McGrath, 2003).

The construction of dams and their associated reservoirs is possibly the main factor threatening fisheries in Brazilian watersheds (Agostinho, Gomes and Pelicice, 2007). For the entire Amazon Basin, about 260 dams are planned (Latrubesse *et al.*, 2017) and 115 dams are expected to be added in the upper reaches of the Paraguay basin (ANA, 2018) Water pollution and bioaccumulation of pollutants resulting from mining activities (Nogueira *et al.* 2010), an increase in fishing effort within and close to urban centers (Petrere *et al.*, 2004), and non-indigenous fish introductions represents additional threats.

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The Bolivarian Republic of Venezuela

The Bolivarian Republic of Venezuela has large basins that flow into the Atlantic (such as the Orinoco and Cuyuní rivers) as well as into the Amazon (Negro River), or that are proximal to the Caribbean (e.g. Lake Maracaibo and the endorheic basin of Lake Valencia), see for example Machado-Allison and Bottini, 2023. There is high fish biodiversity and, of the 1 000 species present in the Orinoco basin, around 60 are important for both commercial and subsistence fishing as well as consumption for the rural and Indigenous Peoples of the basin (Machado-Allison and Bottini, 2010).

Reflecting the diversity of species and environments, fishing is carried out with gears including gillnets, beach trawls and longlines, which are used to catch coporo (*Prochilodus mariae*), morocoto (*Piaractus orinoquensis*), palometa (*Mylossoma albiscopum*) and zapoara (*Semaprochilodus laticeps*). Longline, bottom spinner gears and single hook lines are used to catch large catfish. The Indigenous Peoples in the Upper Orinoco and Delta have particular procedures for subsistence fishing, using traditional gears including traps, harpoons, and poisons (*barbasco*) to catch small- to medium-sized species such as *Piaractus orinoquensis*, *Curimata* spp., *Semaprochilodus kneri*, *Ageneiosus* spp., *Hypostomus plecostomus*, or *Liposarcus multiradiatus* (Royero, 1993). In the Apure River system, the most important gears are trammel nets, gillnets, hooks, trawls, and *atarraya* (Barletta *et al.*, 2016). The total number of registered fishers in the different basins amounts to approximately 10 000 people (INSOSPESCA, 2014).

The Bolivarian Republic of Venezuela provided fish landing data to FAO (2021) up to 2016, from which production could be estimated. Average annual fish production is estimated to be in the range of 50 000 tonnes (Machado-Allison and Bottini, 2010) to 79 000 tonnes (Lewis *et al*,. 2001), with figures reported to FAO of less than half of this – at 22 000 tonnes. Among the characids that have historically represented almost 50 percent of the catch, *Colossoma macropomum*, *Mylossoma albiscopum*, *Prochilodus mariae* and *Piaractus orinoquensis* stand out for their contributions (Machado-Allison and Bottini, 2010). Overall, large catfish made up around 21 percent of the volume captured, with *Pseudoplatystoma orinocoense* being the most important species, but exhibiting a decreasing trend. Petrere (2009) estimated a potential annual fish production of 422 920 tonnes, higher than the official catches recorded and suggesting that fishing pressure, with the exception of some preferred species such as *Colossoma macropomum* and some migratory catfish, may not be high.

The support infrastructure for fish marketing in the different basins is considered poor or even non-existent (MPPAT, 2007; FAO, 2005), making it difficult to obtain information on processing and trading activities. Traditionally, fish is sold as fresh (gutted or whole) or preserved in brine (salted). Some 75 percent of fish is sold through intermediaries (*caveros*) and many local markets sell fish that do not conform to regulatory sizes (INSOPESCA, 2012). Small-scale fisheries, including subsistence fishing, are important components of livelihood strategies, with those of the Orinoco River being the most important in terms of both volume and economic value. Based on surveys in 2005, the number of fishing communities identified in the Orinoco and Apure River systems was 223, representing 2 721 fishers (FAO, 2005). Lasso and Sánchez-Duarte (2011) noted that among certain peoples in the Amazon Basin, consumption can be fairly high, with per capita daily consumption of 83–163 g (average 123 g) – equivalent to 44.7 kg annually.

Other types of fishing include recreational and ornamental fisheries. Recreational fisheries are based on about 15 species (Machado-Allison, 2005). These fisheries can be organized, with the largest national recreational fishing tournaments taking place at the Guri and Caruachi dams, mainly targeting *Cichla* spp. Other target species include large catfish (Rodríguez *et al.*, 2007). The capture of fish for ornamental purposes can be significant and represents 90 percent of the species that are exported (Cabrera, 2005). Lasso *et al.* (2013) also report that the capture of fish for ornamental purposes represents 70 percent of the catch in some rivers, surpassing the catches of fish for consumption. The legal framework for inland fisheries has promoted the strengthening and consolidation of national fisheries and aquaculture councils and other organizational bodies (Bottini, 2009). There are social and economic assistance programs for fisher communities at the national level, implemented through the fisheries administration. There are currently no documented successful examples of co-management.

There are a number of pressures on aquatic environments with a growing deterioration of water quality (Arco Minero del Orinoco) due to the use of mercury in the process of extracting gold in gold mining activities (Machado-Allison, 2017; Trujillo *et al.*, 2010; Lasso and Pérez, 2006). This affects not only biodiversity but also increases the risk of consumption of contaminated fish amongst Indigenous Peoples and rural populations (Machado-Allison, 2017). In the Orinoco Delta area, Lasso and Sánchez-Duarte (2011) mention other threats, including dredging, oil activities, shrimp trawling and mangrove deforestation. Commercial fisheries are considered problematic for several species (Velásquez *et al.*, 2018; INSOPESCA, 2012). This includes indiscriminate fishing during the reproductive migrations of *cachama* and *morocoto* (Petrere, 2009). The presence of dams in the upper Orinoco Basin has also affected migratory species (Velásquez, Castillo and Villegas, 2018; Barbarino Duque, Taphorn and Winemiller, 1998; Lilyestrom and Taphorn, 1980).

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Colombia

Colombia has five basins of particular relevance to inland fisheries: the Caribbean, Magdalena, Orinoco, Amazon, and Pacific (Jiménez-Segura *et al.,* 2023). Some 27 percent of the total area of the country are wetlands. According to Jaramillo-Villa, Cortés-Duque and Flórez (2015), most of these are found in the Orinoco basin (14 million ha), followed by the Magdalena-Cauca (5.7 million ha) and the Amazon (6.2 million ha). Fish biodiversity is high and for the Amazon and Orinoco basins, approximately 170 species have been recorded being caught for consumption (Lasso *et al.*, 2011a, 2011b). In the Caribbean Basin the numbers are lower, with about 60 species are caught, although this basin is the one that has historically contributed most to national production.

The most productive fishing basin in terms of biomass is the Magdalena River and the most diverse fishery is located in the Amazon Basin, followed by the Orinoco, Caribbean, and Pacific basins and is mainly focused on potamodromous species (Olaya-Rodríguez *et al.*, 2017; Lasso *et al.*, 2011c). Different types of fishing gears are used including trawl nets (*chinchorros*), *atarraya*, gill nets, longlines, traps, harpoons, and arrows. The historical peak production was recorded in 1972 with 82 787 tonnes, which began to decrease in 1987 and has since stabilized at around 20 000 tonnes.

Historically, the Magdalena-Cauca River Basin represents between 50 and 70 percent of the annual landings, reaching approximately 40 000 tonnes but this has declined to below 15 000 tonnes. In the Orinoco Basin, annual landings are much less and for the period 1995–2009 were estimated to be between 1 024 tonnes and 7 742 tonnes (Ramírez-Gil and Ajiaco-Martínez, 2011), while the estimated production in the area of Leticia in the Colombian Amazon is 5 500 tonnes per year and approximately 200 species are caught, mainly by small-scale fishers for subsistence (Gutiérrez-Bonilla and Barreto, 2019). Fishing in this region involves some 10 000 rural fishers and typically one person from each household fishes for subsistence. Fish consumption reflects this, with an average annual per capita consumption of 26 kg, compared to the national average of 6 kg (Agudelo *et al.*, 2011).

Fish remain a fundamental part of the diet of the Amazonian riparian population, where daily per capita fish consumption ranges from 170 g to 500 g (Sirén, 2021; Rodríguez, 2010). Elsewhere, fish production in reservoirs is sustained by the stocking of species such as common carp (*Cyprinus carpio*), Nile tilapia (*Oreochromis niloticus*), rainbow trout (*Oncorhynchus mykiss*) and largemouth bass (*Micropterus salmoides*) and therefore dependent on non-indigenous species (López-Sánchez *et al.*, 2018; Jiménez-Segura *et al.*, 2011). Documentation is not always available but based on continuous records between 2000 and 2009, the Urrá reservoir had annual production of around 100 tonnes of native species.

The number of small-scale fishers nationally is close to 150 000, of which 74 percent carry out the activity permanently and 23 percent occasionally (Gutiérrez-Bonilla and Barreto, 2019). There is little in the way of post-harvest processing, except when filleted for sale in supermarkets (typically Pimelodidae species). In general, three to four stages have been identified in fisheries value chains and distribution networks in the different basins, with much of the fish produced transported to intermediate cities and departmental capitals.

There are an estimated 433 000 recreational fishers in Colombia and recreational fishing is widely practiced across almost the entire national territory, though the basins where it is most concentrated are the Amazon and the Orinoco. In these locations, fishing targets around 40 species, including *Osteoglossum bicirrhosum*, the large catfishes of the genus *Brachyplatystoma*, *Colossoma macropomum*, and *Piaractus* spp. In the Magdalena-Cauca Basin, 28 species have been identified in catches (Lasso *et al.*, 2019) and the most coveted target species are *Brycon moorei* and *Salminus affinis*. Fishing in reservoirs will target non-indigenous species such as *Oncorhynchus mykiss* and *Micropterus salmoides*. The total recreational catch is estimated to be 3 357 tonnes, of which 40 percent on average is retained (Embke *et al.*, 2022).

Ornamental fish fisheries are also of note and target between 300 and 400 species (Ortega-Lara, 2015). This includes a rane of species, including various silurids and characids, with fishing mainly carried out in the Orinoco and Amazon basins where between 80 percent and 85 percent of the total is caught, but also in the MagdalenaCauca and Atrato basins (Ajiaco-Martínez *et al.*, 2012; Gutiérrez-Bonilla, 2011a, 2011b).

Fisheries and aquaculture management is the responsibility of the National Aquaculture and Fisheries Authority (AUNAP). The fisheries authority has made efforts to monitor the country's fish landings and follow up on landings in 108 ports. Fisheries management includes regulations associated with minimum catch sizes, fishing restriction areas, prohibited fishing methods, and fishing closures. Recently, fishing agreements have been promoted as part of collective construction processes involving Colombian state entities as well as fishers and inhabitants of the regions.

Impacts and threats to fishing are linked principally to modifications in land use, reduced connectivity, reduction of flooded areas, blockage of migration routes, and spawning areas caused by reservoirs (Lasso *et al.*, 2014). There are currently 18 works built or under development in the river basins to generate hydroelectricity (Palacios Sierra, 2017), with plans to double the installed capacity by 2027 with the construction of nearly 200 new reservoirs (Jiménez-Segura *et al.*, 2011). Other impacts come from pollution, regulation of the flow regime, overfishing, and introduction of non-indigenous species (Alvarez-Leon, GutiérrezBonilla and Rodríguez-Forero, 2002).

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Peru

Peru's fisheries are found on the Pacific slopes, in the Andean region and in Amazonia (Cañas *et al.*, 2023). The Pacific rivers have short courses and are generally torrential, with irregular flows – high floods in summer and practically dry in winter – making them of little relevance to fisheries. The main fishing environment in the Andean region is Lake Titicaca, with a surface area of 8 562 km², that is shared with the Plurinational State of Bolivia and of which 56 percent (4 772 km²) belongs to Peru. There are numerous rivers in the Amazon Basin, which together contribute more than 22 percent of the freshwater that the Amazon River discharges into the Atlantic Ocean (Goulding *et al.*, 2003).

The Amazon is the main fishing area and fishing activity is supported by at least 80 identified species that are exploited for human consumption, either subsistence or commercial (Ortega *et al.*, 2012). The most important fishing areas or regions are Loreto, Ucayali and Madre de Dios.The fishery is based on the capture of several species among which, those that stand out are: *Prochilodus nigricans*, *Potamorhina altamazonica*, *Mylossoma albiscopum* and *Mylossoma aureum*, *Hypophthalmus* spp., *Arapaima gigas*, *Colossoma macropomum*, *Brachyplatystoma rousseauxii, Pseudoplatystoma* spp., *Zungaro zungaro*, and *Piaractus brachypomus* (Mateussi*, Oliveira and Pavanelli*2018). In the lower Amazon, fisheries are artisanal, seasonal, dispersed and multi–geared (Zorrilla *et al.*, 2016; Tello and Bayley, 2001). The black prochilodus (*Prochilodus nigricans*) represents almost 30 percent of the total annual catch and, together with *Potamorhina altamazonica* and *Psectrogaster* sp., constitutes almost 55 percent of the total catch (Ortega *et al.*, 2012). Fisheries based on *Rhamdia*, *Astyanax*, *Chaetostoma* and *Ancistrus* genera, as well as medium to larger migratory fish such as the shovelnose catfish (including *Pseudoplatystoma punctifer* and *Pseudoplatystoma fasciatum*), take place in the upper rainforest region.

Fishing activity in the Amazon region stands out as a subsistence strategy during the dry season, directly associated with the phenomenon known as *mijano* (migration of large schools of fish), given that fisheries in this region are sustained by highly migratory species. In the Andean region, the main fishing activity is in Lake Titicaca and fishing is based on both native species (*Orestias* spp.) and non-indigenous species such as the rainbow trout (*Oncorhynchus mykiss*) and pejerry (*Odonthestes bonariensis*). In the Andean region, fishing is of low importance and is limited to smaller characid and catfish species including *Brycon atrocaudatus, Brycon atrocaudatus, Chaetostoma bifurcum*, *Trichomycterus punctulatus* and *Chinchaysuyoa ortegai* (Ortega *et al.* 2012).

Fisheries statistics from the Ministry of Production are the only statistics provided for the Peruvian Amazon and only record commercial fishing in the regions of Loreto, Ucayali and Madre de Dios, with Loreto and Ucayali accounting for 50 percent and 17 percent, respectively, of production (PRODUCE, 2022). Sirén (2021) estimated catches in the Peruvian jungle zone at 87 000 tonnes (2015–2019), of which subsistence fishing contributed around 49 percent. Official estimates show that for the 2005–2021 period, total inland fish catches varied between 44 259 tonnes and 89 684 tonnes. This is close to the estimates of Bayley *et al.* (1992), who calculated annual catches of 80 000 tonnes per year. Sirén (2021), for his part, concluded that the total annual catch in the Peruvian Amazon could reach 117 000 tonnes, including 91 000 tonnes in the subsistence fisheries and 26 000 tonnes of commercial catches. These official fishery values are well above those reported in FishStat (18 237 in 2021). This is potentially due to the fact that the latter does not include all fishing regions of Peru and possibly not all fish–processing variants, including fresh, salted and driedsalted categories. For their part, catches in the Titicaca region show a marked decline since 1995, from which time onwards they have been sustained at levels equal to or less than 2 000 tonnes per year. PRODUCE (2018) indicates that the Peruvian provinces with the highest annual per capita fish consumption are Loreto and Ucayali at 45.9 and 34.9 kg, respectively. Valbo-Jørgensen *et al.* (2008) found an average of 25 kg, but with values of up to 140 kg, which reveals the importance of inland fisheries in parts of Peru. According to Sirén (2021), average daily per capita consumption is higher in rural areas than in urban areas, at an estimated 0.22 kg.

In addition to fish for consumption, ornamental fish fisheries also play important roles. These fisheries have developed mainly in the Iquitos area, from which about 300 species are exported. The species most in demand are the silver arowana (*Osteoglossum bicirrhosum*) and river stingray (*Potamotrygon motoro*) and the main family of ornamental fish exported are the Loricariidae catfish (Ortiz and Iannacone, 2008). By 1994, it was estimated that 17 million fish were exported annually (Valbo-Jørgensen *et al.*, 2008). It has been estimated that exports employ 3 000 families and involve overall close to 100 000 people (Gerstner *et al.*, 2006; SannaKaisa and Jukka, 2004).

In the Peruvian Amazon there are a set of regulations that seek to manage fishing activities and promote sustainable development. In the Madre de Dios Basin, "Fishing Management Units" have been implemented, where specific management measures are applied according to the characteristics of the fisheries in each region (Cañas, 2013). The Pacaya Samiria reserve program includes three communities with co-managed fisheries (Del Aguila, Tang and Piana, 2003).

In the Madre de Dios River Basin in southeastern Peru, the main threats causing the current degradation of aquatic systems are accelerated deforestation, the advance of the agricultural frontier and informal mining (Cañas, 2013). In Loreto, signs of the effects of high levels of fishing pressure have been identified (De Jesús and Kohler, 2004; García *et al.*, 2009) and several dams are planned for the Marañón and Ucayali basins. There are also plans to promote the development of a waterway in the department of Loreto, which includes the Amazon, Ucayali and Marañón rivers. In the Altiplano environments such as Lake Titicaca, fish populations can be affected by fishing as well as the introduction of non-indigenous species such as *Odontesthes bonariensis* and *Oncorhynchus mykiss* (Ortega *et al.*, 2012).

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Paraguay

Paraguay has 15 river basins and 22 wetland regions, six of which have been recognized as Ramsar sites. Some 25 percent of the surface area of the country is covered by permanent wetlands. The main rivers associated with inland fisheries are the Pilcomayo (835 km long), Paraguay (1 265 km long), and Paraná (689 km long), which make up the Río de la Plata Basin (Ríos-Morínigo, 2023). In addition, there are several inland rivers used for subsistence, commercial, and recreational fishing in the eastern region. Among the reservoirs, the Itaipú reservoir stands out with 1 350 km², shared with Brazil, and the Yacyretá reservoir covering 1 600 km², that is shared with Argentina. The most important inland reservoirs with fisheries are Acaray (60 km²) and Yguazú (620 km²), respectively. In terms of fish biodiversity, there are 99 recorded fish species in Paraguay that important in the fisheries.

In the Paraguay and Paraná Rivers, 80 percent of the catch is made up of large species such as dorado (*Salminus brasiliensis*), pacu (*Piaractus mesopotamicus*), boga (*Leporinus elongatus*), sabalo (*Prochilodus lineatus*) and various catfish (*Pimelodus* spp.). The most commonly used gears are drift nets (*mallón*), and longlines. In the Pilcomayo River the largest catches correspond to sabalo, and fishing for subsistence purposes using beach trawls and scissor nets to catch them. There are no specific authorized landing ports and fishing is also practised informally in and around the most important cities (FAO, 2005).

According to Albiol Flores (2007), fishing in Paraguay involves around 9 000 people, distributed among almost 4 000 households that depend on this activity for their livelihoods. Espinach Ros *et al.* (1991) estimated that there were 1 000 fishers in 1982 but that this had increased to 2 800 in 1990 and to 5 700 full-time fishers in 2007 (MADS, 2007). In turn, Yanosky (2009) notes that around 15 000 people are engaged in fisheries, of which 7 064 are registered as professional fishers and around 8 000 are recreational fishers. CIC Plata (2016a) mentions a similar total figure of 13 000 fishers in 2009.

