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Conservation of freshwater biodiversity in key areas of the Colombian Amazon

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CONTENTS

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ABSTRACT

Freshwater ecosystems maintain incredible ecological processes that support millions of species, including human beings. Important goods and services ranging from food and building materials to water cleansing, flood and erosion control, cycling of nutrients and flow of energy are provided. With expansion of the human population, the maintenance of economies based on extraction patterns and the dependence of people on natural resources (especially aquatic resources), the conservation of freshwater ecosystems is at serious risk.

Due to this crisis it is a priority to implement effective conservation strategies that ensure the mitigation and prevention of threats and contribute to the proper use of freshwater biodiversity. Currently, the identification of key conservation areas has become one of the most accepted strategies among conservationists and local inhabitants. This strategy is essential in a country like Colombia where Amazonian rivers and lakes hold approximately 3000 species of algae and fish, provide at least 80% of the animal protein consumed by local communities, support daily transport, communication and recreation activities, and are the main supply of drinking water.

This research constitutes the first attempt to systematically identify key conservation areas in the freshwater ecosystems of the South of the Colombian Amazonian Trapezium. This effort considered not only fine filter targets (species) as central elements of decision making, but coarse filter targets (habitats), ecosystem services, social benefits, and threats. Due to the complexity of the study area, a multi-criteria assessment constituted the best way to tackle the issues affecting a complex ecological, cultural, social, economic and political territory.

The use of conservation surrogates (species and habitats) constitutes an accurate conservation strategy to identify the dynamics between humans and the environment, enabling the identification of human stressors to the ecosystem.

Five of the ten sites assessed, the Tarapoto Lakes System (1), Caballo Cocha Lake (Peru) (2), Yahuarcaca Wetland System (3), Loreto River (4) and the Mocagua Island and surroundings (5), are considered critical areas for special protection. The remaining five sites, Patrullero Island and surroundings (6), Atacuari River (7), River Amazon – Naranjales area (8), River Amazon – San Jose area (9) and Yahuarcaca creek (10), although were not considered as important as the former ones, but their inclusion in all conservation initiatives is vital to ensure the continuity of all ecological processes and biodiversity maintenance in the area.

Conservation initiatives and management actions are proposed not only aiming to ensure the conservation of habitats and species, but also to ensure the protection of ecosystem services and the improvement of the livelihoods of local communities. These actions are addressed through nine working lines: Fisheries Management, Agricultural practices improvement, Habitat restoration, Environmental Education, Local Communities Empowerment, Spatial Planning, Stakeholders Network Enforcement, Scientific Research, and Central and local Governments organization and primordial actions. These lines and actions are intended to strengthen self-management processes of the local hydro-biological resources respecting both aquatic and terrestrial realms as well as the socio-cultural patterns of the region. This research attempts to make an effective contribution to the conservation of the freshwater biodiversity and the quality of life of local inhabitants of the Colombian Trapezium as well as to contribute to the implementation of the objectives of the Convention on Biological Diversity (CBD), Ramsar Convention on Wetlands, the Convention on International Trade in Endangered Species (CITES), the Convention on the Conservation of Migratory Species of Wild Fauna and objectives proposed in the Colombian and Amazonian Environmental Policies.

CHAPTER 1

GENERAL INTRODUCTION

1.1. Background: The importance of inland aquatic systems

Freshwater habitats cover less than 1% of the Earth's surface and provide shelter to 7% (126,000 species) of the estimated 1.8 million species described (Gleick 1996, Balian *et al*. 2008). According to Groves *et al*. (2000), they are considered dynamic groups of ecological aquatic communities joined by similar hydro-geomorphologic patterns and similar ecological processes or environmental gradients. They provide important goods and services ranging from food and building materials to water cleansing, flood and erosion control, cycling of nutrients and flow of energy. However, growth of the human population, the expansion of economies based on extraction patterns and dependence of people on natural resources (especially aquatic resources), are putting freshwater ecosystems at serious risk. (Millennium Ecosystem Assessment 2005). Freshwater habitats as the most threatened and fragile ecosystems, even more than forests, grasslands and coastal systems (Cowx *et al*. 2004, Revenga *et al*. 2005). This decline in the environmental integrity of these particular habitats has brought aquatic ecosystems to the point where conservation actions must address their rehabilitation, rather than target prevention of their deterioration or destruction. Rehabilitation initiatives are not a reversal of degradation due to the complexity of the dynamics of these ecosystems, but may at least recover basic habitats that will support groups of species and allow continuity of vital ecological processes (Armanatrout 1995, Coates 1995, Welcomme 1995; 1997, Collares-Pereira & Cowx 2004, FAO 2009).

According to the Millennium Ecosystem Assessment (2005), approximately 50% of fresh waters have been lost and 60% of large rivers have been fragmented due to dams and other infrastructure. Moore *et al.* (2010) stated that there are some 45,000 dams that are a source of conflict around the world and there are only a few rivers that remain untouched by this intervention. The impacts caused by dams range from displaced human populations (estimated between 40-80 million), large scale alteration of natural hydrological regimes to emissions of large amounts of greenhouse gases (GHG) causing up to 4% of all human-induced GHG emissions (Mäkinen & Khan 2010). Around 472 million river-dependent people have had their livelihoods affected by dams (Richter *et al.* 2010). Against this, 20% of reservoirs have been degraded by flow of sediments coming from rivers affected by human activities and 30% of sediments destined to reach the oceans are now intercepted by dams. With the growth of human population, pressures on the use of natural resources to meet essential needs for survival are increasing. Human activities, including water abstraction for domestic, industrial and agricultural use, effluent disposal, mining, dams and hydro-ways, over exploitation of fish stocks, wrong use of fishing gears, hunting, logging, aquaculture farms, and navigation (Cowx *et al.* 2004), have interrupted, degraded or destroyed the functioning of aquatic habitats and

with it have caused the extinction of many species as well as the reduction of populations of aquatic mammals, reptiles and amphibians.

According to Silk and Ciruna (2004), the extinction rate for freshwater biodiversity is predicted to be five times faster than other groups of species. Nowadays, more than 90% of the freshwater species are listed as at risk: vulnerable, endangered, critically endangered or extinct[1], due to the high impact of human activities, and 71% of the fish extinctions around the world are induced by humans (Abell *et al.* 2007). According to the IUCN Red List, restricted freshwater fauna and their associates are highly threatened, 1157 out of the 15,170 valid recognized freshwater fish species are listed endangered, while only 241 out of the 16,764 valid marine species are listed (Eschmeyer *et al.* 2010). There are also approximately 2088 of 6340 amphibian species (Wake & Vredenburg. 2008), 158 of 8259 reptile species (Island Press 2009), 2134 of 7520 bird species (Hawkins *et al.* 2007) listed as threatened (Critically Endangered, Endangered, Vulnerable, or Nearly Threatened) according to the IUCN Red list (Coates 2001, Saunders *et al*. 2002, Suski & Cooke 2007, IUCN 2010). In addition, the seven species of river dolphins are vulnerable or endangered with one species ecologically extinct in 2006 (Yangtze River Dolphin – Baiji – *Lipotes vexilifer* (Miller 1918)) (Turvey *et al.* 2007), the four species of Sirenia are considered Vulnerable (IUCN 2010) and 5 of the 7 species of river otters are classified as endangered, vulnerable or nearly threatened (Silk & Ciruna 2004, IUCN 2010).

In South America, the situation is equally as critical. Eschmeyer (2009) and Revenga *et al.* (2005) showed that 465 new freshwater fish were described between 2000 and 2005; a figure that corresponds to a new species every four days. Although these data must be treated with caution, the declaration of new species has accelerated in recent years, illustrating how many other species still have to be described (Coates 2001). New and more effective strategies for conservation must be sought to ensure that threats are mitigated and prevented, whilst at the same time, natural resources and the welfare of local communities are protected and conserved.

[1] According to the IUCN (2011): **Extinct** (EX): "A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form".

Critically Endangered (CR) "A taxon is Critically Endangered when the best available evidence indicates that it meets any of the following criteria: Reduction in population size; Geographic range in the form of either extent of occurrence or area of occupancy or both; Population size estimated to number fewer than 250 mature individuals, and Quantitative analysis showing the probability of extinction in the wild is at least 50% within 10 years or three generations, whichever is the longer (up to a maximum of 100 years)".

Endangered (EN) "A taxon is Endangered when the best available evidence indicates that it meets any of the following criteria: Reduction in population size, Geographic range in the form of either extent of occurrence or area of occupancy or both, Population size estimated to number fewer than 2500 mature individuals, and Quantitative analysis showing the probability of extinction in the wild is at least 20% within 20 years or five generations, whichever is the longer (up to a maximum of 100 years)".

Vulnerable (VU) "A taxon is Vulnerable when the best available evidence indicates that it meets any of the following criteria: Reduction in population size; Geographic range in the form of either extent of occurrence or area of occupancy or both, Population size estimated to number fewer than 10,000 mature individuals, Population very small or restricted, and Quantitative analysis showing the probability of extinction in the wild is at least 10% within 100 years".

1.2. Importance of freshwater ecosystem services to livelihoods and conservation

Human society and cultures, knowledge systems, religions, heritage values, and social interactions have always been influenced and shaped by the nature of freshwater ecosystems, but, conversely, these ecosystems have been shaped and transformed by human actions. The wellbeing of human society is based on the use of natural resources; agricultural production and the collection and extraction of resources from the forest and rivers (fisheries) as the main examples for South America. The dependency on natural resources and especially on the goods and services provided by freshwater ecosystems (fisheries and clean water for human consumption) is a key driver of the livelihood patterns of many societies. Nowadays, prospects for major production systems, such as forestry, agriculture, fishing and ecotourism and aspects like health, are all directly linked to freshwater ecosystem services, while other sectors such as insurance and banking are strongly, if less directly, influenced by changes in ecosystem services (Millennium Ecosystem Assessment 2005). Rivers and other aquatic ecosystems are exposed to direct and indirect drivers causing changes in their ecology, functioning and balance. The magnitude and extent of the changes are also influenced at temporal and spatial scales that vary according to the geographical area as well as the type of system.