Paraguay does not have an organized system for obtaining fishery statistics, and catches by commercial fishers are recorded through the collectors, who in turn transmit them to the Secretariat of the Environment (SEAM). Reports to FAO indicate consistent catches of about 17 000 tonnes since 2010 (17 560 in 2021). Espinach Ros *et al.* (1991) estimated the annual production of the Paraguay River and its floodplains at between 12 000 and 26 000 tonnes, suggesting an expansion potential of between 17 000 and 65 000 tonnes. Reflecting the value of the fisheries, the Paraguay and Paraná rivers are the object of intense commercial fishing, partly for domestic consumption and partly for the foreign market. In most cases commercial supply is based on direct sale or to wholesalers through intermediaries operating in fishing ports. Approximately 50 percent of fish production is destined for domestic consumption. There are several estimates of annual per capita fish consumption ranging from 3.7 kg to 6.3 kg (e.g. Albiol Flores, 2007). There are other fisheries and the number of recreational fishers has grown steadily to about 8 000 (FAO, 2005). CIC Plata (2016b) recognizes a total of 19 species of sporting interest in the Paraná River. In addition to the recreational fisheries there are also fisheries for ornamental fish. The latter is an aspect on which there is little information despite the apparent importance of fishing for ornamental purposes. In the Paraná River, 52 species have been identified that are targeted for the ornamental fisheries (CIC Plata, 2016b).

The management of inland fisheries is challenging given the nature of the fisheries and the little or no participation of the different social actors in decision-making, and the absence of reliable catch statistics. While management is centralized, the commercial fishers distributed in different localities in the country are organized in local guilds (SEAM, 2016). *Secretaría del Ambiente* (SEAM) is the national authority responsible for regulating Paraguayan fisheries and its responsibilities include obtaining information on artisanal and recreational fisheries. The binational entities Itaipú and Yacyretá managing these reservoirs also collect information in the basins where these dams are located. One of the usual management activities consists of restocking native species in the Itaipú and Yacyretá reservoirs. Paraguay has bilateral agreements with Argentina through the Comisión Mixta Argentino Paraguay del río Paraná (COMIP) and with Brazil in waters under shared jurisdiction for fisheries management.

The formation of the Itaipu and Yacyereta reservoirs has led to a reduction in migratory species, which have been replaced by other species of less commercial value (Roa *et al.*, 2002). Other threats to the fisheries are urban and industrial water pollution and an increase in navigation and associated infrastructure works, due to the development of the Paraná-Paraguay waterway (Göttgens *et al.*, 2001; Hamilton, 1999).

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Argentina

Inland artisanal fisheries in Argentina are almost entirely concentrated in the large rivers of the lower La Plata basin, which provides 90 percent of the catch (Baigún, 2015). The main rivers where fishing is practiced are the Paraná, Paraguay, and Uruguay, Bermejo and Pilcomayo. In the Paraná Basin the Yacyreta reservoir is of particular note (1 000 km^2), and in the Uruguay basin the Salto Grande reservoir (745 km^2), where artisanal fisheries are developed. Other occasional or seasonal fisheries take place in large shallow lakes in the Pampas region. Furthermore, in the Patagonian region some small-scale fisheries operate discontinuously in lakes Cardiel (370 km^2) and Musters (342 km^2) (Baigún, 2023).

Fishing communities in the rivers of the La Plata Basin are organized into full-time or part-time fishers for whom fishing is a way of life. It is estimated that this activity is practiced in the Paraná-Paraguay corridor by between 7 000 and 10 000 fishers (GEF Project, 2015), but this figure may underestimate the scale of the activities and the real number is possibly double this estimate. In the Bermejo and Pilcomayo fishing is more subsistence-oriented, but there is no census or estimate available of the number of fishers. Small-scale fisheries are typically multi-species, targeting around 20 species. The majority of species targeted are migratory characid and silurid species of medium to large size. Among them is the sabalo (*Prochilodus lineatus*), which in certain parts of the Parana Basin is caught for export (Baigún *et al.*, 2013). These fisheries are mainly regulated by flood and drought cycles that influence the catch levels (Rabuffeti *et al.*, 2016).

In the Bermejo and Pilcomayo rivers, fisheries are targeting mainly sabalo and the fisheries are strongly seasonal, with production associated with the hydrological regime (Stassen *et al.*, 2010). In some of the shallow lakes in central-eastern Argentina the fish assemblages are different, and artisanal fisheries target species like pejerrey (*Odontesthes bonariensis*) (Baigún and Delfino, 2002) and in Patagonia rainbow trout (*Oncorhynchus mykiss*), perca (*Percychtys trucha*) and pejerrey patagonico (*Odontesthes hatcheri*). Fishing methods also differ and in large rivers, fishing is practiced with gillnets that are set in the main channel of the rivers and are also used together with longlines in the lagoons that form within the floodplain. In the Bermejo and Pilcomayo rivers, fishing is practiced by Indigenous Peoples who use traditional gears including scissor nets and *atarraya*, and in some places, purse seines are used (Baigún and Salazar, 2019).

Commercial fishing catch data in Argentina were collected in the past by the National Directorate of Inland Fisheries until 1987, and since that date only information based on exported species, mainly on sabalo, has been available. Based on these data, annual production peaked at almost 40 000 tonnes in 2004, and since 2006 it has fluctuated between 10 000 and 20 000 tonnes, standing at 17 267 tonnes for 2021. Export of sabalo represents 74 percent of the volume marketed through cold storage plants in the central and southern sectors of the Paraná Basin, with 24 percent directed to domestic markets (Álvarez *et al.*, 2017). There are no statistics on freshwater fish consumption, but in the rivers of the La Plata Basin, it is estimated at least 5 000 tonnes annually, with average annual per capita consumption not exceeding 5 kg.

Recreational fishing has become an important part of inland fisheries in Argentina, with the country having one of the highest recreational fishing catch rates in the world (Embke *et al.*, 2022). In Patagonia, Nyboer *et al.* (2022) estimated a total of 14 000 anglers per year who fish for resident salmonids, and anadromous species in a few rivers (Baigunet *et al.*, 2022). In the Pampean lakes and reservoirs of the center, west and north, the pejerrey dominates the recreational fisheries, while in the Parana, Uruguay, and Paraguay rivers the main target species are characids such as dorado (*Salminus brasiliensis*), pacu (*Piaractus mesopotamicus*), boga (*Megaleporinus obtusidens*) and large silurids such as the surubi (*Pseudoplatystoma* spp.), manguruyu (*Zungaro jahu*), and pati (*Luciopimelodus pati*). López *et al.* (2001) estimated a total participation in the region of 1.1 million recreational fishers, while Baigún and Delfino (2001) and Nyboer *et al.* (2022) estimated 1.5 million and 1.35 million respectively, which again indicates the importance of these fisheries. For the reservoirs in central and northern Argentina, Nyboer *et al.* (2022) estimate a total of 243 000 fishers participating annually. The economic movement of this activity in the country is estimated to be in the region of USD 37–47 million and it can also contribute to food security, with an estimated 47 percent of the recreational catch consumed (Embke *et al.*, 2022). Fishing for ornamental fish is another important strand of inland fisheries, with fishing taking place in the various wetlands of the La Plata Basin. The economic value of these ornamental fish fisheries has not yet been assessed.

Fisheries management in can be considered strongly centralized and top-down, with little participation from the different actors in decisions and little development of governance mechanisms (Baigún *et al.*, 2016) or investment (Castillo *et al.*, 2023). In the La Plata Basin, the greatest threats to inland fisheries are detected in the lower Paraná Delta, where the lagoons in the flood valley are impacted by increasing livestock, agricultural, aquaculture, forestry and urban development (Baigún *et al.*, 2008). Urban and industrial pollution is also an issue in some areas. The impacts of the Santa Fe waterway have also partly altered the functioning of fisheries on the main channel (Baigún and Minotti, 2021).

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Uruguay

The main inland fisheries are concentrated in the basin of the lower Uruguay River and the upper Río de la Plata, where fish stocks are shared with Argentina, and in the reservoirs of the Negro River, the main tributary of the Uruguay River on its right bank (Crossa, 2023). For the whole country, the National Directorate of Aquatic Resources (DINARA) has defined 12 zones based on their fisheries characteristics. These zones include rivers and reservoirs, two of which are large (Salto Grande, shared with Argentina, and Rincón del Bonete). The main species targeted by the fisheries for both local consumption and trade include characids such as dorado (*Salminus brasiliensis*), boga (*Megaleporinus obtusidens*), tararira (*Hoplias aff. malabaricus*, *Hoplias australis* and *Hoplias lacerdae*) and, to a lesser extent, sabalo (*Prochilodus lineatus*). Also targeted are silurid catfish such as painted surubí (*Pseudoplatystoma corruscans*), brindled surubí (*Pseudoplatystoma fasciatum*), pati (*Luciopimelodus pati*), manguruyú (*Zungaro jahu*), manduvi (*Ageneiosus militaris*), yellow catfish (*Pimelodus maculatus*), white catfish (*Pimelodus albicans*), black catfish (*Rhamdia quelen*), common armado (*Oxydoras kneri*) and armado chancho (*Pterodoras granulosus*). In the reservoirs of the Negro River it is common to catch tararira and silversides (*Odontesthes* spp.), but for export the main target species are sabalo, bogas, catfish, tarariras and dorado.

In the Uruguay and Negro rivers, fishing is practiced with gill nets and spinner nets. The use of purse seines is common in the lower stretches of the lower Uruguay River. In the Río de la Plata there are several fisheries mainly targeting *Plotosus lineatus* and *Megaleporinus obtusidens* that use gillnets. In 2010, approximately 1 250 fishers worked full or part time in the fisheries, a number that would increase to 3 750 people if indirect employment were also taken into account. Outside of the rivers, DINARA (2020) has estimated that the fisheries include the participation of about 253 fishers.

Fishery information or statistics are based on export values and catch data provided in the fishing records submitted by fishers (fishing reports). There has been an increase in fishing since 2008, and information provided to FAO with 2017 catches of up to almost 7 000 tonnes and the most recent report of 10 910 tonnes in 2021. Catches traded annually on the domestic market have be estimated at about 583 tonnes. In general, fishers are self-employed and sell to local wholesalers who in turn either supply fish processing plants or sell directly to frontier markets. The main export species has been *P. lineatus* (48 451 tonnes equivalent to a value of USD 9 million). The higher volume of fish exported over those reported to DINARA for landings would suggest that fish catches are underestimated and there may be fisheries that are not addressed in the current data collection system.

Per capita annual fish consumption in Uruguay was estimated at 9.3 kg in 2014 (FAO, 2019). In many lowerincome localities along the Uruguay River or on the outskirts of some cities, fish plays an important role in providing protein and generating money to meet basic needs. There is some recreational fishing that is particularly important in the Uruguay and Negro rivers, where the activities and interests compete with small-scale fisheries, particularly in relation to the larger species.

For inland fisheries, DINARA is responsible for the guidance, promotion and development of activities related to the responsible use in fisheries and aquaculture, as well as the conservation of ecosystems. The new Fisheries Law was approved in 2014, but is not yet fully implemented. The law provides a broad regulatory framework, collating provisions that were scattered in the previous fisheries regulation, and addressing the sustainable and responsible development of fisheries and aquaculture. The new law focuses particularly on small-scale fisheries, zonal management and types of vessels as the basis for management measures. The law also seeks to support and promote fisheries co-management through the creation of Fisheries Advisory Councils. However, management is still centralized and there are still numerous administrative obstacles that currently act as obstacles to greater participation and to co-management in practice. The realization of management in shared areas also differs – in the area bordering Argentina regulations for the use of shared stocks are joint, while for the Merín Lagoon (shared with Brazil) each country's regulations apply.

New forms of land use in some river basins seem to have an impact on fisheries. The growth of agricultural activity has particularly increased the problem of agrotoxin concentration in aquatic systems, which has been perceived in the basin of the Uruguay River, the Negro River and the basin of the Merín Lagoon (Achlar *et al.*, 2006). Similar to experiences elsewhere in the region, the Salto Grande dam has been identified as a factor in the reduction of migratory species upstream.

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The Plurinational State of Bolivia

Artisanal fisheries in the Plurinational State of Bolivia are concentrated in the Amazon Basin, the Rio Platense Basin, and the endorheic basins that drain the Altiplano (Van Damme *et al.*, 2023). In the Amazon Basin, which has between 100 000 and 150 000 km^2 of wetlands that are seasonally or occasionally flooded (Crespo and Van Damme, 2011), the main rivers for inland fisheries – principally small-scale – are the Mamoré, Madre de Dios, Beni, and Iténez. In the La Plata Basin, which covers an area of 113 080 km^2 within Bolivian territory (Maldonado *et al.* 2019), the main rivers are the Bermejo and Pilcomayo, whose headwaters originate at an altitude of more than 4 000 m above sea level, in areas where there is mining activity. The aquatic environments of importance for inland fisheries in the Altiplano are Lake Titicaca (8 370 km^2), Lake Poopó (3 190 km^2), and Lake Uru Uru (114 km^2).

Carvajal-Vallejos *et al.* (2014) reported the presence of 790 native fish species and 12 non-indigenous fish species in the Bolivian Amazon Basin, but only about 40 species are targeted, including by small-scale commercial fishing (Carvajal-Vallejos *et al.*, 2011). In terms of catch composition, more than 80 percent of fish landings consist of migratory species (VanDamme *et al.*, 2011). Subsistence fishing for household consumption is carried out within numerous riverine communities throughout the Amazon and represents a key element and even the basis of their livelihoods. There is also a specialized fishery based on paiche (*Arapaima gigas*), which is an introduced species, in the Beni and Madre de Dios rivers (Van Damme *et al.*, 2015; Carvajal-Vallejos *et al.*, 2011) and that has invaded the Itenez and Mamore basins (Carvajal-Vallejos *et al.*, 2017a, 2017b). Most of the catches in the Amazon are made using gillnets that target large species such as *Pseudoplatystoma*, *Colossoma*, *Piaractus*, and medium-sized species. In the main channels of the rivers, hooks are also used to catch large catfish such as the muturo (*Zungaro zungaro*), general (*Phractocephalus hemioliopterus*), and dorado (*Brachyplatystoma rousseauxii* and *B. filamentosum*).

In the La Plata Basin, the presence of approximately 93 species of fish has been estimated (Maldonado *et al.*, 2019). The most emblematic and abundant species in the Bermejo and Pilcomayo River basins is the shad (*Prochilodus lineatus*), but it is also common to capture species such as bogas (*Leporinus obtusidens*, *Schizodon* sp.), pintado (*Pseudoplatystoma* sp.) and dorado de escamas (*Salminus brasiliensis*). For this purpose the *pollera* net (or *atarraya*), scissors net, spoon or codend, trawl net (or *chinchorro*) and traps are used (Baigún and Salazar, 2019). In the Altiplano region, the main native species with fishing importance are the ispis (*Orestias* spp.) and *Trichomycterus* and introduced species such as rainbow trout (*Oncorhynchus mykiss*) and silverside (*Odontesthes bonariensis*). All of them are caught with gillnets, hooks, *atarraya*, and *chinchorro* nets. It is also important to mention the important contribution of the *paiche* that provides around 12 percent of Amazonian catches (Carvajal-Vallejos *et al.*, 2017a, 2017b; Van Damme *et al.*, 2015).

Annual inland fisheries production for the country has been estimated at 11 000 to 12 000 tonnes (IPD PACU, 2016) although Barletta *et al.* (2016) mention that the total catch, including commercial and consumer catch, could reach 8 000 tonnes. This compares with the reported catches of 7 600 tonnes in FishStaJ for 2021. Allison (1998) estimated a fishing potential for the Bolivian Amazon of between 9 000 to 21 000 tonnes, while Van Damme *et al.* (2011), suggest that the potential is between 12 000 and 14 000 tonnes. In the Pilcomayo River Basin, it is estimated that approximately 400 tonnes is produced annually (Baigún and Salazar, 2019). In the Altiplano environments, IPD PACU (2016) estimated an annual catch of approximately 7 000 tonnes in Lake Titicaca and less than 300 tonnes in Lake Poopó.

An estimated 5 000 commercial fishers work full- or part-time in the small-scale fisheries throughout the country (IPD PACU, 2016). Wiefels (2019) estimated average annual per capita fish consumption in urban centers as between 2 kg and 5 kg, but that in Amazonian Indigenous Peoples, it would rise to between 15 kg and 80 kg (Camburn, 2011) and 40 to 60 kg in the Pilcomayo Basin (Pérez and Argote, 2019). There is some recreational fishing that is practiced mostly in the Iténez, Mamoré and other smaller rivers, but no specific data are available, nor are there statistics available concerning ornamental fishing.

At the national level, fishing is managed by the IPD PACU. The Plurinational State of Bolivia has a new Sustainable Fisheries and Aquaculture Law that is intended to improve the management of small-scale fisheries. In the Amazon Basin, the main threats are associated with deforestation in the headwaters, the advance of the agricultural frontier for cattle ranching and intensive agriculture, the development of hydroelectric dams, which are mostly located in the Andean headwaters (Anderson *et al.*, 2018), and gold mining in the upper basin of the Madre de Dios River. Despite supporting certain fisheries, the introduction of *paiche* as a non-indigenous species is also considered a threat (e.g. Van Damme *et al.*, 2015).

In the La Plata Basin, rivers are mainly affected by mining activity (Van de Ven *et al.*, 2019), deforestation (Maldonado *et al.*, 2019), and other changes in the lower basin that affect fish migrations (Baigún *et al.*, 2019). The large lakes of the Altiplano suffer from urban and industrial pollution, the reduction of water levels as a consequence of mining as well as watercourse diversions, salinization and desiccation, and the introduction of non-indigenous species (Pouilly *et al.*, 2014).

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Suriname

Suriname has seven major river systems, of which the Corantijn (67 600 km^2) and Marowijne (68 700 km^2) basins are the largest (Mol, 2012), with the Suriname (480 km long) and Saramacca (255 km long) rivers having important fisheries (Valbo-Jørgensen and Baigún, 2023). There are no real lakes in the country, with the largest body of water in the country being the Brokopondo reservoir (1 560 km^2) (Mol *et al.*, 2007). There is no documented description of inland fisheries, but there are an estimated 900 boats and canoes in inland waters, including estuaries. The main gears used in inland fisheries include gillnets, spinner nets, and beach trawls in lagoons. The target species in lagoons include *Megalops atlanticus*, *Oreochromis mossambicus* and ariid catfish while in rivers *Plagioscion surinamensis*, *Cichla ocellaris*, *Pseudoplatystoma* sp. and *Colossoma macropomum* are all important elements of the catches (FAO, 2019).

Suriname reported inland fisheries catches of 865 tonnes in 2016, the peak amount reported by the country, with a similar 2021 catch of 850 tonnes. Richter and Nijssen (1980) however estimated the annual potential production of the Brokopondo reservoir alone at 3 500 tonnes per year, very similar to the 3 000 to 4 000 tonnes estimated by FAO (1983), representing an average annual productivity of 23 kg per hectare. In addition to this, there are also several brackishwater lagoons that may have fisheries of some importance (Mol, 2012). In terms of employment and livelihoods, it has been estimated that inland fisheries provide between 1 000 and 1 200 jobs (FAO, 2019). Many of the fishers are from rural and very poor backgrounds and fishing plays an important role as part of overall livelihood strategies, typically being combined with local agricultural activities (Smith and Burkhardt, 2017). Apparent average annual per capita fish consumption is estimated to be around 16.5 kg (FAO, 2016), however this average figure does not reflect the variations in inland fish consumption that exist between populations that depend on inland fisheries (Mol, 2012).

Recreational fishing is a traditional activity, particularly in freshwater environments and there are almost no restrictions. For other fishing activities, fishing is authorized to be practiced in rivers – including their mouths (FAO, 2019). There is some licensing and the highest number of licences has been granted in the Suriname River, highlighting its importance as a fishery (Smith and Burkhardt, 2017).

Physical alteration, habitat loss, water extraction, pollution, and the introduction of non-indigenous species all represent threats to the freshwater fish fauna of Suriname. The construction of the Brokopondo Dam has had a major impact on the fish fauna of the middle Suriname River, with numerous local extinctions (Mol *et al.*, 2007). Another major threat is gold mining in the east of the country, which contaminates small jungle rivers and large rivers with mercury (Mol *et al.*, 2001). Mining also increases sediment input and modifies the fish assemblage (Mol and Ouboter, 2004). In some cases, contamination of fish with mercury or pesticides from fish farming is also a problem for fish consumption (Mol and Van der Lugt, 2004; Oosterveer and Van Ravenswaay, 2004).

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Ecuador

Ecuador is a country with a rich hydrographic network, including just over 2 000 rivers that originate in the Andes Mountains and drain both to the west towards the Pacific Ocean and to the east towards the Amazon River Basin (Barriga, 2023). The characteristics of the inland fishing zone in Ecuador are linked to the hydrographic network and can be subdivided into three geographic and faunal regions: (1) the lowlands between the Pacific Ocean and the Andes, called *El Litoral*; (2) the Andean region proper, called *La Sierra*; and (3) the lowlands east of the Andes, also called *El Oriente*, which is part of the Amazon Basin (Meschkat, 1975).

Th majority of inland fish catches come from the streams, rivers, and lakes of the these regions. In the Amazon, 193 species have commercial value, of which 64 species are the most utilized (Barriga, 2004; Stewart and Barriga, 1998). Four groups of fish species have been recognized in the Amazon basin based on their market value. The most prized group is made up of the milk catfish (*Brachyplatystoma filamentosum*) and the silver catfish (*Brachyplatystoma flavicans*). The second group is made up of the striped catfish (*Brachyplatystoma juruense*), the slimy catfish (*Brachyplatystoma platynemum*), the marbled catfish (*Leiarius marmoratus*), the zebra catfish (*Brachyplatystoma tigrinum*), the black catfish (*Zungaro zungaro*) and the macaw (*Phractocephalus hemioliopterus*). The third group is made up of the corvina (*Plagioscion squamosissimus*), the whiting (*Potamorhina altamazonica*), the bocachico (*Prochilodus nigricans*), the mice (*Leporinus fasciatus* and *Leporinus friderici*), willi (*Hoplerythrinus unitaeniatus*), guachiche (*Hoplias malabaricus*), tarpon (*Brycon melanopterus*), palometa (*Mylossoma duriventris*), gamitana (*Colossoma macropomum*) and paco or cachama (*Piaractus brachypomus*). Finally, in the fourth group is the paiche or pirarucu fish (*Arapaima gigas*), which is considered the best quality fish and whose value exceeds the rest of the species mentioned (Usma *et al.*, 2016).

In Ecuador, fishing is also practiced in the main reservoirs with the main commercial species being tilapia (*Oreochromis* spp.), freshwater lobster (*Cherax quadricarinatus*), dica (*Pseudocurimata lineopunctata*), vieja azul (*Andinoacara rivulatus*), dama (*Brycon alburnus*), guanchiche (*Hoplias microlepis*) and chame (*Dormitator latifrons*). In the coastal region, fishing is mainly for household consumption and only in the provinces of Los Ríos and Manabí is commercial fishing practiced, where the fishing of dica stands out and tarpon (*Brycon oligolepis*), guachinche (*Hoplias malabaricus*), guaña (*Chaetostoma marginatum*), guacuco (*Hypostomus annectens*), macho (*Mesoheros ornatum*) and chame or chalaco (*Dormitator latifrons*) are also targeted. In the eastern region of Ecuador, most fishing activity takes place in the Napo River Basin, where Barriga and Escobar (2014) report the most important species being bocachico (*Prochilodus nigricans*) and large catfish (*Pseudoplatystoma tigrinum*, *Brachyplatystoma filamentosum*, and *Zungaro zungaro*). The most commonly used fishing methods in river fisheries are *esparaveles* or *atarrayas*, hand lines, longlines, net enclosures, bamboo traps and *chinchorros*. In reservoir fisheries different sets of gears are used, typically gill nets, seines and traps. There are several lakes and rivers throughout Ecuador where sport-recreational fishing is practiced, the main species of interest being rainbow trout (*Oncorhynchus mykiss*).

As reported to FAO, catches have declined since 1984 with a peak of 994 tonnes, and since 2007 there has been a stable annual production of about 100 tonnes (FAO, 2023). This contrasts with information available for the Napo River basin, where stable catches between 500 and 600 tonnes are reported. Sirén (2011) estimated a total consumption of 8 362 tonnes of fish per year by Indigenous Peoples in the Ecuadorian Amazon, and Sirén and Valbo-Jørgensen (2022) estimated a catch of 4 478 tonnes per year for consumption by fishers. The fish of the Ecuadorian Amazon are an important component in the diet of the people of the region and their economic importance has been underestimated. Tello (2013) estimated a daily consumption of 183 g per person, with values of up to 644 g per person. Fishing information is obtained through the National Fisheries Institute and is based on monitoring of river fish landings in the provinces of Los Ríos and Guayas and also includes catches, fishing gears, type of vessels, fishing effort, as well as biological information (total length, weight, sex, maturity, and gonadal weight).

Inland fisheries in the rivers and associated waterbodies is threatened due to impacts associated with the construction of dams or roads that negatively impact the flow and water quality of the rivers. In the Amazon, fishing is also impacting stocks, including through the use of illegal fishing methods. In the river basin, high levels of contaminants have been detected in fish, which is a concern where this might coincide with high consumption levels (Webb *et al.*, 2004; Webb and Mainville, 2009).

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Guyana

Guyana, in the Amerindian language means "land of many waters" and the country is rich in freshwater environments. The main inland fishing areas are located on the Courantyne, Berbice Demerara, and Essequibo rivers and fishing takes place in rivers, streams, lakes, reservoirs, canals, and savanna areas (NDS Secretariat, 2000; Valbo-Jørgensen and Baigun, 2023). The Essequibo River forms the largest river system in the country and its basin (66 663 km^2) covers most of the country (US Army Corps of Engineers, 1998). Fishing activities take place primarily during and after the rainy season, when the savannah area becomes flooded. Inland fishing is mainly carried out as a subsistence activity by Indigenous People living far from the coast as one of a number of activities, interacting dynamically with agricultural activities, such as rice or sugarcane harvesting. Mistry *et al.* (2004) note that in this regard, fishing represents the mainstay of life for Indigenous Peoples in the Northern Rupununi and that fish make up 60 percent of their diet. Gears used reflect the diversity of fish species and sizes, with gill nets, trawls, trawls, and shore nets being used to catch particularly small species. For large fish, Indigenous People use traditional methods including bow and arrow and small quantities of poisons (Ministry of Agriculture, 2009).

Guyana reported between 700 to 800 tonnes of production from inland fisheries from 2001 to 2019 but only 23 tonnes in 2021. The possibility of harvesting 90 tonnes of fish per km^2 from the flooded savannas has been suggested and Shephard *et al.* (2022) determined that fishing in the North Rupunini area could be considered as low intensity. Fish consumption is important for the Indigenous Peoples of the Rupununi River and per capita fish consumption is as high as 130 g per day or nearly 51 kg annually (FAO *et al.*, 2021). There is a small but active inland fishery for ornamental fish (Maison, 2007) and an estimated 4.2 million fish are exported annually (Watson, 2005).

Inland fisheries are managed through a Fisheries Law that seeks to optimize the development of fisheries through effective management to create employment and stable sources of income for fishers and communities involved in fishing, optimize the amount of fish protein available for domestic consumption and export, and promote the sustainable development of inland fisheries, including ornamental and sport-recreational fishing and the diversification of economic activities. However, management measures still need to be developed to meet these objectives, although there are some fisheries where territorial use rights policies are applied (Maison, 2007).

To recover *Arapaima gigas* populations, a community-based management approach is being used (Fernandes and NRDDB, 2004; Maison, 2007), and pilot community management plans are being implemented in part of the Essequibo, Rupununi, and Rewa rivers (FAO *et al.*, 2021). However, some of the greatest threats to inland fisheries in Guyana derive from outside of fisheries and include the expansion of mining and forestry operations (NDS Secretariat, 2000). This generates pollution and habitat degradation with negative impacts on reproduction and recruitment.

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Chile

Chile is a 4 200 km long narrow strip of land bordered on the west by the Andes and to the east by the Pacific Ocean. Parts of the country have low temperatures and it is extremely dry with less than 2 mm of precipitation per year. Chile has different types of basins and the endorheic and Pacific basins stand out for their greater diversity of rivers and lakes (Valbo-Jørgensen and Baigun, 2023). The country also has 20 reservoirs, most of which are located in the IV and VI regions in the central part of the country (Niemeyer and Cereceda, 1984). Chilean rivers are torrential and short and drain from the Andes Mountains to the Pacific Ocean. The total number of lakes is 375 and they cover an area of 11 190 km^2. Most of the lakes are located in the XI and XII regions in the southern part of the country and are of glacial origin.

The fish fauna is relatively poor with only 44 native species, 11 of which are silurids (Habbit, Dyer and Vila, 2006). Brenner (1994) estimated a potential production of 1 500 tonnes in the lakes of the central part of the country, while FAO (1983) estimated 4 000 tonnes for the same area. No catches were reported to FAO for 2021. FAO/FishCode (2004) reported a very small-scale inland fishery in a coastal lagoon to the south of the country, where Indigenous Peoples were involved in subsistence fishing, and artisanal extraction of river shrimp in some altiplano lagoons and rivers. However, it is not known if this is still extant as Chile has now prohibited commercial fisheries in inland waters (Valbo-Jørgensen, Soto and Gumy, 2008). As a result, most inland water bodies are used for recreational fishing and about 50 000 recreational fishers have been registered in the national territory (FAO/FishCode, 2004). Recent estimates suggest that the total number of recreational fishers may be around 327 600 and that these fishers catch around 58 tonnes of fish, of which around 50 percent is retained (Embke *et al.*, 2022).

The recreational fishery targets salmonid species that have been successfully introduced, generating around USD 10 million annually (Valbo-Jørgensen, Soto and Gumy, 2008). Recreational fishing is regulated by laws allowing the creation of preferential areas with management measures specific to the requirements of each territory. Possibly the biggest problem associated with the conservation of Chile's inland fisheries is the fragmentation of rivers by hydroelectric dams. The rivers in Chile have potential for further hydropower development with estimates of an energy potential of 15 000 MW for dams that could be installed in 12 basins (Ministerio de Energia, 2016).

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French Guiana

French Guiana is drained by eight river basins flowing south to north and many small coastal creeks and streams (Valbo-Jørgensen, and Baigún, 2023; Lointier and Gaucherel cited in Mérona, Tejerina-Garro and Vigouroux, 2012). The largest basins are the Maroni (66 000 km^2) and the Oyapock (27 000 km^2). The rivers have only small floodplains (Mérona, Tejerina-Garro, and Vigouroux, 2012), and the Petit-Saut dam (350 km^2) has been created on the Sinnamary River. The Sinnamary River is one of the most important fishing locations, but for which there is almost no catch data.

Occasional information on landings suggests production of about 44 tonnes based on catches of *Hypophthalmus edentatus.* Annual production for the period 2010 to 2021 has been estimated at between 30 and 60 tonnes (FAO, 2023). Megapesca (n.d.) mentions that there are 17 small-scale vessels registered in the inland fishery and 34 people employed in the activity. Fréry *et al.* (2001) found a high dependence on fish among Indigenous Peoples with average annual consumption levels of up to 115 kg among 26 to 45 year olds and indicated that, seasonally, people may eat up to 600 g per day.

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7.5.2 Central America

Country/territory	Inland capture fisheries catch (tonnes in 2021)	Percentage of global inland fish catch	Population (2021)	Per capita inland fish production (kg/cap/year)
Mexico	160 385	1.41	126 705 138	1.27
Guatemala	2 360	0.02	17 608 483	0.13
Panama	1 030	0.01	4 351 267	0.24
El Salvador	848	0.01	6 314 167	0.13
Honduras	600	0.01	10 278 345	0.06
Nicaragua	548	0.00	6 850 540	0.08
Costa Rica	50	0.00	5 153 957	0.01
Belize	0	0.00	400 031	0.00

The Central American subregion includes Mexico, which spans both the North and Central American subregions, because of socio-economic similarities and the continued importance of inland fisheries as a source of food catch rather than recreational purposes. Mexico contributes the majority of inland fishery catch accounting for nearly 97 percent of the officially reported catch. Of the other Central American countries, almost 1.5 percent comes from Guatemala with the remainder shared between Costa Rica, Nicaragua, El Salvador, Panama and Honduras, with Belize not reporting any catches from inland waters.

Catch composition is a mixture of North American and South American species. Other notable species are the non-indigenous tilapias and common carp, which together make up over three-quarters of the officially reported catch. This reflects the importance in the subregion of enhanced fisheries and of stocked lake and reservoir fisheries in particular.

Mexico

The Mexican National Water Commission has identified 731 river basins in the country (Conagua, 2011). The largest river basins are those of the Bravo River with an area of 225 242 km^2 in Mexico and a further 241 697 km^2 located in the United States of America, and the Balsas River with an area of 117 406 km^2. The total length of rivers in the country is 633 000 km (Conagua, 2016). The country has five large lakes, among which the Chapala Lake (1 116 km^2) is the largest and also has the largest number of fishers. In addition, there are more than 5 163 dams and reservoirs. The largest reservoirs are the Angostura (640 km^2), Presidente Alemán (500 km^2) and Vicente Guerero (468 km^2) reservoirs (Sugunan, 1997). According to CONANP (National Commission of Natural Protected Areas), there are 142 wetlands included in the Ramsar Convention, covering a total area of 8.6 million ha in the country. In Mexico, inland fishing is mainly small-scale (Pedroza-Gutiérrez, 2018) and according to the new national development plan (2020–2024), the country is divided into four fishing regions for the purpose of management.

The predominant species in inland fisheries production since its introduction are carp (*Cyprinus carpio*) and tilapia (*Oreochromis* spp.), both non-indigenous. Tilapia represents approximately 35 percent of the inland fishery catches by volume, followed by carp (28 percent) and catfish (*Ictalurus punctatus*) (15 percent), the latter being a native species. The largemouth bass (*Micropterus salmoides*), which is also an non-indigenous species, contributes 11 percent and is relatively common in the country's reservoirs, being a particular target of recreational fishing (DOF, 2012). The total number of fishers nationwide is 295 033, but there is also many fishers that remain unregistered and therefore not included in the estimates. The most commonly used fishing gears are pots, gill nets, and hook and line.

The fish from inland waters is mainly destined for the domestic market and in the rural areas is mostly for household consumption. Since 2011, there has been a notable increase in catch reaching a peak in

2018 with 223 625 tonnes, mainly as a result of increased tilapia catch and perhaps an improvement in catch records. Current 2021catch data are 160 385 tonnes (FAO, 2023). Ninety percent of the recorded catches of tilapia and carp are concentrated in the country's large reservoirs: Infiernillo, La Angostura, Temascal and Vicente Guerrero (García-Calderón *et al.*, 2002). Although there are official records of the catch for most of them, and the reported volume may be less than the total production, potentially representing up to 60 percent of total production from these fisheries. The current annual per capita consumption recorded in Mexico is around 13 kg, but in coastal and inland areas closer to the fisheries, it could be higher as fishing households are known to eat fish five times a week (Pedroza-Gutiérrez, 2018). This local importance of inland fisheries to rural communities, because of their capacity to provide food security for a large number of (often unidentified) rural households, means that valuations of inland fisheries based on the aggregate economic contributions risk downplaying or overlooking these other crucial roles and values. According to a report by SECTUR (2011), in 2012 there were almost 4 million people were participating in recreational fishing in Mexico, 84 percent of which were carried out in inland waters. Embke *et al.* (2022) provide a similar number in a recent review. The main species for recreational fishing in Mexico is the largemouth bass. It is suggested that the inland fish catch may be up to 21 tonnes, of which around 40 percent may be retained.

The SAGARPA (Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación), through CONAPESCA (Comisión Nacional de Pesca), is the main organization in charge of fisheries management. The National Fisheries Institute (INAPESCA) is the decentralized public agency of SAGARPA and has 15 regional centers dedicated to fisheries and aquaculture research. Fisheries management is based on the General Law of Sustainable Fisheries and Aquaculture and its regulations, which define legal aspects such as fishing effort, permitted fishing gears and methods, fishing seasons, closed seasons, minimum sizes, fishery protection zones and areas where aquaculture may be carried out. It also regulates and establishes organizational and control requirements for fishers' cooperatives and other actors involved in this activity (DOF, 2007). Another legal instrument of utmost importance for inland fisheries management is the National Fishing Charter (CNP), which produces technical sheets with the necessary information for evaluation, conservation, and management (DOF, 2000). Each CNP contains information for managing the main reservoirs. INAPESCA prepares the CNP based on the basic principles and norms in the Code of Conduct for Responsible Fisheries (FAO, 1995). On the fishers' side, in general they are organized within unions or cooperatives, as these organizations serve as a management body through which fishing permits and government support are processed.

One of the principal management measures for inland fisheries has been the introduction and stocking of non-indigenous species, including carp and tilapia. Other measures relate to addressing the use of non-permitted gear, including small mesh sizes targeting juveniles, and related conflict (Pedroza-Gutiérrez, 2018). Pollution of water bodies is a problem affecting inland fisheries. According to the results of monitoring carried out by CONAGUA in 2009, 21 basins were recognized as heavily polluted according to one or more indicators. The CNP reports that 22 percent of fisheries located mainly in reservoirs and lakes and lagoons to a lesser extent present a state of degradation (DOF, 2012).

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Guatemala

The waterbodies of Guatemala cover an area of 1 339 km^2 including seven lakes, 306 lagoons, 826 lagoons and 15 reservoirs (PREPAC 2005). There are 38 major basins, of which 22 are transboundary, situated in three watersheds: the Gulf of Honduras with an area of 57 005 km^2; the Mexican Gulf with 50 803 km$^{2;}$ and the Pacific Ocean with 23 990 km^2 (MARN, 2013 cited in GWP Central America 2015). The most important rivers for inland fisheries are the San Pedro, La Pasión, Dulce, Sarstún, and Motagua. Fishing in inland waters is small-scale and includes both subsistence and recreational activities. Very few people have inland fishing as their only activity, as it is almost always combined with agricultural activities.