The human population depends on the good quality of aquatic ecosystems; this dependency is potentially stronger for those who live in tropical countries where large river systems exist and an elevated number of people live on their banks. The dynamics of use of fresh waters between the developed world and third world countries differ markedly. In the third world or developing countries, rapid changes in modern society and the influence of an economy based on capitalism has forced traditional (indigenous, tribal and peasant) communities to integrate into a dynamic market and economy, changing their perceptions and the way they use and trade natural resources. Nowadays the extraction and use of freshwater resources are no longer to meet the needs of local families, but to supply local, regional, national and international markets. According to Trujillo (2007), market integration decreases the dependency on the environment (as a share of household income) but increases the extraction of forest and aquatic products in absolute terms. Trujillo also stressed that increases in total household income are thus associated with both more market income and more income from natural resource extraction. Consequently, as markets open and household incomes increase, pressures on environmental resources are also likely to increase.

This market integration is now more evident in inland fisheries, one of the most important and visible activities in the use and exploitation of aquatic resources. In developing countries food security is provided mainly by fish (FAO 2009), Welcomme *et al*. (2009) estimated that some 10 million tonnes were harvested from the inland waters of the world in 2007; 65.5% came from Asia (34.3% of catches come from China, the single largest producer of inland water products), 24.6% from Africa and 4.1% from South America. In summary, 60% of the catches (excluding China) come from developing and emerging economies. This entire process is estimated to involve more than 56 million people (Welcomme *et al.* 2009) and in places like the Amazon River Basin, fish provides 80% of the protein consumed by locals. Fisheries is one of the most

important extraction activities that combine biological, ecological, social, cultural, and economic aspects of communities and regions, and are considered a key element to understand functioning of freshwater ecosystems, their components and the dynamics of their use. The importance of fisheries goes beyond a simple human activity, and it is now considered critical to include them in any freshwater conservation programme (identification of fish species, fishing areas and gears as well as the social aspects of fishermen and their dependents).

Aside from fisheries, most of the other goods, services and benefits provided by these systems have not been taken in to consideration by researchers and stakeholders. A wider approach to freshwater ecosystems and all their components (including humans) is being considered and is included in several freshwater resources' planning strategies such as conservation and development programmes. Earlier conservation strategies were focused on the protection of a particular animal or plant species without the inclusion of any social or environmental aspect that could influence its existence and/or conservation. The lack of success of some conservation actions in the past could be explained in part because of this narrow vision.

1.3. Global Conservation Strategies

It was not until 1992 at the Convention on Biological Diversity (CBD) held in Rio de Janeiro that the world of conservation changed. The concept of Sustainable Development was introduced and when conservation strategies stopped being linked to ecosystems, species and genes, but also to the socio-economic realities of local communities and regions. Since then, governments from all over the world have been committed to addressing their policies to reach the three aims established by the Convention: "conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources" (CDB 2005). As part of the meetings (Conference of the Parties – CoP) held by the CBD over the last two decades, different approaches to overcome biodiversity loss and to ensure conservation success have been described. In 1996 the concept of an *ecosystem approach* evolved, proposing a more integrated management of land, water and living resources. In 1998, the *inland water* diversity concept was described to establish the importance of the biodiversity associated to any continental water systems as a significant source of food, income and livelihood, particularly in rural areas in developing countries. In 2001, the *Protected Area* (PA) coverage was endorsed by the seventh Conference of the Parties (CoP7) as an indicator for reducing the rate of biodiversity loss and highlighting the importance of PAs as the foundation of biodiversity conservation, key habitats maintenance, refugia presence, species migration and movement, and ensuring natural processes continuance across the landscape. In 2004, the CBD Parties made the most comprehensive and specific protected area commitments ever made by the international community by adopting the Programme of Work on Protected Areas (PoWPA). With all these advances and the commitment of 193 parties (168 signatures by 2011), policies and conservation strategies on a global scale began to be conducted differently.

Specific freshwater conservation initiatives took place in 2003 during the IUCN V Congress of World Parks held in Durban, South Africa, where the need to implement integrated river basin management using Freshwater Protected Areas (FWPA) as a tool to the conservation of these ecosystems was recognised. This proposal was supported by the Ramsar Convention on Wetlands, which agrees and enhances the identification and maintenance of representative continental aquatic systems as the most appropriate way to reduce freshwater biodiversity loss and habitat degradation.