The main target species are pepesca (*Astyanax aeneus*), mojarras (cichlid species), bluegill (*Lepomis macrochirus*), tepemechín (*Dajaus monticola*) and pupos (*Poecilia* spp.). Subsistence fishing is carried out mainly in lakes and large rivers, catching mainly mojarras, catfish (*Arius* spp.), snook (*Centropomus* spp.) and bluegill. The ironhead catfish (*Cathorops* spp.), smallmouth bass

(*Rhamdia* spp.), curuco (*Potamarius nelsoni*), and jolote (*Ictalurus meridionalis*) are abundant species of great importance for food security, since they are targeted and caught in the subsistence fisheries. Freshwater shrimp (*Macrobrachium americanum*, *M. tenellum* and *M. rosenbergii*) and pigua (*M. carcinus*) are the most valuable species. They are marketed fresh and are very popular in local food culture for making broth. Other crustaceans and invertebrates that are part of the subsistence catches are crabs (e.g. *Potamocarcinus magnus*), snails (e.g. *Pomacea flagellata*) and clams (*Diplodon* spp. and *Unio* spp.). The most commercially valuable fish, such as snook, are sold to traders in the fishing communities. Most of the products are marketed as fresh and dried-salted. All inland fishery products are destined for national consumption, with the main channel being local markets and restaurants, with dried-salted products for the country's highlands.

The fishing gears used include hook and line, gillnets, longlines, pots, harpoons, *pita*, and *fisga*. OSPESCA (2012) estimated fisher numbers operating in the country's inland waters at around 6 200 while and earlier study by PREPAC (2005) suggested a total of 5 242. UNIPESCA (2006) estimated annual catches of 2 405 tonnes for the main water bodies in the country, while PREPAC (2005) suggested a much higher total of over 13 000 tonnes, which is considered to be above the potential for the water bodies. Cabrera *et al.*, (2023) more recently estimated that the inland fish production of Guatemala is in the order of 4 961 tonnes, which is still more than twice the 2 360 tonne estimate provided by FAO in 2021. The most productive environments are lakes, responsible for providing 49 percent of total production, followed by rivers at 33 percent and lagoons at 9 percent. Annual per capita fish consumption is estimated to be almost 3 kg (FAO, 2013), of which inland fisheries contribute 7.8 percent. However, in some areas near lakes and rivers in the country, the consumption rate increases up to around 77 kg, as for example in the community of El Estor, Izabal (CONAP, 2003).

Recreational fishing is mainly carried out in large lakes and rivers, including the San Pedro, la Pasión and Rio Dulce for species such as snook, tarpon (*Megalops atlanticus*), and largemouth bass (*Micropterus salmoides*). Quantitative data on recreational fishing activities are not available but most fishing events take place in bodies of water within protected areas. Several species with potential as ornamentals have been identified, however, there are no data on the quantities extracted for these purposes (Cabrera *et al.*, 2023).

Guatemala's fishing law establishes that inland fishing is reserved exclusively for subsistence, artisanal, and small-scale fishing. It also regulates the permitted fishing gears. The national fishing authority is the Dirección de Normatividad de la Pesca y Acuicultura, but almost all bodies of water have specific regulations on fishing gear and how they operate. The main watersheds have a local authority that is involved in conflict resolution processes in the communities, and some carry out water quality monitoring and provide logistical support for control and surveillance activities. The PREPAC study (2005) found that 66 percent of the fishers in Guatemala's lakes are organized and have agreed to implement specific regulations in some cases, such as the fishers of Lake Atitlan. Except Lake Amatitlan, there is no permanent monitoring program for inland fisheries. There are currently three restocking programs in the country based on the restocking of white fish, tilapia (*Oreochromis* spp.), mojarra and freshwater snail (*Pomacea* sp.).

The main impacts identified in the lake ecosystems are contamination by industrial and household waste, river diversion, drying of lagoons, introduction of non-indigenous species, and fishing pressure. One of the most serious problems in inland fishing is the use of illegal fishing gear, as occurs in Lake Izabal and the estuaries of the southern coast. Some species, such as machorra or peje lagarto (*Atractosteus tropicus*), are under pressure due to loss of habitat and fishing pressure and are highly threatened. Generally fishing pressure is reported to be highest in the smaller reservoirs under 150 ha. Mitigation of the impacts of change is often limited to stocking mostly with non-indigenous tilapia, which has been done regularly by the Ministry of Agriculture, Livestock and Food since the 1960s.

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Panama

Panama has 52 river basins, with about 500 rivers, 70 percent of which are in the Pacific watershed and 30 percent in the Atlantic (García Rangel and Abadí, 2023). Reservoirs represent 71 percent of the water bodies, the main ones being Gatun (420 km²), Bayano (350 km²), Alajuela (50 km²), and Fortuna (12 km²). Other important types of environments are wetlands and marshes, which account for 29 percent of the total area of the inventoried waterbodies, and the reservoirs, which are very small bodies of water used to retain rainwater or small watercourses for use during the dry season (PREPAC, 2005). Fish such as tilapia (*Oreochromis* spp.), common carp (*Cyprinus carpio*), and colossoma (*Colossoma macropomum*) have been introduced. Although the number and total extent of reservoirs in Panama are small, about 25 percent of fishers are active in these small waterbodies.

The PREPAC study (2005) identified a total of a total of 6 052 fishers based in 173 fishing communities in inland waters in Panama, of which 77 fish in reservoirs, 18 in wetlands, 2 in coastal lagoons, 70 in reservoirs, and 4 in lagoons. Different gears are used, including hook and line, gillnets, trammel nets, harpoons, and *atarraya*. Fishing is small-scale in nature and based on 10 native species and 8 non-indigenous species. Tilapia (*Oreochromis niloticus*) is an non-indigenous species that has come to be of great value in the Gatun, Alajuela, and Bayano fisheries. Common carp (*Cyprinus carpio*), grass carp (*Ctenopharyngodon idella*) and tiger carp (*Parachromis managuensis*) are also important in the fisheries of the Fortuna Reservoir. Fish such as tilapia, common carp, and colossoma (*Colossoma macropomum*) have been introduced into the reservoirs and contributes to the productivity of the fisheries (García Rangel and Abadia, 2023). PREPAC (2005) estimated annual yields of up to 174 kg per hectare in these types of environment.

Although fishery statistics have occasionally been collected in the Gatun, Alajuela, and Bayano reservoirs, at present they only exist in the latter and then only with partial coverage. Data reported to FAO indicate a maximum catch of 3 555 tonnes in 2006, but between 2013 and 2021 the maximum landings have been lower and currently (2021) stand at 1 030 tonnes. Reported catches consist of tilapia (97 percent) and sergeant (3 percent). PREPAC (2005) estimated an annual catch of 4 730 tonnes of fish, of which 96 percent came from reservoirs. Of the reservoirs, the Bayano reservoir has been identified as particularly important (Abadía, 2010; Morales, 2006). OSPESCA (2012) estimated a continental catch of 13 300 tonnes in 2010, which represented 39 percent of all artisanal catches in the country and exceeded the data reported to FAO for the same year by six times.

Fish from inland fisheries is generally consumed by fishing households or sold locally within the local communities. Commercial fish trade is poorly developed (ARAP, 2017). Bayley (1986) studied fish consumption around Lakes Alajuela and Gatun, and found that annually people ate, respectively 7 and 15 kg fish per person – the latter figure almost twice the national average at that time. Only Lake Bayano produces fish in a quantity and regularity that allows the supply to foreign markets, with 98 percent of the tilapia caught being exported. Other species such as *Colossoma* sp. and Chinese carp have a very limited market in terms of volume but can be very lucrative (Abadía, 2010). Recreational fishing is also present in Panama and key species targeted include sargassum (*Cichla monoculus*) and tarpon (*Megalops atlanticus*). There is a considerable recreational fishery in some reservoirs, particularly Lake Gatun, where a mixture of boat-owning local residents and boat-renting tourists participate. There are also people selling small fish for use as live bait. Abadia (2017) identified 25 boats, 68 fishers and 25 to 30 tour operators that are mainly dedicated to this activity in Arenosa. While there have been no further attempts to quantify the contribution to the local economy, it can provide important employment and income generating opportunities for the inhabitants of the reservoir shores.

Panama’s Fisheries Resources Authority (ARAP) is the organization responsible for the development and management of the country’s fisheries. However, the reservoirs, which are the most important environment for inland fisheries in Panama, are under the management of the National Environmental Authority (ANAM) and the Panama Canal Authority (ACP). The only place where management measures have been established or implemented are in the Bayano Reservoir through a management plan. Recreational fishing in reservoirs currently lacks regulations, management or statistics.

Traditionally, management has focused on the reservoirs and consisted of stocking lagoons, micro-dams, and hydroelectric reservoirs, almost exclusively with non-indigenous species – above all tilapia. These fish increase the productivity of the artificial environments and benefit the part-time small-scale fishers. Inland fishers generally have a very low level of organization and have limited and interaction with ARAP or participation in the development of management plans. However, there are examples of organized groups of fishers in the Gatun, Alajuela, and Bayano reservoirs that meet in monthly assemblies to discuss issues and make decisions related to fishing activities (Abadía, 2010).

Except tilapia in the Bayano Reservoir, capture fisheries in inland waters generally show no signs of overexploitation. The greatest threat is from watershed fragmentation due to the construction of hydroelectric dams and their effects on fish and diadromous shrimp that use much of the Atlantic slope river basins (McLarney *et al.,* 2010), as well as a change in water quality due to permanent stratification (McLarney and Mafla 2007).

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El Salvador

El Salvador has four major river basins: the Lempa, Goascorán, Grande, and Paz (US Army Corps of Engineers, 1998). Of the total surface area of aquatic environments (522 km^2), 36 percent are reservoirs, 26 percent lakes, and a large part of the rest is coastal lagoons and estuaries (PREPAC, 2005). Among the waterbodies, the Jaltepeque estuary has been recognized as particularly important for fishing (PREPAC, 2006).

Freshwater ichthyofauna is composed of 101 species (McMahan *et al.*, 2013). The main target species of the inland fisheries are two non-indigenous species, tilapia (*Oreochromis niloticus*) and guapote tigre (*Parachromis managuensis*), together with the native fish mojarra (*Astatheros macracanthus*), ejotes (*Atherinella guija*), catfish (*Arius* sp.) and silver (*Astyanax fasciatus*), as well as freshwater prawns (*Macrobrachium* sp.), other crustaceans and snails (including *Pomacea flagellata*). In the coastal lagoons, there are many more species due to the presence of euryhaline species that enter the continental environments on a regular or occasional basis. Among the most commercially important species are curiles (*Anadara tuberculosa*), curilillas (*Anadara similis*), macarelas (*Scomberomorus sierra*), roncadores (*Haemulon* spp.), pargos (*Lutjanus* spp.), róbalos (*Centropomus* spp.), mullets (*Mugil* sp.), sambos (*Dormitator latifrons*), sea bream (*Diapterus* spp., *Eucinostomus* spp.), tamalitos (*Caranx caballus*), sardines (*Lile stolifera*) and shrimp (*Litopenaeus* spp.).

Inland water fisheries production represents an important source of employment, in addition to contributing significantly to the food security of rural households. Data from a study conducted by PREPAC (2005) estimated that more than 13 000 people in 166 locations were involved in inland fisheries, operating across 35 inland water bodies. A variety of gears are used, including gillnets, *chinchorros*, traps, hooks and lines, *lumpe* or baskets, and harpoons (FAO, 2005). Most inland fishers only work part-time, catching fish and other aquatic organisms – including punche (*Ucides occidentalis*), crabs (*Callinectes toxotes* and *Portunus acuminatus*), tihuacales (*Cardisoma crassum*), curil (*Anadara* sp.) and clams (*Chione* spp.) – by the aforementioned methods and also occasionally by hand (PREPAC, 2006).

From 1950 to 2016, El Salvador regularly reported inland catches to FAO. The data series shows a general increase in production up to the 1990s, reaching a peak of 5 136 tonnes in 1992, declining to the current situation with almost 848 tonnes reported in 2021. However, it is possible that the difference, and potentially some of the change, is that catches from coastal lagoons and estuaries are recorded as marine fisheries due to difficulties in separating species by origin. This may explain the differences between the official data and the results of the PREPAC study (2005), which indicated an annual production of 12 302 tonnes for 2005 (six times more than the official data for the same year). The water body with the highest production is the Cerrón Grande reservoir (accounting for 36 percent of total annual production), followed by Bahía de Jiquilisco (19 percent) and Estero de Jaltepeque (15 percent).

Data from PREPAC (2005) also show 13 172 people harvesting fish and other aquatic organisms in inland waterbodies. Beltrán (2014) provided a similar figure, reporting that there were a total of 11 000 fishers in the country. The annual per capita consumption of fish (marine and inland) has been estimated at 6.8 kg (FAO, 2024). These studies also revealed that fish serves the dual purpose of contributing to household food supply and to household income, together with foods and income from other sources. Fish that is sold is only minimally processed by gutting and scaling before being sold to intermediaries, who typically keep it on ice or frozen before taking it to the different national markets. Only 20 percent of fish caught is sold directly to the consumer (PREPAC, 2006).

CENDEPESCA is the state agency responsible for fisheries management and determines management measures throughout the country. These are mainly related to input measures based on limiting the number of fishing gear per fisher or boat, gear dimensions, mesh size, and number of hooks. Catches are monitored in three lakes, three lagoons, and three reservoirs. Fisheries enhancement measures are also used, and tilapia is the most common species used for stocking in lakes and reservoirs (Sampson and Hernandez, 2010). The decline of fish populations in El Salvador's inland waters is partially explained by fishing effort but there is also an incidence of illegal fishing Other identified causes are the unregulated increase of salt and shrimp farms; pollution from agrochemicals, solid waste, domestic and industrial discharges; erosion from agricultural and livestock practices; indiscriminate logging and conversion of forests into agricultural land; and expansion of human settlements, among others (MARN, 2013). Fishing in reservoirs, lakes, and lagoons is also reported to have been affected by the introduction of non-indigenous species such as mirror carp (*Cyprinus carpio*), tilapia and the tiger guapote.

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Honduras

There are approximately 237 inland water bodies in Honduras with an area of 1 596 km^2 (PREPAC, 2005). More than half (57 percent) are coastal lagoons, 27 percent are lagoons and 7 percent are reservoirs. In the central zone, a total of 1 000 fishers located in 25 fishing communities have been identified. Fishing is a small-scale activity, and the fishing gear used are hook and line, trammel nets, *atarrayas* and, to a lesser extent, harpoons. The most abundant species caught are the non-indigenous tilapia (*Oreochromis niloticus*), followed by black bass (*Micropterus salmoides*), and to a lesser extent, common carp (*Cyprinus carpio*). Other important species include the common sleeper (*Gobiomorus dormitor*), the chunte or channel catfish (*Ictalurus punctatus*), the bocachele (*Vieja maculicauda*), two kinds of catfish (*Rhamdia guatemalensis* and *Cathorops melanopus*) and the common guapote (*Parachromis motaguensis*). Other estimates from the northern zone identified a total of 1 828 small-scale subsistence fishers and 10 recreational fishers located in 57 communities. These fishers operated in the 17 bodies of water in this zone.

The most abundant species targeted for sale are, in first place, snook (*Centropomus* spp.), followed by corvina (*Micropogonias furnieri* and *Cynoscion* sp.), followed by loggerheads (*Eugerres plumieri*), mullet (*Mugil cephalus*), grunts (*Pomadasys* spp.), jack mackerel (*Caranx latus*), snappers (*Lutjanus* spp.), yalatel (*Ocyurus chrysurus*), mackerel (*Scomberomorus maculatus*), and catfish (*Bagre marinus*). Many of these species overlap with the coastal marine fisheries. Gears used to target these species include hook and line, trammel nets, and *atarrayas* (Rodriguez, 2023). In the southern zone, which has the most fishers, most fish in the winter lagoons and when these dry out they fish in the estuaries or work as hired labour on shrimp farms.

The most abundant species in the seasonal winter lagoons and estuaries that are commercially caught are shrimp (*Litopenaeus vannamei*, *L. stylirostris*, *L. occidentalis*, *Penaeus californiensis*, *Xiphopenaeus kroyeri* and *Trachypenaeus* sp.). Together these species account for 75 percent of the catch. The remaining 25 percent corresponds to fish such as snook (*Centropomus* spp.), corvina (*Cynoscion reticulatus*), mullet (*Mugil cephalus*), guavina (*Nebris occidentalis*), guiche (*Ariopsis felis*), snapper (*Lutjanus* sp.), and occasionally tilapia (*Oreochromis niloticus*). There are an estimated 8 000 fishers and 98 percent of the shrimp and fish caught is sold on the domestic market.

Data collection by DIGEPESCA are incomplete because there is no systematic monitoring of inland fisheries. PREPAC (2005) mentions that there are fishing activities in about 40 water bodies with a total catch of almost 4 000 tonnes and that the environments with the highest catches are in the coastal lagoons. Honduras has not submitted data on inland catches to FAO from 2001 to 2018 but reports 600 tonnes from that date to 2021. The inland landings reported to FAO likely correspond to production from Lake Yojoa while the reported catches from coastal lagoons are recorded as marine catches. It has been estimated that the average value of the total annual production from inland fisheries would be in the region of USD 17 million. Apparent average annual per capita fish consumption based on estimated production in Honduras is 4 kg (FAO, 2013) and inland fisheries contribute at least 20 percent of the fish consumed nationally. Fish are typically preserved in freezers, coolers, ice, or fresh, and marketing is done through collection centers.

There is some recreational fishing in the Hidroeléctrica Morazán dam (El Cajón), Lake Yojoa, and Jucutuma Lagoon, with an estimated 565 recreational fishers participating annually. Total annual production from recreational fishing in Jucutuma Lagoon is estimated at 4 tonnes. The Secretaría de Agricultura y Ganadería (SAG), through the Dirección General de Pesca y Acuicultura (DIGEPESCA), is the regulatory body and administrator of all fisheries in Honduras. Regulations include mesh sizes and seasonal closures. As part of inland fisheries management, management plans have been developed for most of the inland water bodies where fishing activities are carried out. In the central zone and in some water bodies in the northern zone there is coordination with fishers' organizations, of which there are a total of 42 in the two zones. Regulation of fishing has been identified as one of the biggest challenges, including the use of illegal fishing gear, catching of prohibited species, or fishing in seasonally closed areas. Pollution of water bodies is also reported to have increased in recent years.

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Nicaragua

After Mexico, Nicaragua is the richest Central American country in terms of water resources with two-thirds of all surface water in the subregion. The total area is 10 506 km², of which 8 144 km² corresponds to Lake Cocibolca (Lake Nicaragua) (approximately the size of Lake Titicaca). PREPAC (2005) counted 86 waterbodies, including coastal lagoons, lakes, and reservoirs. of which 68 were used for fishing. The country also has 82 major rivers (INIDE 2016), among which the most important for inland fisheries is the San Juan River, the outlet of Lake Cocibolca whose basin has a total area of 29 824 km² (PREPAC, 2006). Lakes contribute 86 percent of the inland water area, while coastal lagoons account for 13 percent.

Commercial small-scale fishing is concentrated in the system composed of lakes Apanás, Lake Xolotlán (Lake Managua), and Lake Cocibolca, which with their tributaries and the San Juan River constitute the most productive inland fishing areas in the country (PREPAC, 2006). The main species of commercial interest at the national level are gaspar (*Atractosteus tropicus*), machaca (*Brycon guatemalensis*), guapotes (*Parachromis dovii* and *P. managuensis*), tilapia (*Oreochromis* sp.) and mojarras (*Amphilophus citrinellus* and *Cribroheros rostratus*). Among the euryhaline species are snook (*Centropomus pectinatus*), grunts (*Pomadasys crocro*) and tarpon (*Megalops atlanticus*), which are caught in the coastal lagoons as well as in the San Juan River and Lake Cocibolca. In addition, a species of river shrimp (*Macrobrachium carcinus*) is caught along the banks of the San Juan River. The most common gear used is the *chinchorro*, hooks, and gill nets (Sánchez, 2023). According to data from INPESCA, there are about 700 fishers operating full-time in inland waters. Most of the product is sold at the landing sites to middlemen. The product is generally marketed as fresh, skinned, and gutted.

Fishing nationwide is small-scale, based on traditional methods but notable because of its importance as the main source of family income. OSPESCA (2012), estimated that there were 4 200 fishers were engaged in fishing. Some 85 percent these are located in the central part of the San Juan River basin. An earlier study by PREPAC (2005) counted 8 545 fishers in water bodies, including 5 823 in coastal lagoons, representing 68 percent of the total. Recreational fishing takes place in Lake Apanás, Lake Cocibolca, and the San Juan River. Species of interest for recreational sport fishing include tarpon and snook (Davies, 1976).

The Nicaraguan Institute of Fisheries and Aquaculture (INPESCA) is the responsible authority for monitoring all fishing activity in the country. Information is collected from the landing sites and monitoring of fish that reaches the processing companies in Managua. However, there are no data available on the fish marketed locally or sold informally to visitors to the communities, restaurants, and hotels (Sánchez, 2023). Nicaragua has reported inland catches to FAO every year since 1950. According to FAO statistics, the largest catch volume was in 1973, when it reached 2 600 tonnes and, apart from 2005 and 2007, has not exceeded 1 000 tonnes thereafter – currently standing at 548 tonnes. There are some differences between the official data and FishStat data from 2005 onwards because the country reports only preliminary data to FAO, which are then later adjusted. Analysis of catches suggest that the lakes provide 66 percent of the national catch.

Compared to the official statistics, the PREPAC (2006) study estimated a catch of 3 135 tonnes, including 1 200 tonnes from Lake Cocibolca that, however, did not take into account locally and informally traded fish, as well as subsistence fishing. OSPESCA (2012) later estimated a catch of 6 300 tonnes of inland fisheries nationwide in 2010. INPESCA (1986) determined a fishing potential for Lake Cocibolca of 7 830 tonnes excluding tributary rivers, while FAO (1983) provided much higher estimates that up to 50 000 tonnes could be harvested from the lake and another 10 000 tonnes from the coastal lagoons. In addition to fishing for consumption and recreational fisheries, INPESCA reported that in 2015 some 150 000 specimens of fish were exported from inland waters for ornamental purposes.

The public entities involved in fishing activities are the Nicaraguan Institute of Fisheries and Aquaculture (INPESCA), the Ministry of Environment and Natural Resources (MARENA), and the Institute of Agricultural Protection and Health (IPSA). However, their visibility and influence are low in remote areas, where there is a lack of monitoring and controls, and there is little knowledge of the rules and regulations on the part of the users. Potentially as a result of this, illegal fishing and trade is a concern, as is pollution from agricultural activities and the discharge of domestic, industrial, and agroindustrial waste that enters rivers and lakes without treatment (Vammen *et al.*, 2012). Mining activity generates liquid waste with high mercury content even though it has not been possible to demonstrate high levels among populations that regularly consume fish (Vammen *et al.*, 2012; Jiménez-García *et al.*, 2009). Several tilapia fish species (including *Oreochromis niloticus*, *O. mossambicus*, and *O. aureus*) and devilfish (*Loricariidae* sp.) have been introduced into Nicaragua where, within a few years, they have established populations across the entire San Juan basin (Härer, Torres–Dowdall and Meyer, 2017). In Lake Cocibolca, the presence of tilapia is understood to have had a negative impact on the abundance of native cichlids (McKaye *et al.*, 1995) and the introduction of devilfish has caused a decrease in the populations of native species, particularly the guapote.

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Costa Rica

The subregional inventory of waterbodies prepared by PREPAC (2005a) counted 510 waterbodies with a total area of at least 682.3 km^2. However, most waterbodies are relatively small and so are the river basins. Costa Rica has 34 rivers, all relatively short, and most inland water bodies in Costa Rica are associated with wetlands, of which the country has an area of 543 km^2 (PREPAC 2005a, 2005b). Since 2016 surface water area has been increased by the Reventazón hydroelectric project that has created a reservoir of 7 km^2.

Inland catches are based on a mix of non-indigenous and indigenous species, but the status of their populations is generally unknown (Segura and Otarola, 2023). Fishing in rivers is generally practiced from the shore or bridges, while boat fishing only takes place in the larger inland water bodies of water, such as Lake Arenal as well as the coastal lagoons, mangroves and estuaries. The country has not reported inland catches to FAO in the recent past. The maximum catch value was recorded in 1996 with just over 1 000 tonnes and thereafter FAO has estimated landings, which has declined and remained at 50 tonnes since 2012. Production data are complicated as fish from estuaries, mangroves and coastal lagoons may be recorded as marine fisheries if the product is delivered to a coastal landing site. In Costa Rica, inland fishing is normally carried out on a part-time basis.

The fishing gears are rope, hook and line, or lures, these being the only legal fishing gear in inland waters. In the 1980s, the Indigenous Peoples of the Caribbean coast used spearguns (harpoons) for fishing in rivers and lagoons in their territories and also *atarraya* in the Reventazón River Basin, these are used to catch booby fish (*Joturus pichardi*). In Barra del Colorado they catch the roncador (*Rhonciscus crocro*) with hooks attached to ropes, as well as mojarra (*Amphilophus citrinellus*) and guapote pinto (*Parachromis managuensis*) during November and December when the river has more flow. Other species that are also exploited in the country are the gaspar (*Atractosteus tropicus*), the guavina (*Eleotris amblyopsis*) and the barbudos (*Rhamdia* spp.) (Chacón 1997). PREPAC (2005b) counted 486 subsistence and recreational fishers in inland water bodies. However, this study also confirmed that subsistence fishing occurs in many other inland water bodies, where there are no catch data available.

In Barra del Colorado, 85 percent of the farmers practice fishing as part of diversified livelihood strategies in which fishing provides for household consumption. Fishing is mainly undertaken in nearby lagoons, canals, and rivers (González and Villalobos, 2012). Recreational fishing, including related to tourism is important for local economies and supports other activities, including food, lodging and transportation. Various species such as blue guapote (*Parachromis dovii*), booby fish (*Joturus pichardi*), roncador (*Pomadasys* spp.), machaca (*Brycon* spp.), snook (*Centropomus* spp.) and rainbow trout (*Oncorhynchus mykiss*) are targeted in different parts of the watersheds.

The Costa Rica Institute of Fisheries and Aquaculture (INCOPESCA) exercises control over fishing and aquaculture activities in marine and inland waters. In inland waters, the Ministry of Environment and Energy (MINAE) is responsible for the protection of fish stocks. Only small-scale fishing and recreational fishing from the shore or using boats is allowed in inland waters. Commercial fishing with any type of fishing gear in the mouths of the country's rivers and estuaries is prohibited, but the use of illegal gear (including *arbaleta* and *atarraya*) is nevertheless reported to be common in inland waters (Bussing, 2002). INCOPESCA has, at certain times, introduced enhancement measures and stocked/restocked some environments.

There are a number of threats to inland fisheries in Costa Rica that are recognized. PREPAC (2005a, 2005b) identified that 76 of Costa Rica's inland water bodies have suffered water volume reductions, exhibit clogging and excessive proliferation of aquatic plants, and 46 percent have more than 10 percent of their water mirror covered by various plants. In recent years, the increased use of pesticides by pineapple plantations, the extraction of materials from rivers, canalization, and construction of dams have caused deterioration in fishing opportunities in inland waters. The increase in population and the consequence of urban expansion is another cause of the decrease in the capacity of the environment to maintain adequate conditions for fish, especially in rivers or bodies of water in areas of influence of large agricultural or industrial activities.

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Belize

There are a total of 18 major watersheds in Belize, including the Hondo River, Belize, and New River (Zapata *et al.*, 2023). The study by PREPAC (2005) reported a total of 95 inland water bodies in the country with a total area of 1 540 km^2 of lagoons. The northern part of the country is especially rich in wetlands and most of them are perennial (Gillett and Myvette, 2008). There are also four hydroelectric dams larger than 10 MW and associated reservoirs. A total of 118 species of freshwater fish have been recorded in the country, but Gillett and Myvette (2008) report fishing for household consumption targets mainly tilapia (*Oreochromis* sp.), white bass (*Centropomus undecimalis*), white fish (*Petenia splendida*), crana (*Cichlasoma urophthalmus*), shad (*Megalops atlanticus*), catfish (*Ictalurus* spp.) and the hicatee or white turtle (*Dermatemys mawii*). While Belize's fisheries are dominated by marine fisheries, and inland fisheries production is unknown, there is no doubt that inland fisheries are of great importance to rural communities, mainly as a subsistence activity and component of diversified livelihoods (PREPAC, 2006). The main fishing gears are handlines and gillnets (Gillett and Myvette, 2008), but spears are also used. The Fisheries Department estimates that there are about 200 people involved in inland fishing and that 90 percent of their catch is for household consumption. Fishing is most intense during the dry season (between January and June). According to PREPAC (2006) there are 421 fishers in Belize's waterbodies.

Belize has not submitted inland fishing statistics to FAO since 1994, when only 1 tonne was recorded, while the highest catch was in 1981 with 40 tonnes. There is anecdotal information suggesting a decline in catches of native fish species over the last three decades. The catches are mainly made up of black tilapia. PREPAC (2006) has estimated an annual production of 37 tonnes of which 43 percent comes from coastal lagoons and 53 percent from ponds. Fish from inland waters are typically marketed fresh and gutted, with black tilapia being the most sold species and increasing due to the decline of native species.

Recreational fishing is an important but largely undocumented activity. Recreational fishing takes place in lagoons, rivers, estuaries, inlets, and mouths (e.g. in the Belize River and New River Lagoon). Popular species for sport-recreational fishing include bonefish (*Albula vulpes*), tarpon, white bass, permit (*Trachinotus falcatus*), and barracuda (*Sphyraena barracuda*). There are many inland fish species in Belize with great potential as ornamental fish (e.g. poeciliid and cichlid families), but the Fisheries Department has no information on such ornamental-fish catching activities in the country.

The Department of Fisheries is responsible for implementing fisheries legislation, which applies to all fishing activities in the country, including those that take place in inland waters (Gillett and Myvette, 2008). In 2016, the Department of Fisheries initiated a program that sought to raise awareness among fishers about fishing regulations, including the use of gillnets. As a conservation measure, the Government of Belize has designated several wetlands as sanctuaries (e.g. Sarstoon Temash National Park, Crooked Tree Wildlife Sanctuary) to safeguard species diversity and to maintain the integrity and functioning of inland ecosystems.

The clearing of forests for agricultural purposes, and the growth of tourism, as well as the creation or expansion of uncontrolled urbanization along rivers or water bodies represent threats to the integrity of these ecosystems on which inland fisheries depend. The potential impact of the installation of the three hydroelectric dams on the Macal River is unknown. In terms of contamination, the presence of mercury and other heavy metals in aquatic ecosystems and fish and crocodile tissues constitutes the most serious problem (W. and Q. Services, 2017). Authorities discourage the consumption of fish from reservoirs where the bio-accumulation problem would be greater. Anecdotally, black tilapia has spread to almost all water bodies throughout the country and there is a widespread belief that the presence of this species has caused the decline of endemic species.

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7.5.3 Northern America

Country/ territory	Inland capture fisheries catch (tonnes in 2021)	Percentage of global inland fish catch	Population (2021)	Per capita inland fish production (kg/cap/year)
Canada	21 864	0.19	38 155 012	0.57
United States of America	14 486	0.13	336 997 624	0.04

The Northern American subregion is comprised of Canada and the United States of America.

Canada

Canada has around 2 million lakes, with around 1 million of these over 10 ha in area, and over 8 500 rivers, which account for around 37 percent of the world’s surface freshwaters (Minns *et al.* 2008). These waters provide habitat to 201 native species, and 21 established non-native species (Mandrak *et al.*, 2023). The northern part of Canada has considerable lake resources, including the large Great Slave and Great Bear Lakes, however low population densities mean that exploitation levels are low.

According to FAO figures, the total production from inland capture in Canada amounted to 21 864 tonnes in 2021. The main species caught commercially are yellow pickerel and coregonids (whitefish). Commercial catches have declined steadily from about 60 000 tonnes in the 1960s to 25 139 tonnes in 2021, although inland capture fisheries still employ around 10 000 people. While the commercial fishery is declining, Canada's inland waters support a important recreational fisheries for both residents and tourists. In 2015, there were 1.8 million active recreational fishers in inland waters, who fished 27 million days and retained 20.9 million fish (Government of Canada, Fisheries and Oceans Canada, Communications Branch, 2019). This has since increased and estimates produced in 2022 suggest that there are now around 2.8 million participants (7.5 percent of the population) who catch around 133 436 tonnes of fish, of which 45 percent is retained (Embke *et al.*, 2022). The main species caught by recreational fishers were Walleye, Trout, Pike and Perch. In additional to the commercial and recreational value of inland fisheries in Canada, Indigenous People depend on inland fisheries for their livelihoods, food and cultural ceremonies, supporting long-standing cultural traditions (Noble *et al.* 2016).

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United States of America

The inland fisheries of the United States of America are based on the extensive Great Lakes system in the north, the Mississippi River and tributaries centrally and to the south, and the west-flowing rivers. Numerous other rivers and lakes are situated throughout the country. Harvests from these systems are likely to be under-reported based on a study by the United States Geological Survey (Murray *et al.*, 2020). The United States of America reported an inland fishery catch to FAO of 14 486 tonnes in 2021 compared to 19 392 tonnes in 2015, although results from Murray *et al.* (2020) suggest the total inland catch exceeded 40 000 tonnes in 2015 when under-reported commercial finfish data are included. Reported catches of inland fish from commercial fisheries in the United States of America have declined steadily since the late 1950s. This can be explained by several factors including competition from global imports, aquaculture, and declining productivity (owing to efforts to reduce nutrient inputs) in historically productive fisheries such as the Great Lakes.

Efforts to manage inland fisheries sustainably for recreational and commercial fisheries have increased through time, especially since the mid-1900s. According to the data reported to FAO, a wide range of fish are caught, particularly catfish (59.4 percent) and buffalo (15.2 percent), which form the majority of reported catches. When data are broadened to include inland fishery harvest unreported to FAO, carp and catfish species make up the most dominant fisheries (Murray *et al.*, 2020).

While commercial inland fisheries are declining, the estimated number of recreational fishers has increased from 39.9 million in 2010 to around 50 million (a 15 percent participation rate) in 2022 (Embke *et al.*, 2022). Retention rates are reported to be around 40 percent. In contrast to the commercial fishery catches reported to FAO, Embke *et al.* (2022) estimated retained inland catches at around 35 000 tonnes, similar to the estimate of 396 000 tonnes provided by Cooke *et al.*, (2017). Cook and Murchie (2013) estimate that the total harvest in the inland waters of Northern America (United States of America and Canada) may be in excess of 480 000 tonnes per year, if these retained recreational fishery catches are included.

Inland fish and fisheries in the United States of America continue to be affected by land use change, pollution and water use, including abstraction and hydropower that affect water quality and degrade and fragment habitats. One trend in the inland aquatic environments of the United States of America is the removal of barriers within basins, with around 75 percent of these removed in the last two decades. The environmental outcomes of removals have also been well documented (Duda *et al.* 2018). In several of these removals, arguments for the removal of barriers and the restoration of river environments and fisheries have drawn on the cultural significance of river environments and fisheries, including the role of fish in traditional diets (Fox *et al.*, 2020).

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7.5.4 Islands of the Americas

Country/territory	Inland capture fisheries catch (tonnes in 2021)	Percentage of global inland fish catch	Population (2021)	Per capita inland fish production (kg/cap/year)
Dominican Republic	2 127	0.02	11 117 873	0.19
Cuba	1 472	0.01	11 256 372	0.13
Jamaica	869	0.01	2 827 695	0.31
Haiti	610	0.01	11 447 569	0.05
Falkland Islands (Malvinas)	0	0.00	3 764	0.00

In the Caribbean there are five islands that report inland fish catch, and the inland fish catch of these islands reflect the limited freshwater resources. Four large islands (Cuba, Jamaica, Haiti, and Dominican Republic) and Puerto Rico account for 90 percent of the land area. The size, topography, and position of the islands in the trade winds determine the precipitation pattern. In general, small islands with flat topography are arid and have no surface water, while on islands with mountain ranges the eastern and windward slopes receive more rainfall and even the smallest islands can manifest significant differences in climate due to this orographic effect. Aquatic environments include mangroves, lagoons, lakes, reservoirs, river mouths, estuaries, and other wetlands that can all support fish populations and fisheries.

Collectively the islands have 167 freshwater fish species, of which 65 are endemic to one or a few islands and, aside from on the larger islands, most fish species live in both marine and freshwater and some exhibit amphidromous behavior. Non-indigenous species such as *Oreochromis niloticus* and salmonids (mostly rainbow trout, *Oncorhynchus mykiss*) have already become established in several rivers, lagoons, and wetlands. For island populations, fish is a fundamental food source. While this is mostly marine fish, there are important small-scale subsistence fisheries in many inland waterbodies, as well as seasonal fisheries targeting amphidromous fish and crustaceans in small rivers. Fisheries in some of the larger lakes and reservoirs can be are maintained by restocking programs, mostly using non-indigenous species. The Falkland Islands (Malvinas) reports no inland fish catch.

Dominican Republic

The inland waters of the Dominican Republic consist of 108 basins and 270 water bodies. Of these, the largest waterbody is Lake Enriquillo, also the largest in the Caribbean, with an area of 256 km^2. According to MARENA (2004), other important water bodies are the lagoons Cabral (30 km^2) and

Oviedo (28 km^2). Inland fisheries are centered in the country's large lakes and reservoirs, as well as in wetlands and coastal lagoons (Colón Alvarez and Mateo, 2023). Lake Enriquillo supports tilapia (*Oreochromis* sp.) populations and most fishing is directed at this species. Other target species include guabina (*Gobiomorus dormitor*), snook (*Centropomus undecimalis*) and tarpon (*Megalops atlanticus*) although these are caught less frequently (Colón Alvarez and Mateo, 2023).

The total number of fishers in the inland fisheries nationwide is probably at least 2 000. The numbers vary by location and in the Boca de Yuna wetland, 981 fishers are registered and in the Ozama wetlands, 102 fishers have been registered. Escalante Suárez (2013) counted 483 fishers in Lake Enriquillo. In this lake, the most commonly used fishing gear include the *chinchorro de ahorque*. According to FAO, the volume of fish from inland waters in the Dominican Republic reached a maximum of 3 774 tonnes in 1994 and in 2021, only 2 127 tonnes was reported.

Catch statistics are only available for 13 water bodies and, of these, the most productive fisheries are those of the Boca de Yuna (132 tonnes) and Higuamo wetlands (127 tonnes). There are no landing data available for the productive Lake Enriquillo or the Hatillo dam reservoir, which are estimated to produce around 500 tonnes per year. Jackson (cited in Marmulla, 2001) made an evaluation of the Dominican Republic's reservoir fisheries and found yields per hectare of between 29 kg and 75 kg. When the reservoirs were created, several non-indigenous fish species were introduced to take advantage of the more lacustrine conditions, including lobina (*Micropterus salmoides*) and tilapia (*Oreochromis* spp.). These species have become the basis for small-scale and recreational fisheries. There is also a conflictive, partially illegal, and quite lucrative fishery for glass eels (larvae of the American eel, *Anguilla rostrata*) for export to Asia (Crook and Nakamura, 2013). Fish from inland waters is usually sold fresh and annual per capita fish consumption in the Dominican Republic was 8.7 kg in 2013. Reported domestic inland fish production only corresponds to 25-30 percent of demand, with the rest covered by marine fisheries and imports.