From the moment freshwater habitats began to be viewed from a more holistic perspective, a new dimension in freshwater conservation evolved. Currently international organizations such as The World Wildlife Fund for Nature (WWF), Conservation International (CI), The Nature Conservancy (TNC) and their associates have developed different freshwater conservation strategies and schemes to overcome the threats identified and to re-establish freshwater ecosystems and their biodiversity. These initiatives have been implemented mostly in temperate freshwater systems and range from Eco-region conservation, Ecosystem Management (EM), Integrated River Basin Management (IRBM) and Integrated Water Resources Management (IWRM). All these initiatives deal with the technical as well as the socio-economic and ecological aspects of the hydrographic units, considering as much as possible every element related to the basin and its components. Countries with temperate climates with small to medium river basins manage to implement these initiatives successfully, in part because of the moderate size of the basins, clearer legislations and stronger enforcement policies, and a considerable reduced number of stakeholders compared with larger tropical river basins.

1.4. Tropical freshwater resources management and conservation strategies: South America and the Amazon River basin

Tropical freshwater ecosystems are extremely dynamic and maintain a diverse structural complexity. Large river-level fluctuations affect environmental conditions on a more or less annual cycle, causing habitats and species to change on a seasonal basis (Junk *et al.* 1997). These changes in water levels and the transitions from an aquatic to a terrestrial phase not only create and destroy a series of heterogeneous aquatic habitats but are the key to maintaining important levels of aquatic biodiversity expressed in complex food webs. The diversity of these systems is also represented by the diversity of the local communities that depend on them. Local peoples from different ethnic backgrounds, as well as political, economic and historic realities, have been modelling their lifestyles according the use of the resources and evolving societal aspirations.

The complexity of tropical river systems and their users make conservation initiatives more complicated to formulate and implement. The current method of protecting the space where a species exists is improving its chances of conservation. Freshwater, marine and terrestrial biodiversity conservation initiatives based on protected areas and the identification of human activities effecting survival, are leading to promotion of areas where important elements of the local, regional, national or even global biodiversity are highly represented. Concepts such as

Areas of High Environmental Value (Jennings *et al.* 2002), Key Conservation Areas, Key Biodiversity Areas (KBA) (CI 2008), Special Areas of Conservation (SACs) or Special Protection Areas (SPAs) (Embling *et al*. 2010), are now used as conservation strategies to identify key sites to conserve important elements of biodiversity and to prevent habitat deterioration and/or the resource depletion. The recognition of these areas also highlights a list of threats, needs and many other facts that characterise special features of the region and its human inhabitants. The identification of these areas normally targets the implementation and creation of Protected Areas (PA) in locations where social, legal and cultural features allow. In terrestrial and marine realms, conservation initiatives vary and differ from each other and from the ones implemented in freshwater realms. For the first two cases, Protected Areas are seen as an integral part of conservation management. According to Koehn (2003), terrestrial PAs have an extensive theoretical basis for their design and include concepts like, island biogeography, patch dynamics and genetics. For marine reserves, that framework is still in its early stages and most of these designs have been drawn from experiences in the terrestrial realm, which sometimes may not be valid due to differences in scale and variability. For Freshwater Protected Areas (FWPAs) there is still little available theoretical basis for their design and until now most of the efforts made for their identification and creation are based on the knowledge that decision makers have about the area and its components.

FWPAs are a key tool for providing a sound basis for freshwater ecosystems, their ecosystem services and endangered species management, helping to maintain ecological processes, conserving species and genetic variability, and maintaining the productive capacities of these ecosystems. However, to accomplish that, PAs should include the whole variety of habitats needed by the species to fulfil their different life stages, as well as those habitats serving as corridors between vital spaces. Protected Areas enable threats to be controlled, but this is not possible outside the boundaries of PAs. It should be noted that PAs can suffer from activities outside its boundaries that influence ecosystem functioning within. For example, discharge of an effluent to a river upstream of PA through which the river flows. These protected areas can also play a key role in conserving the historical and cultural characteristics of local people and their traditional lifestyles (Portocarrero-Aya *et al.* 2010), and they must also be thought of as a piece of a larger adaptation strategy rather than as a stand-alone intervention (Pittock *et al.* 2008). From a conservation point of view, the protection of large areas is ideal but aspects related to social and economic dimensions could constrain the size and objectives of a PA and influence its management and the resources available to maintain its integrity (Embling 2010). In areas of high environmental value where is not possible to establish a FWPA because of legal, political or social reasons, it is important to develop a different strategy or management mechanism to enable protection (Cowx & Portocarrero-Aya in press).

One area where such a scenario is being enacted is the Amazon River Basin, where the scale of its freshwater systems places it as one of the most important areas of freshwater biodiversity in the world and at the same time where increasing threats are risking its integrity. This freshwater system has always been in the focus of conservationists and despite the well-

publicised rate of its deterioration (Scherr & Yadav 1996), a very low percentage of it is legally protected by any kind of conservation strategy. Only a few of its aquatic ecosystems are incidentally protected within the boundaries of terrestrial PAs (Saunders *et al*. 2002). In South America the representation of freshwater protected areas (FWPAs) is generally low compared with other regions. For example, according to the 'List of Wetlands of International Importance' (Ramsar Convention 2011), the total number of Ramsar sites for South America is 86. Of these only 10 are located in the Amazon River Basin. Protected Areas located in lowland rivers and streams are also poorly represented. Here, as in the rest of the world, rivers are seen as markers, borders, navigation paths rather than highly dynamic and important habitats requiring protection. The paucity of FWPAs and effective conservation strategies is contributing to the increased risks and threats faced by the Amazonian freshwater biodiversity.

Of the Protected Areas designated specifically for the protection of elements of aquatic biodiversity in the Amazon region, only the Pacaya-Samiria Reserve in Peru (20,800 km^2) was created specifically for the protection of an aquatic species (the fish pirarucu or paiche *Arapaima gigas* (Muller, 1843)) (Junk *et al.* 2007). In Brazil, the Mamiraua Sustainable Reserve (57,000km^2) embraces the protection of flooded forest as a conservation objective. In Colombia the NNP La Paya (42,200 km^2) in the Putumayo region was created for its wetlands (Castellanos-Mendez 2001). The identification of these conservation objects or surrogates as representatives of the local or regional biodiversity is valuable for establishing key freshwater areas and is crucial for conservation purposes. Lack of data regarding species, ecosystems and their processes can sometimes affect their conservation; consequently, conservation surrogates can be part of the solution to this problem. These surrogates are species or habitats, that due to certain features become representatives of other less visible species, taxa or the overall biodiversity (umbrella and flagship species), a shortcut to monitor or solve conservation problems, and elements to assess anthropogenic disturbances (indicator species) (Caro & O'Doherty 1999, Margules & Pressey 2000).

The Amazon River basin is seriously threatened and this current status could be jeopardizing the ecological integrity and conservation of the largest freshwater systems on earth as well as the livelihoods of a big part of the human population. This basin supports 50% of the global biodiversity and discharges into the Atlantic Ocean 20% of the fresh water delivered to the oceans by rivers (McClain *et al.* 2001). It has more than 1000 tributaries, three of them longer than 3000 km (Madeira, Purús and Yurua rivers) (ACTO 2004) and also supports about 39 million people, including more than 420 indigenous groups. The basin has an extension of 7,435,509 km² and the Amazon River is considered the largest in the world with a length of 6992 km (UNEP & ACTO 2009). It has been estimated that the availability of water in the region has been decreasing as a consequence of a series of human activities related to the increase of agriculture, the destruction of highland ecosystems and recent climate alterations (Ruiz *et al.* 2007).

Dinerstein (1995) recognized the western Amazonia, and especially the areas close to the Andean foothills, as spaces of well-known and surprising diversity in species and endemism.

This heterogeneity can be explained by differences in its geology and geomorphology, which create environments with a wide diversity of drainage systems and soil qualities that create important differences in ecosystem composition and structure. The diversity of the flora and fauna species in this basin has facilitated their use as food (agriculture or gathering of natural products), handicrafts or medicine. According to UNEP & ACTO (2009), there are more than 2000 species of plants identified as useful for nutritional and medicinal purposes, and for oils, greases and waxes.

The Amazonian terrestrial biodiversity is highly recognized. It is possible to find one third of world's known vascular plants only in Brazil, Colombia and Peru. Brazil not only has the greatest territorial extension of the continent but it also is the country with the greatest number of plant, mammal, bird, reptile and amphibian species (more than 58,000 species). Colombia follows it with almost 49,000 species; Peru, with 38,020 species; and Bolivia, with 22,268 species (UNEP & ACTO 2009).

Amazonian aquatic biodiversity is also very rich and, like the chemistry of its waters, is diverse and complex. Different studies revealed around 274 species of micro algae, 149 species of Rotifera, 3000 registered species of fish (Galvis *et al*. 2006, Ruiz *et al*. 2007, UNEP & ACTO 2009). The total number of Amazonian fish species may be as high as 9000 (Olson *et al*. 1998). The high numbers of fish are associated to the diversity of habitats created by the dynamics of the river and its freshwater system. There are also two species of river dolphins (*Inia geoffrensis* (De Blainville) and *Sotalia fluviatilis* (Gervais and Deville)), one species of manatee (*Trichechus inunguis* (Natterer)), two river otters, (*Lontra longicaudis* (Olfers) and *Pteronura brasiliensis* (Gmelin)), as well key reptiles such as the anaconda (*Eunectes marinus* (Wagler)), the black caiman (*Melanosuchus niger* (Spix)) and the charapa (*Podocnemis expansa* (Schweigger)), the largest freshwater turtle in the world, weighing up to 45 kg. The region is endowed with 427 species of amphibians (Ruiz *et al.* 2007) and thousands of birds and invertebrate species (Olson *et al.* 1998, Revenga & Kura 2003).

Currently, the Amazon River basin can be considered as an area that is relatively healthy compared with other tropical river basins in Africa and Asia (WWF 2008). Eight countries compose the basin (Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname and Venezuela), and each one has its own environmental, social, economic, political and historical characteristics, which makes it difficult to find harmony and congruency in proposed conservation programmes.