The Dominican Council of Fisheries and Aquaculture (CODOPESCA) is the body responsible for the development and management of fisheries in the country. Within the framework of the strategy or policy defined for inland fisheries, it is expected that a water body management model will be established based on restocking according to the carrying capacity of the water bodies. In terms of the management challenges, there is increasing fishing pressure in some lakes and reservoirs resulting from the migration of fishers, creating conflicts with resident fishers (Escalante Suárez, 2013). Native species are gradually being displaced by non-indigenous species. The predatory catfish (*Clarias gariepinus*), is an invasive species that is not appreciated by fishers and this also makes it difficult to exert any control over its expansion.

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Cuba

Cuba has several small, short rivers and there are 30 south-flowing and 11 north-flowing rivers in Cuba with a total length of 3 932 km (Sugunan, 1997). There are few natural lakes but there are some swamps and a network of lagoons along the coast. Reservoirs are abundant and especially small (< 1 000 ha) and the total area of reservoirs is estimated to be 1 460 km^2 (Coto, 2010). Fishing takes place in many of the reservoirs and wadeable rivers. Fishing is carried out with hook and line and gill nets and in reservoirs, a trawl net pulled by two boats is used. Fishing in reservoirs is mainly directed at catching the catfish *Clarias gariepinus* and cyprinid species (Valbo-Jørgensen and Baigun, 2023).

The native freshwater fish fauna in Cuba is quite poor, with 54 native species, of which only 36 are truly freshwater, the rest are anadromous or catadromous. Cuba has reported landings from inland fisheries to FAO very regularly since 1956. The highest recorded catch was in 1990 with 15 143 tonnes, declining and then stabilizing around 2 000 tonnes. The most recent statistic is from 2021, with production of 1 472 tonnes of blue tilapia (*Oreochromis aureus*). There remain differences between these reported figures and other sources. For example, Coto (2010) suggests a total harvest of 16 374 tonnes in the first nine months of 2010. Estimates from that time suggest that the total number of fishers in the state and private sector is 2 593 (Coto, 2010) and average annual per capita fish consumption was estimated at 5.5 kg in 2013 (FAO, 2013).

Since the 1970s, many of the reservoir fisheries have been managed through stocking programs. In reservoirs of more than 500 ha this can be relatively intensive, involving not only the supply of fish (often a variety of non-indigenous species) but also feed and fertilizer. Fish harvesting is managed using minimum mesh sizes, effort regulations and closed seasons. There are little recent data and production may be recorded as aquaculture rather than inland capture fisheries. In the past, average yields per hectare of around 138 kg have been observed (Sugunan, 1997). Quirós (1999) and Quirós and Mari (1999) observed that when there is adequate natural recruitment, stocking of reservoirs has no impact, especially for tilapia.

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Jamaica

Jamaica has ten basins that include more than 100 streams and rivers. The largest watershed is the Black River with 1 639 km^2 (NEPA, 2015). Most of the major rivers are fished by local people, as mentioned by CRFM (2015). Fishing is particularly important as a traditional activity for Afro-descendant communities, who use spears and traps as well as biodegradable poisons (John, 2007). Fishing is based mainly on mullets and crustaceans and increasingly on introduced tilapia (*Oreochromis mossambicus*), thanks to their stocking in several waterbodies. Jamaica began reporting inland catches to FAO in 2012, with current production reported as 869 tonnes. While catch composition is not specified, the volume of production would correspond to *O. mossambicus*. The use of pesticides for fishing has been reported, particularly in the Rio Grande, which may affect the traditional fishing practices and livelihoods of Afro-descendant settlers (Kimberly, 2007).

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Haiti

The total area of inland waters in Haiti is estimated at 220 km^2, of which about 85 percent is constituted by four main water bodies. The Azuéi brackishwater lake is the largest freshwater environment with an area of 113 km^2 and the Péligre reservoir is the second at 48 km^2 (Valbo-Jørgensen and Baigun, 2023). In addition, there are numerous small water bodies (Vlaminck, 1990). There are 31 permanent or near-permanent rivers (JICA, 2011), but most rivers are small and disappear during the dry season (Miller, 2015). The only river with fishing potential is the Artibonite River with a catchment area of 8 908 km^2 (Vlaminck, 1990). Haiti has 48 species and those that occur in freshwater are marine visitors or catadromous species. Some freshwater species have been introduced, most notably common carp (*Cyprinus carpio*) and tilapia (*Oreochromis* spp.) to increase the productivity of lakes and reservoirs (Vlaminck, 1990).

In 2009 reported catches were 600 tonnes and in 2021 were 610 tonnes. Vlaminck (1990) estimated a total potential for the four largest water bodies of 1 500 tonnes. According to the Ministry of Environment, there are an estimated 1 071 fishers in inland waters (Ministère de l'Environnement, 2001), although Felix (2012) suggests the number is possibly closer to 800. Hargreaves (2011) indicates that there are 3 000 fishers around Lake Azuéi, of which 60 percent rely solely on fishing for their income and 33 percent on a mix of livestock and fishing. Fish marketing is either fresh or dried and is carried out by a few small traders who buy the fish directly from the fishers or through an intermediary (Ministère de l'agriculture des Ressources Naturelles et du Développement Rural, 2010). The most important management measure is occasional stocking activities by the fisheries department. During the 1990s, when FAO supported a restocking program with *O. mossambicus* in Lake Azuéi, there were annual catches of 140 tonnes. This was reduced to only 45 tonnes when the program and regular stocking were suspended (Ministère de l'agriculture des Ressources Naturelles et du Développement Rural, 2010).

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The Falkland Islands (Malvinas)

A variety of freshwater bodies occur in the Falkland Islands (Malvinas), including coastal barrier ponds, oxbow ponds, glacial tarns and erosion hollows, as well as slump features in peat. There are six species of fish in freshwater and brackishwater in estuaries and in the lower reaches of rivers (Otley *et al.*, 2008). The two indigenous fish species are the inanga (*Galaxias maculatus*) and the zebra trout (*Aplochiton zebra*). Brown trout (*Salmo trutta*) have also been introduced (McDowall, Allibone and Chadderton, 2001; Otley *et al.*, 2008) as the basis for a recreational fishery. These three species all follow a diadromous life cycle, but can also survive in land-locked waterbodies. Three marine species: Patagonian blennie (*Eleginops maclovinus*) and two species of silversides (*Odontesthes nigricans* and *O. smitii*) are also found in the lower reaches and estuaries of streams and rivers. There have been attempts to introduce rainbow trout (*Oncorhynchus mykiss*), brook char (*Salvelinus fontinalis*) and Atlantic salmon *(Salmo salar*), but none of them have become established (Otley *et al.*, 2008).

The Falkland Islands (Malvinas) have reported an annual catch of one tonne of sea trout from inland fisheries since 1996 (FAO, 2023). This probably corresponds to the catches by the small company that supplies sea trout for people and restaurants (Otley *et al.*, 2008). Since 2000, there has been a small-scale beach seine fishery for Patagonian blennie in creeks around the Goose Green, North Arm and Port Louis areas, with catches marketed locally (Otley *et al.*, 2008). In addition to the commercial fishing operations, there is recreational fishing for the anadromous trout (McDowall, Allibone and Chadderton, 2001).

A number of threats to inland fisheries have been identified, and these include intensive grazing and associated damage to streamsides, changes to water quality because of pollutants such as effluent from homes and livestock sheds, physical changes to watercourses such as installation of culverts, creation of dams, and removal of water (Otley *et al.*, 2008).

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Antigua and Barbuda

FAO (2007) indicates that although there are no commercial inland fisheries, there is some traditional harvesting of freshwater and estuarine species in salt ponds and inland dams or ponds on a subsistence basis. Species harvested include mullets, tarpons, tilapia, cockles and crabs. Crabs are primarily hunted during the rainy season and can be especially popular during festivals. Cockle is harvested year round and is marketed locally.

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Barbados

Freshwater prawns (*Macrobrachium carcinus*), referred to locally as crayfish, occur in catchments in Barbados and are caught occasionally by hand or using nets for household consumption but there is no organized fishery or record of catches (CRFM, 2015).

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Dominica

There is a traditional fishery for goby fry in river estuaries. The fishery is governed by lunar phases and takes places for three days a month from July to April. There may also be some fishing of prawn postlarvae for grow out in culture ponds (FAO, 2002). There is also some limited recreational fishing that takes place in La Romana, Río San Juan and Lake Hatillo above the Hatillo dam on the Yuna River.

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Grenada

A small number of finfish and crustaceans (e.g. *Macrobrachium* sp.) are harvested in small streams for household consumption mainly using handline and spear gun. While there is no organized fishery, some rural families depend fishing as part of household food strategies (FAO, 2007).

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Montserrat

There is a fishery for crustaceans in rivers and tilapia in ponds (Department of Fisheries Montserrat cited in CRFM, 2015).

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Saint Kitts and Nevis

Tilapia and mullets are fished in ponds and lagoons (Department of Fisheries Saint Kitts and Nevis, cited in CRFM, 2015).

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Saint Lucia

Several species of shrimp were fished until 1994 when a moratorium was implemented (Department of Fisheries Saint Lucia, cited in CRFM, 2015).

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Saint Vincent and the Grenadines

There is a traditional fishery for goby fry in river mouths and estuaries of some economic importance (Fisheries Division Saint Vincent and the Grenadines, cited in CRFM 2015). Saint Vincent and the Grenadines have reported inland water catches to FAO twice: in 1996 and 1997 with catches of 2 and 1 tonnes respectively.

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Trinidad and Tobago

Fish and crustaceans are harvested on a subsistence basis in rivers and streams. Inland food fish production is small and not statistically reported. The catch consists mainly of tilapia and shellfish species (e.g. *Hoplosternum littorale*). Various fishing gears are used, including hand harvesting of crabs, oysters, brackish water species and shellfish (FAO, 2007). There is commercial exploitation of teta (*Hypostomus robinii*) as an ornamental fish (Alkins-Koo *et al.*, 2004).

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7.6 OCEANIA

Country/territory	Inland capture fisheries catch (tonnes in 2021)	Percentage of global inland fish catch	Population (2021)	Per capita inland fish production (kg/cap/year)
Papua New Guinea	13 500	0.12	9 949 437	1.36
Fiji (Republic of)	2 600	0.02	924 610	2.81
New Zealand	339	0.00	5 129 727	0.07
Australia	64	0.00	25 921 089	0.00
Micronesia (Federated States of)	5	0.00	113 131	0.04
French Polynesia	61	0.00	304 032	0.20
Samoa	0	0.00	218 764	0.00
Solomon Islands	0	0.00	707 851	0.00
Vanuatu	0	0.00	319 137	n/a

The Oceania subregion comprises the continent of Australia, New Zealand and Papua New Guinea together with many Pacific Small Island Developing States (SIDS). The main inland fisheries are in Papua New Guinea with over 80 percent of the total production for the subregion. Most of the smaller Small Island Developing States have limited freshwater resources and no appreciable inland fisheries.

Papua New Guinea

Papua New Guinea has water resources including the Fly (1 200 km) and Sepik (900 km) rivers and corresponding basins. In addition, there are over 5 000 (mostly small) lakes. Over 87 percent of the human population of Papua New Guinea live inland and have no direct access to marine aquatic resources. Even in highland areas, where fish stocks are limited, over 50 percent of the population engages in fishing activities. Traditionally the target has been eels, but more recently catches include a number of non-indigenous species (Coates, 1996). Papua New Guinea's rivers and floodplains naturally have low productivity and this has been attributed to a depauperate fish fauna (Coates, 1989). During 1984 to 1997, six non-native species were introduced into the Sepik River: *Barbonymus gonionotus*, pacu (*Piaractus brachypomus*), red belly tilapia (*Coptodon rendalli*) and *Prochilodus argenteus* were introduced to lowland floodplains and snow trout (*Schizothorax richardsonii*) and golden mahseer (*Tor putitora*) were introduced to higher altitude streams. All of these species have now established breeding populations and contribute to inland fisheries (Kolkolo, 2005). Elsewhere, introduction of tilapia (*Oreochromis* sp.) has led to the species becoming dominant in markets where it is appreciated for being easy to catch and sell (Roeger *et al.*, 2024). Before the introductions the inland fishery of the country was mainly based on the Fly River.

FAO has been estimating inland fisheries catches since 1980. The current estimate of 13 500 tonnes (2021) has been unchanged since 1992. Alternative estimates of inland fish production include 25 572 tonnes based on household surveys (Fluet-Chouinard, Funge-Smith and McIntyre, 2018) and 20 000 tonnes based on extrapolated catch estimates (Gillett, 2016), both in excess of the current reported catch estimate.

Papua New Guinea also has a commercial fishery (~170 tonnes) for sea bass (*Lates calcarifer*) a dominant species in the Fly River. A commercial gillnet fishery was developed in the 1960s in coastal and estuarine waters. Annual catch reached 330 tonnes in the 1970s. The fishery was closed in early 1990s after decline of the fishery from effects of mining, overfishing and drought. A management plan was implemented in 2004 and annual catch has now reached 170 tonnes from the middle Fly River. Several other species are considered to have some economic potential (Jellyman, Gehrke and Harris, 2015).

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Republic of Fiji

The Republic of Fiji is a mountainous island state with a large number of rivers and streams, although these are not evenly distributed. The Republic of Fiji accounts for almost 16 percent of regional inland fisheries catch and a large proportion of this is freshwater clams (*Batissa violacea*), known as kai. The kai are found in all the major river systems in the country. Fishing in inland waters is fairly common, even where there are also marine fisheries and inland fisheries can be important for women, who will target fish with nets and traps, contributing to household foods, providing income and also playing cultural roles (Kitolelei *et al.*, 2022). Estimates of inland fish catch was 2 600 tonnes in 2021 and catches of freshwater finfish consist mainly of eels, mangrove prawns and introduced fish such as tilapia and carps. The fish biodiversity in Fijian rivers has been significantly affected by a loss of catchment forest cover and introductions of tilapia (Jenkins *et al.*, 2009).

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New Zealand

New Zealand had a total reported catch of 339 tonnes in 2021. Freshwater species caught include eels, trout and salmon. Also, some freshwater species such as eels, inanga (*Galaxias maculatus*) and koura (a native freshwater crayfish) are important to the Maori for their spiritual and customary needs and have been reported to have been a motivation for seasonal movements of human populations (McDowall, 1991). The New Zealand commercial eel fishery has an estimated catch of 500 tonnes. The commercial fishery for eel started in the 1960s, reaching more than 2 000 tonnes by the early 1970s, after which it collapsed. Freshwater eels were brought into New Zealand's Quota Management System in the 1990s and the commercial eel fishery currently produces approximately 500 tonnes per year and 80 percent of this is *Anguilla australis* (Jellyman, Gehrke and Harris, 2015). The cultural significance of eel have also made the status of eel populations and the eel fishery important in the context of debates over decision-making related to basin land use changes (Brodwich *et al.*, 2022).

Recreational fisheries are also important in New Zealand, including for the introduced brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*) and Chinook salmon (*Oncorhynchus tshawytscha*), the latter on the South Island. According to Embke *et al.* (2022) there are in the region of 870 000 participants in the recreational fisheries, representing around 17 percent of the population. Total catches from the recreational fisheries were estimated to be around 2 533 tonnes, of which about 50 percent is retained. By volume of retained fish, this is greater than the commercial catches.

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Australia

Australia's water resources include the MurrayDarling systems and a number of smaller rivers. Across the country there are estimated to be 315 freshwater fish species occurring in Australia. There are a number of non-indigenous species including brown trout (*Salmo trutta*), tilapia and Siamese fighting fish (*Betta splendens*).

Reported catch in 2021 was 64 tonnes. Catches from Australia have always been relatively low (maximum catch 3 512 tonnes in 1992 (FAO, 2023) and have declined from 1992 onwards. There was a small commercial fishery in New South Wales with a catch of 344 tonnes, with trap fisheries in New South Wales targeting eel, yabby, Murray cod and carp (Grant *et al.*, 2004). This inland commercial fishery in New South Wales had a mean annual catch of 344 tonnes (1965 to 1995), was worth USD 1.7 million in 1995–96 (Reid, Harris and Chapman, 1997). The fishery was phased out in 2001. Commercial estuarine fisheries still exist in the north and northeast, targeting barramundi (*Lates calcarifer*) and mullet. Eels have also been commercially harvested from southeastern coastal rivers (Jellyman, Gehrke and Harris, 2015). In Victoria State, commercial fishing existed for native species, eel and baitfish, however the commercial licences were all bought out in 2002 or all species were excluded except eel and baitfish.

Recreational fisheries have become the more significant part of inland fisheries. It is estimated that annually over 4 million people participate in inland recreational fisheries in Australia (almost 17 percent of the population). Total catch has been estimated to be around 6 700 tonnes, of which about 40 percent (2 700 tonnes) is retained (Embke *et al.*, 2022). These fisheries take place in many estuaries, rivers and lakes and additional fisheries, often of the put-and-take variety, have been created in many of the reservoirs created for water storage and management and supported through stocking programmes. These are suggested to have the beneficial effect of reducing fishing pressure on wild populations elsewhere (Jeanson *et al.*, 2021).

Across the country, threats to inland fish include land use change, habitat fragmentation, salinization and the impacts of introduced fish species and feral pig (Lintermans *et al.*, 2021). Fish populations in the main Murray-Darling River system are severely stressed because of river regulations and desiccation of the river channel and riparian wetlands (Gehrke *et al.*, 1995).

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Federated States of Micronesia

The Federated States of Micronesia (FSM) comprises around 700 islands but has a land area of just 701 km^2. The larger islands have some streams and ponds, although the largest river, the Nanpil

Kiepw, is only 10 km in length. Fisheries are important and part of the subsistence activities of many households but the focus is on marine fisheries. The main freshwater and estuarine species caught are eels, tilapia and *Macrobrachium*.

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French Polynesia

Most inland fisheries are subsistence and target fish within lowland rivers and estuaries, for example in the largest river – the Papenoo (23 km). There are a reported 37 species of freshwater fish and 18 species of decapod crustaceans (Keith, Watson and Marquet, 2002). The most important species for inland fisheries are juvenile gobies (*Sicyopterus lagocephalus* and *S. pugnans*), *Macrobrachium*, tilapia, *Kuhlia* spp. and eels. No official estimate is made for inland fishery catch, however Gillett (2016) cites estimates by staff of Service de la Pêche that, on average, catches fluctuate around 100 tonnes per year. Sea-level rise is expected to increase the area of estuarine habitat and may therefore increase the potential of inland fisheries.

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Samoa

The larger rivers of Samoa, including the Sili (51 km^2) and Vaisigano (33 km^2) provide a limited range of freshwater and estuarine fish and crustaceans. ADB (2008) reports that 2 percent of all households in Samoa engage in at least some fishing in inland rivers and lakes. People fish primarily for household consumption with some fish shared or sold. The annual catch of one tonne of freshwater fish is estimated by FAO. Gillett (2016) reports that main species in inland fisheries are tilapia, eels and freshwater shrimp and that the total annual harvest is unknown, but likely to be about 10 tonnes per year. According to Tiitii, Sharp and Ah-Leong (2014), annual average per capita finfish consumption has been estimated as 46.15 kg and invertebrates 54.74 kg (marine and inland).

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Solomon Islands

Water resources in the Solomon Islands include rivers that are 30–40 km in length such as on Guadalcanal, as well as many upland streams. Some 68 percent of households in Solomon Islands catch fish or shellfish, and one-third of all households in urban areas are engaged in fishing activities (SINSO 2015). Despite high levels of participation, information on inland fisheries and foods from inland aquatic environments remain limited. The large islands of the country mean that a relatively large inland population have no direct access to marine foods and there is a significant inland subsistence fishery (Gillett, 2016). About Anecdotal information and survey reports focused on single islands suggest that flagtails, gobies, eels, and freshwater shrimps are important native species. Tilapia, an introduced species, appears to be important, especially in small ponds and lakes. Women in inland areas harvest a range of freshwater aquatic foods consisting mainly of fish, shellfish and freshwater crustaceans from small streams and ponds that are important in traditional cooking and food preparation Gomese *et al.*, (2022). The Solomon Islands record an inland subsistence fishery landing some 2 000 tonnes per year, which do not appear in FishStat (FAO, 2009). Gillett (2016) estimates the 2014 catch to be 2 300 tonnes.

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Vanuatu

It is reported that the distribution of the various freshwater ecosystems is patchy throughout the Vanuatu archipelago, covering only 1 percent of the total land area (FAO, 2024). There are 18 families of native freshwater fish, 3 families of introduced fish, and several species of shrimps and crab. The most important taxa for fishery purposes are the native species (five genera of fish [*Khulia*, *Lutjanus*, *Gerres, Monodactylus, Scatophagus*], four species of mullets, and several species of freshwater eels), introduced species (cyprinids and two species of tilapia) and invertebrates (several species of *Macrobrachium*) (Amos, 2007). Recent annual catch from inland fisheries in the country is about 80 tonnes per year, and is almost entirely for subsistence use, except for the *Macrobrachium* shrimp which is sold in urban areas (FAO, 2024). An estimate of recent annual catch from inland fisheries in the country is about 88 tonnes per year (Gillett, 2016).

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Other countries

Catches from some island groups do not appear in the FishStat database.

7.7 ARABIA

Country/ territory	Inland capture fisheries catch (tonnes in 2021)	Percentage of global inland fish catch	Population (2021)	Per capita inland fish production (kg/cap/year)
Bahrain	0	0.00	1 463 265	0.00
Kuwait	0	0.00	4 250 114	0.00
Oman	0	0.00	4 520 471	0.00
Qatar	0	0.00	2 688 235	0.00
Saudi Arabia	0	0.00	35 950 396	0.00
United Arab Emirates	0	0.00	9 365 145	0.00
Yemen	0	0.00	32 981 641	0.00

This subregion is almost totally arid. There is no reported inland catch to FAO from any of the countries.

ANNEXES

ANNEX 2-1

SUBREGIONAL INLAND FISHERIES CATCH

Region and subregion	Inland fishery production in 2021 (tonnes)	Population (2021)	Production per capita (kg/year)
AFRICA			
Great Lakes	1 361 386	208 350 569	6.53
Western Coast	588 072	353 394 105	1.66
Nile Basin	455 292	285 950 678	1.59
Sahel	329 250	110 569 738	2.98
Congo Basin	298 788	109 528 257	2.73
Southern	264 498	198 947 702	1.33
Northern	16 125	100 252 776	0.16
Eastern Coast	200	21 791 450	0.01
Africa Total	**3 313 611**	**1 388 785 275**	**2.39**
ASIA			
Southern Asia	3 381 268	1 860 908 126	1.82
Southeast Asia	2 174 876	675 796 064	3.22
China	1 197 835	1 489 975 659	0.80
Western Asia	181 006	268 331 155	0.67
Central Asia	115 624	136 206 766	0.85
Eastern Asia	28 802	202 414 578	0.14
Asia Total	**7 079 411**	**4 633 632 348**	**1.53**
EUROPE			
Eastern Europe	59 223	156 405 446	0.38
Northern Europe	36 214	33 619 956	1.08
Western Europe	22 183	267 860 558	0.08
Southern Europe	15 503	141 522 786	0.11
Europe Total	**133 122**	**599 408 746**	**0.22**
AMERICAS			
South America	341 936	434 250 356	0.79
Central America	165 821	177 661 928	0.93
Northern America	36 350	375 152 636	0.10
Islands	5 078	36 653 273	0.14
Americas Total	**549 186**	**1 023 718 193**	**0.54**
OCEANIA			
Oceania Total	**16 568**	**43 268 641**	**0.38**
Russian Federation			
Russian Federation Total	**271 795**	**145 102 755**	**1.87**
Global	**22 727 389**	**7 955 486 054**	**2.86**

ANNEX 3-1

MODELS FOR PREDICTING POTENTIAL MULTI-SPECIES YIELD

Potential yield models for predicting multi-species potential yield from rivers, lakes, reservoirs, and coastal lagoons where a and b are the constant and slope parameters of the linear regression model: $Y = a + bx$, and where n is the number of observations, R is the correlation coefficient, and P is the probability that the slope parameter, $b = 0$. S_b is the standard error of the estimate of the slope coefficient, b, S^2_{YX} is the residual mean square, and $\overline{X}$ is the mean value of the observations of the explanatory variable.

River Fisheries

Model	Continent	a	b	S_b	n	$\overline{X}$	S^2_{YX}	R	P
ln catch vs ln FPA	Asia	2.086	0.996	0.083	13	4.31	0.531	0.97	< 0.001
ln catch vs ln length	Asia	−14.88	3.234	0.585	5	8.06	0.680	0.96	0.01
ln catch vs ln DbA	South America	−3.60	0.936	0.218	15	12.87	1.457	0.77	0.001

Lake Fisheries

Model	Continent	a	b	S_b	n	$\overline{X}$	S^2_{YX}	R	P
ln catch vs ln Area	Africa	2.668	0.818	0.042	94	4.34	1.131	0.90	< 0.001
ln catch vs ln Area (NS)	Africa	2.761	0.786	-	88	-	-	0.90	< 0.001
ln catch vs ln Area (NS)	Asia	2.895	0.856	-	39	-	-	0.76	< 0.001
ln catch vs ln Area (S)	Asia	4.545	0.552	-	25	-	-	0.76	< 0.001
ln catch vs ln Area (NS)	South America	2.646	0.665	-	12	-	-	0.60	0.040

Reservoir Fisheries

Model	Continent	a	b	S_b	n	$\overline{X}$	S^2_{YX}	R	P
ln catch vs ln Area (NS)	Africa	2.274	0.876	-	45	-	-	0.91	< 0.001
ln catch vs ln Area (S)	Asia	3.048	0.413	-	54	-	-	0.50	< 0.001
ln catch vs ln Area (NS)	Asia	2.278	0.823	-	57	-	-	0.70	< 0.001
ln catch vs ln Area (NS)	South America	2.767	0.726	-	70	-	-	0.73	< 0.001

Lake and Reservoir Fisheries

Model	Continent	a	b	S_b	n	$\overline{X}$	S^2_{YX}	R	P
ln CPUA vs. ln Rainfall (NS)	Asia	−13.73	2.113	-	12	-	-	0.72	0.009
ln CPUA vs ln Total P (S)	Asia	0.507	0.821	-	27	-	-	0.74	< 0.001
ln CPUA vs ln Total N (S)	Asia	−3.969	1.302	-	25	-	-	0.62	0.001
ln CPUA vs ln surface Chla (NS)	Asia	−3.468	2.183	-	8	-	-	0.90	0.002
ln CPUA vs ln Zoo prod (NS)	All	4.822	-0.984	-	8	-	-	0.80	0.020

Source: Hoggarth *et al.* (2006).

Lagoon Fisheries and Floodplain Lakes

Model	Continent	*a*	*b*	S_b	*n*	$\bar{X}$	S^2_{YX}	*R*	*P*
ln catch vs ln Area	Africa	2.583	0.953	-	31	-	-	0.73	< 0.001
ln catch vs ln Area	Asia	2.016	0.871	-	4	-	-	0.99	0.002
ln catch vs ln Area	South America	1.626	0.920	-	32	-	-	0.72	< 0.001
ln catch vs ln Area	Asia	3.165	0.847	-	13	-	-	0.95	< 0.001

Notes: S – stocked, NS – not stocked), FPA – Floodplain area (km^2); length – river length (km); DbA, drainage basin area (km^2); Area – lake or lagoon surface area (km^2); Rainfall – mean annual rainfall (mm/y); Total P – total surface phosphorus concentration (µg/l); Total N – total surface nitrogen concentration (µg/l); surface Chla – chlorophyll α concentration in the surface waters (µg/l); Zoo prod- zooplankton production ($g/dwt/m^2/y$).

Prediction intervals for yield corresponding to new observations of *X*, $\hat{Y}_{new}$ is given by:

$$\hat{Y}_{new} \pm t(1-\alpha; 2;\ n-2).\, s\{\hat{Y}_{new}\}$$

Where $s\{\hat{Y}_{new}\}$ is the standard error of the estimate given by:

$$s\{\hat{Y}_{new}\} = \sqrt{s^2_{Y.X}\left(1+\frac{1}{n}\right) + \frac{(X_i-\bar{X})^2}{\frac{s^2_{Y.X}}{s^2_b}}}$$

where S^2_{YX} is the residual mean square (the variance of *Y* taking into account the dependence of *Y* on *X*) and S^2_b is the standard error of the estimate of the slope coefficient, *b* of the linear regression model (Zar, 1999).

Potential yield models for predicting multi-species potential yield from reservoirs and lakes from several countries where a and b are the constant and slope parameters of the linear regression model: $Y = a + b.\log(x)$, where *x* is the surface area (km^2), *n* is the number of observations, *r2* is the coefficient of determination, and *P* is the probability that the slope parameter is significant from $b = 0$. Between brackets are the standard errors of the slope and intercept parameters (van Zwieten *et al.*, 2011).

Area	*N*	*b* (SE)	*a* (SE)	*r2*	*P*
China	79	2.5 (0.2)	0.69 (0.07)	0.52	< 0.001
Thailand	20	2.8 (0.4)	0.79 (0.10)	0.74	< 0.01
Sri-Lanka	19	4.1 (0.9)	0.43 (0.28)	0.12	< 0.05
Philippines	21	2.3 (0.4)	1.10 (0.11)	0.85	< 0.01
Indonesia	9	3.3 (0.9)	0.52 (0.34)	0.25	< 0.01
Cuba	86	3.0 (0.13)	0.72 (0.05)	0.68	< 0.001
Mexico	7	3.6 (1.81)	0.59 (0.37)	0.34	< 0.01
India	86	0.8 (0.36)	0.98 (0.12)	0.52	< 0.001
African Lakes	19	2.7 (1.2)	0.80 (0.22)	0.45	< 0.01

Empirical models of species aggregated catch per unit area, CPUA as a function of fisher density. Confidence intervals around predicted values can be calculated from the confidence intervals around the model parameter estimates provided in the references for each model.

Region/ Country	Ecosystem	Model	Units	Reference
Africa	River floodplains	$CPUA = \frac{99}{1 + \exp[1.04(1.97 - i)]}$	kg/ha/year fishers/km^2	Lorenzen *et al.* (2006)
	Lakes and reservoirs	$CPUA = i \exp(1.064 - 0.036i)$	t/km^2/year fishers/km^2	Halls *et al.* (2006)
	Lakes	$CPUA = \frac{76}{1 + \exp[5.3(0.74 - i)]}$	kg/ha/year fishers/km^2	Lorenzen *et al.* (2006)
Asia	Lakes and reservoirs	$CPUA = i \exp(0.936 - 0.007i)$	t/km^2/year fishers/km^2	Halls *et al.* (2006)
Americas	Amazon lakes	$CPUA = \frac{92}{1 + \exp[0.11(30 - i)]}$	kg/ha/year hours/ha/year	Lorenzen *et al.* (2006)
Lao People's Democratic Republic	Lakes (stocked)	$CPUA = \frac{547}{1 + \exp[0.0023(1630 - i)]}$	kg/ha/year hours/ha/yr	Lorenzen *et al.* (2006)
	Lakes	$CPUA = 609(1 - (1 - [0.00005(i - 13)])^2$		
	Floodplain	$CPUA = 157(1 - (1 - [0.0011(i - 7.6)])^2$		
All	River floodplains	$CPUA = i \exp(1.027 - 0.073i)$	t/km^2/year fishers/km^2	Halls *et al.* (2006)
Bangladesh	Closed beel	$CPUA = 1.1844E + 0.00069E^2$	kg/ha/year days/ha/year	Halls and Mustafa (2017)
	Floodplain beel	$CPUA = 410.7[1 - \exp(0.00233E)]$		
	Haor beel	$CPUA = 391.1[1 - \exp(0.00424E)]$		
	Open beel	$Y = \left(\frac{774}{1 + \exp(0.013(213.1 - E))}\right)$		
	River	$Y = \left(\frac{690.2}{1 + \exp(0.00191(891.9 - E))}\right)$		

ANNEX 3-2

SUMMARY OF CATCH PREDICTION OR INFERENCE MODEL ASSUMPTIONS

Summary of catch prediction or inference model assumptions, major sources of error, additional data and processing requirements, conditions for successful application and likely magnitude of the error in the catch estimate.

Model type	Submodel	Major assumptions / Major sources of error	Additional data or data processing requirements.	Conditions or prerequisites for successful application.	Likely error in catch estimate (Low; medium; high)	Comments
Fishing Effort	Per capita and per fisher	*Major assumptions*: Per capita or fisher catch rates are constant irrespective of population size and remain unchanging through time. *Major sources of error*: Global per fisher catch rates were derived using employment statistics that did not distinguish between full, part-time, and occasional fishers. Hence fisher catch rates are likely to be very imprecise.	*Optional:* Estimates of number of vessels type by category (no vessel, non-motorized, motorized).	None	High	Estimates derived from these models might only be useful for triangulation with estimates derived using other methods.
	Atomistic fisheries habitat yield models.	*Major assumptions*: Each fish habitat included in the assessment is an independent source of fish production. The total catch from each fish habitat category varies only with the overall area of each habitat in a linear manner. *Major sources of error*: Accurately estimating the areas of each fish habitat category included in the assessment. Existing published estimates of areal yield by major habitat category may not be representative or current. No areal yield estimates are currently available for estuarine habitat. Estimates of national inland fish catch may be underestimated because remote sensing methods cannot yet resolve small waterbodies. Area used for aquaculture which may be difficult to estimate without existing records or ground observation and measurement.	Regional estimates of areal yield by habitat category provided in Table 8 can be used in the absence of nationally derived estimates If existing regional estimates are to be applied it may be necessary to re-classify existing wetland/land use areas according to the five major categories employed by Lymer *et al.* (2016), i.e. Lakes, Reservoirs, Rivers, Floodplain, and other wetlands. Areas used for aquaculture should be identified and omitted from the analysis.	Reliable estimates of the areas of each fish habitat category over the entire area of the country, and corresponding up-to-date national estimates of areal yield. If mean areal yield values are applied (not non-linear submodels) then the areas of permanent waterbodies present in the country (lakes and reservoirs) should ideally follow a normal distribution. A prevalence of small or large waters could generate bias estimates of total yield for these habitat categories.	Probably medium in most cases, but potentially low when accurate national estimates of habitat areas and areal yields already exist or can be made, and where aquaculture production areas can be reliably estimated. Error may be higher compared to holistic fisheries habitat models because of the major model assumptions and challenges associated with determining the areas of each (seasonally connected) fisheries habitat.	Properly designed catch assessment surveys could provide reliable estimates of areal (and total) yield by species (and fishing effort) for each habitat category to meet national fisheries management and assessment needs.

Model type	Submodel	Major assumptions / Major sources of error	Additional data or data processing requirements.	Conditions or prerequisites for successful application.	Likely error in catch estimate (Low; medium; high)	Comments
Fish Habitat Models	Holistic fish habitat yield models.	*Major assumptions:* The total catch from each fish habitat category varies only with the overall area of each habitat in a linear manner. *Major sources of error*: Existing published estimates of areal yield by major habitat category available for SE Asia may not be representative or current. No estimates are currently available for estuarine habitat. Estimates of national inland fish catch may be underestimated because remote sensing methods cannot yet resolve most of the smaller rivers and streams outside the main flood zone. Estimate of area used for aquaculture, particularly in the rain-fed zone.	Existing regional estimates of areal yield by habitat category provided in Table 9 can be used in the absence of nationally derived estimates to provide preliminary estimates of national yield. If existing regional areal yield estimates for SE Asia are to be applied it may be necessary to re-classify existing wetland/land use areas according to the four major categories employed by Hortle and Bamrungrach (2015), i.e. Flood zone, rain-fed zone, large permanent waterbodies outside the flood zone, and aquaculture. Areas used for aquaculture should be omitted from the analysis.	Reliable estimates of areas of categories of fisheries habitats over the entire area of the country, and corresponding up-to-date estimates of areal yield. If mean areal yield values are applied (not non-linear submodels) then the areas of discrete waterbodies present in the country (lakes and reservoirs) should ideally follow a normal distribution. A prevalence of small or large lakes or reservoirs bias estimates of total yield for these habitat categories.	Probably medium in most cases, but potentially low when accurate estimates of habitat area and areal yields already exist or can be made, and where aquaculture production areas in the rain-fed habitats and outside the flood zone can be reliably estimated. Areal yield estimates can be 'tuned' to generate national catch estimates that match those derived using fish consumption methods.	Areal yield estimates for existing regional (SE Asian) rain-fed areas (particularly in Lao and NE Thailand) and floodplain-river habitats require strengthening. Properly designed catch assessment surveys could provide reliable estimates of areal (and total) yield by species (and fishing effort) for each habitat category to meet national fisheries management and assessment needs.
	Non-linear submodels: Morphology and production index-based models of catch and catch per unit area (CPUA) for lakes, reservoirs and floodplain rivers.	*Major assumptions*: Predicted yields are potential (maximum) values hence fisheries habitats are assumed to be fished at optimal levels. Similar habitats in different locations have similar fisheries yields despite natural variation in productivity and potential variation in rates of exploitation. *Major sources of error*: Applications when rates of production are atypical or where rates of exploitation do not correspond to optimal rates. Most models provide predictions for finfish only – other aquatic animals are normally excluded.	Model predictors such as river drainage basin area, floodplain area or length, or productivity indicators for large lakes and reservoirs) may need to be estimated if not already available. It may be practical to apply these models only to large rivers, lakes and reservoirs. Yield from the remaining smaller areas of fish habitat may need to be estimated as the product of the estimated mean areal yield for the habitat and the sum of the small areas of fish habitat.	Model predictor values exist or can be estimated. Rates of exploitation in fish habitats included in the assessment are close to their optimal rates.	Probably medium in most cases.	
	Non-linear submodels (continued): Fishing effort-based models of catch per unit area (CPUA) for lakes, reservoirs and floodplain rivers.	*Major assumptions*: Variation in yield arises only from rates of exploitation (fisher density) not from differences in rates of production. Catchability is constant among fishers irrespective of their type and gear use. *Major sources of error*: Existing model parameter estimates which may not be representative or current (accurate) owing to changes in mean habitat productivity and catchability of fishers since model development. Significant deviation in the mean proportions of full, part-time, and occasional fishers forming the fishery compared to those of the model. Most models provide predictions for finfish only – other aquatic animals are normally excluded.		Habitats have average rates of production. Reliable estimates of fisher density. Proportions of full, part-time, and occasional fishers forming the fishery are similar to those of the prediction model.	Probably medium because of the challenges associated with reliably estimating fisher density.	Models were developed to provide management guidance with respect to sustainable levels of fishing effort in different waterbodies rather than for estimating national inland fish catch.