This region is now not only thought to be a symbolic or cultural place, but also a frontier for science and technology in the development of biotechnologies and genetic engineering (MMA 2002). Its importance in the worldwide economy, industry and scientific research is now leading the region to a situation no longer defined by its socio-environmental importance bringing implications to its maintenance and conservation.

The deterioration of aquatic ecosystems in the Amazonian region has not always been perceived as a threat due the macro analysis used to assess the situation. The immense river has always being thought of as a sponge that absorbs the impacts of human activities both on land and water. If the problem is considered on a smaller geographical scale many threats and pressures arise exposing the alarming deterioration of aquatic ecosystems of in region, as well as making the needs of riparian communities more apparent.

1.5. Current status of the Colombian Amazonian freshwater biodiversity and peoples

Despite the pressures being put on the natural resources, it is estimated that in a country like Colombia, 85% of its Amazonian territory is still considered natural or minimally transformed (Ruiz *et al.* 2007, UNEP & ACTO 2009). The Colombian Amazon has an area of 477,274 km² corresponding to 41.8% of the National Territory and 6.4% of the entire Amazon Basin (UNEP & ACTO 2009). The low intervention that has taken place in this area is, in part, because of the presence of a series of conservation strategies. For example Indigenous Reserves cover 100,712 km² of the South of the Colombian Amazon (Ruiz *et al.* 2007). These reserves can only be exploited by their occupants (indigenous communities) and although the sub-soil belongs to the State, the indigenous groups are powerful enough to stop the state from using their land. These reserves, together with other conservation tools (9 Natural National Parks, Forest reserves and Districts of integrated management), have contributed to maintaining the natural conditions of the region (Murcia Garcia 2003).

Having the smallest representation in the Amazon Basin is not an impediment to Colombia making a major contribution to the region's biodiversity. Its location between the Andes Mountains, the Amazon floodplain and the Guyana shield, gives it special value within a bio-geographic mosaic with elaborated features of habitats, landscape units and vegetation (Ruiz *et al.* 2007).

However, as in the rest of the Amazon River basin, the Colombian Amazon is facing an environmental crisis that is affecting its freshwater ecosystems and their components (species and ecological processes). Rapid changes in local communities' patterns, conflicts with the territory ownership and the lack of law enforcement by the local authorities are now concerning those who are trying to conserve the local biodiversity and the cultural identity of the local communities. Historically, there has been a lack of success in some conservation strategies and in the weak enforcement of the legislation making the implementation of more accurate, effective and new conservation measures a priority. The effectiveness of these strategies will not only depend on an ability to understand the complex processes of the aquatic ecosystems and the way local communities interact with them, but also on how these strategies are formulated and implemented.

The aspects considered above highlight the importance of this territory given its extension and importance for local communities, the country and humanity. The maintenance of terrestrial and aquatic biodiversity, the regulation and production of freshwater, the storage of carbon in lakes,

vegetation and soils, the regulation of global climate, as well as the preservation of an incredible rich cultural knowledge are also vital to global sustainability. Regarding fisheries, this area contributes a large part of the inland fish harvested in the country. The port of Leticia contributes an average of 8600 t of fish per year (Agudelo *et al.* 2006). Conservation priorities to protect the biodiversity and the ecological processes of the Colombian Amazon as part of the River Amazon basin, are being addressed to achieve the objectives established in the Convention on Biological Diversity (CBD), the Convention on Trade in Endangered species (CITES), Ramsar Convention on Wetlands, the Convention on the Conservation of Migratory Species of Wild Animals (CMS), the Amazon Cooperation Treaty Organization (ACTO), as well as the related targets set in national policies where endangered species and key ecosystems are considered conservation priorities.

The south of the Colombian Amazon is called the Amazonian Trapezium (Figure 1.1). This area is delimited in the south by the Amazon River and Peru, in the North by the Putumayo River, in the west by Peru and in the east by Brazil. The area bordering the Amazon River from the City of Leticia (in the east) to the Atacuari River in the west (116 km), comprises 45 indigenous communities from different ethnic groups, mostly Ticuna, Cocama, Yagua and Uitoto, settled along the entire extension of the north bank of the Amazon river (Trujillo 2007). This area is also the point where the lives of Colombians, Brazilians and Peruvians intersect. Consequently, the use of the aquatic resources is shared, and differences in national policies have made standardizing methods and regulations to address the current threats to the freshwater ecosystems difficult. These range from the over-exploitation of fish stocks, the misuse of fishing gears, violation of fishing regulations, illegal hunting of endangered species, to the use of dolphins as bait to catch the mota fish, *Calophysus macropterus* (Lichtenstein). The deliberate slaughter of dolphins by fishermen, the use of rivers and lakes for effluent disposal, the transformation of riparian forests in expand agriculture, the increase of regulated and unregulated tourism (contributing US$ 6.6 million to the region) (Hoyt & Iñíguez 2008) and finally the loss of the cultural heritage of these communities are all part of the transformations affecting the freshwater ecosystem.