Model type	Submodel	Major assumptions / Major sources of error	Additional data or data processing requirements.	Conditions or prerequisites for successful application.	Likely error in catch estimate (Low; medium; high)	Comments
Fish consumption-based models	**n/a**	*Major sources of error*: Per capita consumption arising from respondent recall or measurement error, under-reporting of consumption, seasonal consumption and survey extrapolation. Pre-processing and preservation factors for fish products: These may need to be estimated from other studies in the region if no national estimates are available. Fraction of inland fish consumed, aquaculture production statistics, trade statistics and estimates of waste and other utilization.	Existing per capita consumption estimates may not be representative of the entire country. Extrapolations may be necessary from areas already surveyed. Depending upon the consumption model used, estimates of production from aquaculture, marine fisheries, trade and other utilization may be required. All fish or fish products caught, cultured, consumed, traded, or otherwise utilized, must be expressed in live weight equivalent quantities. This requires knowledge of pre-processing and preservation factors, preferably by species, and considerable computations.	Availability of accurate, precise, complete and representative national per capita fish consumption estimates that account for any seasonal fish consumption. Good knowledge of pre-processing and preservation factors. Relatively insignificant, or accurate estimates of, aquaculture production, marine fish production, imports and exports of fish, waste and other utilization. Applicable to countries with minimal trade, aquaculture, marine fisheries, waste and other utilization. May not be reliable in countries where informal (unreported) cross-border trade in fish is significant.	Probably medium for most countries but potentially very high for countries where freshwater aquaculture and marine fisheries production is high compared to inland capture fishery production, or where informal trade in inland fish is high.	Fish consumption surveys require fewer resources to implement compared to catch assessment surveys owing to the lower variance in per capita consumption compared to per capita catch rates. However, disaggregating the consumption-derived catch by species is not practical because consumption survey respondents may either lack the necessary taxonomic expertise to reliably report the species they consumed, or because the consumed fish was in some processed or prepared form making species identification impossible.

ANNEX 4-1

NUTRIENT CONTENT OF SELECT SPECIES AND RECOMMENDED NUTRIENT INTAKE FOR KEY NUTRIENTS

Nutrient content of select freshwater fish species and select marine fish species per 100 g of raw, edible parts

Fish Species Name	Common Name	Protein (g)	Calcium (mg)	Iron (mg)	Zinc (mg)	Vitamin A RE (µg)
Freshwater Species						
Rastrineobola argentea[23]	Dagaa/Sardines	21.40	48.00	0.90	0.40	43.00
Amblypharyngodon mola	Mola carplet	17.10[24]	767.00[17]	3.80[24]	3.19[24]	134.00[25]
Engraulicypris sardella	Usipa/Lake Malawi sardine	15.10[26]	340.00[26]	4.60[26]	3.89[27]	29.90[27]
Marine Species						
Salmo salar[23]	Atlantic salmon	18.50	11.30	0.38	0.25	11.90

Recommended Nutrient Intake (RNI) of key nutrients for adult women and children 7–12 months of age.

		RNI for adult women		RNI/RDAs for children 7–12 months	
	Calcium (RNI, mg)	a	1 000	a	400
	Iron (RNI, mg)	a	29.4	a	9.3
	Zinc (RNI, mg)	a	4.9	a	4.1
	Protein (RNI, g)	b	51.9	c	6.6
	Vitamin A (recommended safe intake, µg)	a	500	a	400
a	Recommended Nutrient Intake (RNI) values taken from WHO and FAO (2004). Recommended iron intake based on 10 percent bioavailability of iron. Recommended zinc intake assumes moderate bioavailability of Zinc.				
b	Based on 0.83 g/kg/d, assuming a mean body weight of 45 kg (pre-pregnancy) plus 14.5 g/d throughout pregnancy and the first 12 months of lactation (WHO, 2007)				
c	Reference intake calculated for a 10 kg infant, with 0.66 g/kg of body weight/day protein requirement (WHO, 2007)				

23 Tanzania Food Composition Database accessed here
24 Based on data from Bangaldesh FCT (Shaheen *et al.*, 2013)
25 Based on median predicted nutrient values from FishNutrients
26 Based on analytical values from Malawi Food Composition Tables (MAFOODS, 2019)
27 Based on median predicted nutrient values from FishNutrients

ANNEX 5-1

ESTIMATED INLAND FISH CATCHES FOR MAJOR RIVER BASINS (TONNES).

Table 5-1.1: Large lakes and reservoirs (> 400 km^2) that support inland fisheries. Estimated production from lakes was 1 935 203–2 457 219 tonnes.

Basin	Catch (tonnes)	Ref	Basin	Catch (tonne)	Ref
Mekong (inc. Tonle Sap)	1 900 000–2 331 808	1,2	Salween River	110 018–198 294	1,2
Nile River (inc. L. Victoria)	1 171 802–1 500 653	1,2	Pearl (Xun-Jiang)	169 836	1
Irrawaddy River	589 452–1 207 888	1,2	Lake Chad Basin	155 000–184 377	1,2
Yangtze River	100 000–1 112 964	1,2	Mexican basins	151 416	3
Brahmaputra River and floodplain	935 089–981 397	1,2	Damodar	116 443	2
Amazon River	653 687–698 678	1,2	Caspian Sea	112 950–131 453	1,2
Ganges River	429 540	1,2	Ziya He	109 149	1
Chao Phraya	364 216	3	Krishna	106,894	2
Hong (Red) River	323 278–351 674	1,2	India East Coast Drainages	103 985	6
Congo (inc. L. Tanganyika)	337 281–372 402	1,2	Zambezi (excl. L. Malawi)	98 354–130 001	1,2
Niger	167 000–326 000	1,2	Orinoco River	91 024–127 742	1,2
Indus River	166 801–242 801	1,2	Godavari	90 400	2
Penner	278 776	2	Amur River	88 787	1
Yasai (India)	251 376	1	Mahanadi	82 741	2
Sumatra	217 808	1	Volta	57 091–82 091	1,2
Philippine Archipelago	203 366	1	Yongding He	72 110	2
Volga	68 200	1	Sabarmati	70 191	1
Sri Lanka (all basins)	66 910	1	Don Jiang	27 210	2
La Plata	63 849	1	Madagascar	25 940	1
India S. Coast (Kerala, Tamil Nadu)	62 913	6	Danube	24 188–25 588	1,2
Java- Timor	58 952	5	Ob-Irtysh	22 834	1,2
Lena Basin	55 434	2,4	Liao He	22 386	2
South Peninsula (Thailand)	52 659	1	Han Jiang	20 998	2
Fuchan Jiang	49 137	2	Luan He	20 105	2
Cauvery	47 913	1,2	Sulawesi	19 365	2
Min Jiang	42 723	1	Laurentian Great Lakes	19 083	1,2
Yellow (Huang He)	40 476	1	Kamchatka Peninsula	17 614	2
Kolyma- RUS	39 678	4	Tocantins-Araguaia	16 360	1,2
Yenisei Basin	39 314	4	Neva	16 255	2
Angola Coastal Drainages	38 514	3	Kalimantan	15 125	2
Finland (all basins)	36 500–40 952	1,2	Casamance	15 000	1
India West Coast	35 519	6	India NE coast drainages	14 807	2
Japan (all basins)	32 868	3	Korean Peninsula (all basins)	14 333	2

Table 5-1.1 (Continued)

Basin	**Catch (tonnes)**	**Ref**	**Basin**	**Catch (tonne)**	**Ref**
Limpopo	31 010	1,2	Ural	13 631	1,2
Senegal	30 540	1,2	Daling He	12 932	2
Dnieper	12 600	2	Kuban	4 000	4
Mahakam	12 350–31 000	1,2	Cross	3 500–8 800	1,2
Brahmani	12 153	2	Murray-Darling	3 433	1,2
Anadyr- RUS	10 669	4	Sepik	3 000–5 000	1,2
Sweden	10 250	1,2	Mahi	3 322	2
Tapti	10 235	1,2	Ogooué river (Gabon)	2 507	2
Narmada	9 619	1,2	Gambia	2 35–2 700	1,2
Pyasina, Taz, Pur, Khatanga	9 036	4	Fly	2 350	1,2
Don	9 000	4	NE S. America, S. Atlantic Coast	1 350	2
Mississippi	8 988–11 041	1,2	Amu Darya	1 000–3 000	1
Tarim	7 658	2	Kura	1 096	2
Ouémé river	6 484	2	Okavango	676–730	1,2
Malaysian Peninsula	5 924	2	New Zealand	832	2
Magdalena	5 808–9 094	1	England and Wales	747	2
Rufiji	5 500–7 500	2	Yukon (Pacific and Arctic coast)	514	1,2
Mezen	4 860	4	Dniester	500	2
Northern Dvina	4 860	4	Kaladan	428	6
Pechora	4 860	4	Iceland	201	1
Shebelli-Juba	100	1	Ireland	78	1
Lake Chany	5 107	4	Narva	2 388	4
Onega	1 430	4	–	–	–

Sources: 1) Ainsworth, Cowx and Funge-Smith, 2021; 2) Ainsworth, Cowx and Funge-Smith, 2023; 3) Funge-Smith 2018; 4) Calculated from Kolonchin *et al*., 2024; 5) Calculated from BPS-Statistics Indonesia, 2018; 6) Calculated from India Department of Animal Husbandry, Dairying and Fisheries, 2014.

Table 5-1.2: Large lakes and reservoirs (> 400 km²) that support inland fisheries. Estimated production from lakes was 1 935 203–2 457 219 tonnes. Sources are the same as for Table 5.1.1.

Country/ Basin containing lake/ reservoir	Lake Name	Catch (tonne)	Ref
Nile Basin	Lake Victoria	752 024–1 061 107	1,2
Mekong Basin	Tonle Sap	179 500–246 000	1,2
Congo Basin	Lake Tanganyika	164 310–188 380	1,2
Chad Basin	Lake Chad	155 000–184 377	1,2
Caspian Basin	Caspian Sea	112 950–131 453	1,2
Nile Basin	Lake Albert	110 000	1,2
Nile Basin	Lake Manzala (brackish)	62 272	1,2
Nile Basin	Lake Burullus (brackish)	52 076	1,2
Volta Basin	Lake Volta	40 000–65 000	1,2
Zambezi Basin	Lake Malawi	33 000–44 000	1,2
Nile Basin	Nasser Reservoir	26 290	1,2
Congo Basin	Lake Kivu	21 400	1
Philippines	Laguna de Bay	20 400	1,2
Nile Basin	Lake Kyoga	15 000–34 700	1,2
Great Lakes Basin	Lake Erie	13 422	1,2
Congo Basin	Lake Bangwelu	12 298–17 849	1,2
Egypt	Egyptian Lakes (Edku, Bardawil, Quarun)	12 798	1,2
Turkey	Lake Van	12 744	1
Philippines	Lake Taal	11 800	1
Philippines	Lake Buluan	11 200	1
Titicaca Basin	Lake Titicaca	10 160	1,2
Philippines	Lake Lanao	10 000	1
Thailand	Songkla Lake	9 634	1
Nile Basin	Jebel-Aulia Reservoir	8 000	1
Bandama Basin	Kossou Reservoir	8 000	2
Zambezi Basin	Lake Kariba	7 593–19 420	1,2
Canada	Lake Winnipeg	6 428	1
Nile Basin	Lake Edward	6 000	1,2
Niger Basin	Kainji Reservoir	6 000	2
Congo Basin	Lake Mweru	5 953	1,2
Philippines	Philippine Lakes	5 828	1
Russia	Lake Chany	5 107	6
Russia	Lake Ladoga	4 794	6
Nigeria	Lagos Lagoon	4 000	2
Turkana	Lake Turkana	3 076–4 413	1,2
Russia	Lake Peipus/ Pepsi	2 388	6
Great Lakes Basin	Lake Huron	2 020	1,2
Great Lakes Basin	Lake Superior	1 844	1,2
Great Lakes Basin	Lake Michigan	1 544	1,2
Democratic Republic of the Congo	Lake Tumba	1 500	1
Russia	Lake Onega	1 430	6
Indonesia	Lake Toba	1 150	1
Canada	Great Slave Lake	1 000	1
Armenia	Lake Sevan	1 000	1
Yenisei Basin	Lake Baikal	789	6
China	Lake Balkhash	459	2
Mongolia	Lake Khövsgöl	325	1
Ethiopia	Lake Tana	292–360	1,2
Great Lakes Basin	Lake Ontario	253	1,2
Canada	Lake Nipigon	152	1

Table 5-1.3: Contribution of aquatic habitats (lakes/ reservoirs, rivers, floodplains and basins) and country data to the estimated global inland fisheries catch. Note a mean value was used for range estimates. Values in parenthesis is the percentage contribution of habitat and country to continental total.

Catch Unit	Continent/Region					
	Asia	Africa	Europe	Northern America	South America	Russian Federation
Country	4 859 081 (54%)	456 535 (17%)	86 964 (99%)	–	676 183 (76%)	283 417 (86%)
Lake/ Reservoir	418 342 (5%)	1 723 587 (66%)	–	26 511 (14%)	18 682 (2%)	14 508 (4%)
Basin	1 580 407 (18%)	73 445 (3%)	1 026 (1%)	151 416 (80%)	1 350 (0%)	17 614 (5%)
River	1 246 156 (14%)	307 392 (12%)	–	10 528.5 (6%)	187 071 (21%)	13 631 (4%)
Floodplain	820 175 (9%)	65 823 (3%)	–	–	1 450 (0%)	–

REFERENCES: GENERAL INFORMATION SOURCES

Throughout the document, specific sources of data and information are referenced, and the full bibliographic references are provided at the end of each chapter. In addition to the specific sources, several large datasets have also been used to support the analysis presented in the review and these are as follows:

Dataset	Source
Global inland fishery production	**FAO.** 2023. FishStat: Global capture production 1950–2021. In: FishStatJ. Available at www.fao.org/fishery/en/statistics/software/fishstatj. Licence: CC-BY-4.0 **Embke, H.S., Nyboer, E.A., Robertson, A.M., Arlinghaus, R., Akintola, S.L., Atessahin, T., Badr, L.M., Baigun, C., Basher, Z., Beard Jr., T.D., Boros, G., Bower, S.D., Cooke, S.J., Cowx, I.G., Franco, A., Gaspar-Dillanes, Ma. T., Puentes Granada, V., Hart, R.J., Heinsohn, C.R., Jalabert, V., Kapusta, A., Krajč, T., Koehn, J.D., Lopes, G., Lyach, R., Magqina, T., Milardi, M., Nattabi, J., Nyaboke, H., Phang, S., Potts, W.M., Ribeiro, F., Mercado-Silva, N., Sreenivasan, N., Thorpe, A., Treer, T., Ustups, D., Weyl, O.L.F., Wood, L.E., Zengin M. & Lynch, A.J.** 2022. Global dataset of species-specific inland recreational fisheries harvest for consumption. *Scientific Data*, 9: 488. https://doi.org/10.1038/s41597-022-01604-y
Population data	**FAO**. 2023. FishStat: Total population Food Balance sheet workspace. In: FishStatJ. Available at https://www.fao.org/fishery/en/statistics/software/fishstatj. Licence CC-BY-4.0 **United Nations Population Division.** 2022. World Population Prospects 2022. [Accessed on 13 November 2023]. https://population.un.org/wpp.
Administrative unit delineation *Hydrological/river basin and sub-basin delineation and descriptions*	**FAO.** 2015. Global Administrative Unit Layers (GAUL). In: *FAO Datasets.* Rome, FAO. https://data.apps.fao.org/catalog/dataset/global-administrative-unit-layers-gaul-2015 **FAO.** 2011. Major hydrological basins of the world. In: *FAO Datasets.* Rome, FAO. https://data.apps.fao.org/catalog//iso/7707086d-af3c-41cc-8aa5-323d8609b2d1
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	IUCN (The World Conservation Union), IWMI (the International Water Management Institute), the Ramsar Convention Bureau & WRI (The World Resources Institute). 2003. *Watersheds of the world*. [CD-ROM]. Washington, DC, IUCN, Colombo, IWMI, Gland, Switzerland, the Ramsar Convention Bureau & Washington, DC, WRI. https://www.wri.org/watersheds-world
Surface water and water storage, dams, lakes and reservoirs	**Messager, M.L., Lehner, B., Grill, G., Nedeva, I. & Schmitt, O.** 2016. Estimating the volume and age of water stored in global lakes using a geo-statistical approach. *Nature Communications,* 7: 13603. https://doi.org/10.1038/ncomms13603 Data available at www.hydrosheds.org
	Lehner, B., Reidy Liermann, C., Revenga, C., Vorosmarty, C., Fekete, B., Crouzet, P., Doll, P., Endejan, M., Frenken, K., Magome, J., Nilsson, C., Robertson, J.C., Rodel, R., Sindorf, N. & Wisser, D. 2011. *Global Reservoir and Dam Database, Version 1 (GRanDv1): Dams, Revision 01.* New York, USA, NASA Socio-economic Data and Applications Center (SEDAC). https://doi.org/10.7927/H4N877QK **BfG (Federal Institute of Hydrology).** 2020. *The GRDC - Global Runoff Database*. Koblenz, Germany. https://grdc.bafg.de/GRDC/EN/Home/homepage_node.html

Biodiversity-related	**Tedesco, P., Beauchard, O., Bigorne, R., Blanchet, S., Buisson, L., Conti, L., Cornu, J.F., Sversut Dias, M., Grenouillet, G., Hugueny, B., Jézéquel, C., Leprieur, F., Brosse, S. & Oberdorff, T. 2017.** A global database on freshwater fish species occurrence in drainage basins. *Scientific Data,* 4: 170141. https://doi.org/10.1038/sdata.2017.141
	Ramsar Convention on Wetlands, n.d. *Ramsar sites information service.* Gland, Switzerland. https://rsis.ramsar.org/ **Froese, R. & Pauly D.,** eds. 2024. *FishBase*. Kiel, Germany. https://fishbase.us **IUCN.** 2024. *The IUCN Red List of Threatened Species. Version 2023-1.* Cambridge, UK. https://www.iucnredlist.org
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Inland capture fisheries are widespread and productive, continuing to provide important opportunities to meet global developmental and environmental goals. The state of inland fisheries provides up-to-date evidence on the status and trends of inland capture fisheries at global, regional and subregional levels. It places these fisheries in the context of overall global fish production and of ongoing environmental and social change. Drawing on available information, contributions in terms of food production, nutrition, employment, and economic roles are highlighted with respect to those countries/regions or subnational areas where these fisheries are particularly important.

Thematic chapters provide contributions advancing the ecosystem approach to fisheries, emphasizing the different dimensions and connections associated with inland capture fisheries. These connections include between participation in inland fisheries and other livelihood activities, fish production and consumption, fisheries and other economic activities at the basin scale and between formal and informal economies and institutions, knowledge and practice. These contributions identify promising avenues for assessment and management, policy, research and capacity building that support the Blue Transformation agenda. Moreover, improved knowledge, and recognition of inland capture fisheries and the roles that they play, can assist with their incorporation into broader integrated water resources, development and environmental planning and policy.

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