Indirect threats related to a current lack of governmental presence in the area, unclear policies and incorrect investment of public economic resources are increasing the poverty in the region and with it environmental, social and economical conflicts are arising. All this has led to an unregulated and uncontrolled use of the natural resources to meet the needs of the local communities as well as the needs of regional, national and global markets.

Over the past 20 years, the region has faced several social and economic transformations forcing local communities to change their way of living and natural resources management and land use patterns (Trujillo 2007). Economic booms, including rubber extraction, cattle ranching, cocaine processing and fishing extraction, have all had a major impact in the region. Furthermore, development and rural extension programmes have recommended cash earning crops suitable for marketing and have encouraged people to increase agricultural production (Hammond *et al*. 1995).

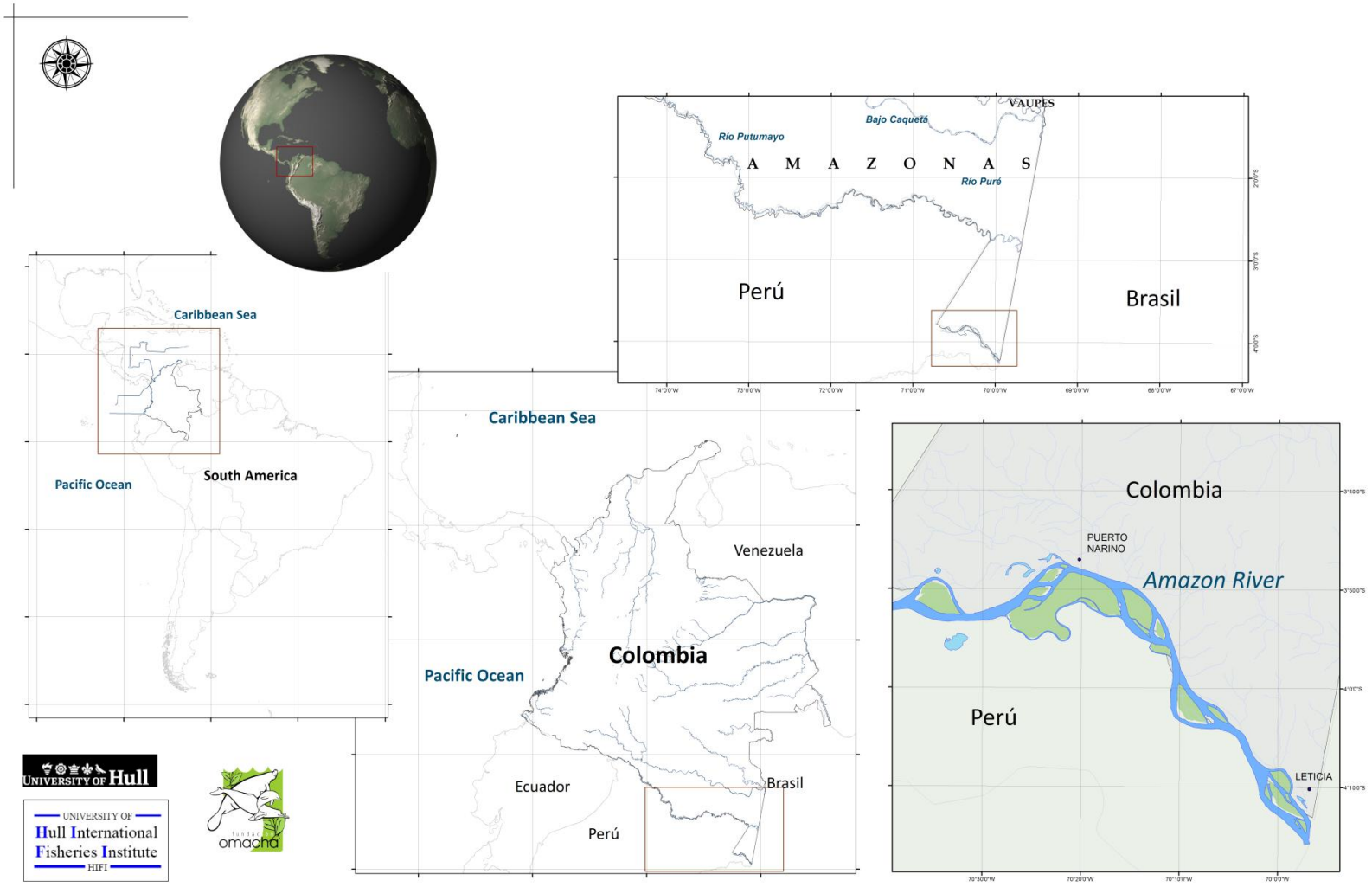

Figure 1.1. The South of the Colombian Amazon Trapezium.

Given that the region lacks roads, transportation between villages is by river (Trujillo 2007). This section of the River Amazon connects two of the most important cities of the region: Iquitos (Peru) and Manaus (Brazil) as well as acting as a biological corridor, especially to catfishes coming from the estuary in Brazil to spawn in upstream areas in Colombia, Peru and Ecuador (Petrere *et al.* 2004). These catfish are the main source of income for the commercial fisheries of the region. The River Amazon and its tributaries at this point are the principal routes of navigation and thus movement of people between villages and countries.

As a strategic site, the Amazonian Trapezium attracts thousands of nationals and foreigners each year (26,000 people in 2008 – DAFEC[2] (2009)) with the interest of having a more natural experience and to get closer to the forest, the river and the indigenous communities that inhabit the area. The government continues to promote the area as a tourist attraction without considering the impact this might have on the natural resources, local people and cultural heritage.

The Amazonian Trapezium is divided into 16 indigenous reserves located on the north bank of the River Amazon and on the shores of the Loreto-Yacu and Atacuari Rivers as well as on the Yahuarcaca creek near the city of Leticia. Since 1991, these indigenous reserves have had the right to be ruled by the peoples own believes, traditions and regulations (Art. 330 – Colombian Political Constitution 1991). The Government recognises the ethnicity and cultural diversity, as well as a series of ethnic, cultural, territorial and political rights fundamental to these different groups (Colombian Political Constitution 1991). As well as the Colombian Constitution, the country has signed Convention 169 concerning indigenous and tribal peoples in independent countries and within it the importance of the peoples and their participation in any decision involving their territories and integrity is proclaimed.

The rest of the territory corresponds to the National Natural Park Amacayacu, a forest reserve area, private conservation reserves (near the city of Leticia), and only a minimum extension of it corresponds to growing urban centres. The diverse commercial and political interests and the variety of stakeholders in this area have resulted in complicated and lengthy decision-making processes. Consequently many incompatible conservation strategies have been developed, negatively affecting the ecosystems and the welfare of the communities.

Due to the role that the Colombian Amazon trapezium plays in the maintenance of important elements of the freshwater biodiversity and key freshwater ecosystems within the region and the country, as well as in supporting the economy of local and regional communities, it is imperative to find the balance between the use of the freshwater resources and the development of the area.

[2] Information provided by Juan Carlos Martinez Quinonez, Director of the Administrative Department of Ecotourism Development, Leticia, Colombia.

1.6. Objectives of the study

The overall aim of this research is to contribute effectively to the conservation of the aquatic biodiversity and ecological processes of the freshwater ecosystems in the South of the Colombian Amazonian Trapezium, as a contribution to the implementation of the objectives of the Convention on Biological Diversity (CBD), the Convention on Trade in Endangered species (CITES) and Ramsar Convention on Wetlands, as well as related targets set by Colombian policies. This study aims to provide elements that will help the region and its stakeholders to achieve the balance stated above through the development of a management framework for the local freshwater ecosystems. It is anticipated that this will contribute to the protection of freshwater ecosystems in the Colombian Amazon and to the benefit of users of these ecosystems.

The specific objectives of the research are:

1. To identify those species and habitats that could represent other elements of the local freshwater biodiversity (surrogates of conservation) in the South of the Colombian Amazonian Trapezium and that contribute to the proper functioning of the local freshwater ecosystems (Chapter 3).

2. To characterize the ecosystem services and societal benefits provided by the local freshwater ecosystems as well as their relationship with internal and external drivers creating pressures on the whole freshwater ecosystem (Chapter 4).

3. To identify key freshwater conservation areas in the study area using a Multi-Criteria Approach (Chapter 5).

The accomplishment of these objectives will give the basis for the formulation of a Freshwater Resources Management Framework for the South of the Colombian Amazonian Trapezium (Chapter 6). This study is designed to be disseminated to local stakeholders as well as policy and decision makers acting and managing the area from outside, and in most of the cases completely unrelated to the Amazonian social and environmental dynamics.

CHAPTER 2

THE ENVIRONMENTAL, ECONOMIC AND SOCIAL REALITY OF THE SOUTH OF THE COLOMBIAN AMAZON (TRAPEZIUM AREA)

2.1. Introduction

The past and present economic, historical, cultural, and social characteristics of the locality play a key role in shaping the environment and in determining the relationships between the people and their territory. Development and conservation strategies in Colombia and especially in indigenous-populated regions like the Amazon have failed to include historical events, as well as social and cultural features within their formulation and implementation phases.

During the past decades the inclusion of wider perspectives in conservation strategies, where social and cultural elements are understood and used as assets for more reliable and successful processes and results has been recognised as important. Several conservation strategies have been developed to overcome ecosystem degradation and biodiversity loss (Ruiz *et al.* 2007), but these strategies have struggled to achieve their desired objectives and new more effective initiatives are sought to protect environmental assets and improve local communities' livelihoods.

It has been shown, that identification of key conservation areas is an effective strategy to protect and support proper management and use of ecosystems and endangered species, helping in the maintenance of ecological processes, conserving species diversity and their genetic variability, maintaining the productive capacities of the ecosystems and the historical and cultural characteristics of the local people, as well as contributing to the generation of opportunities of development for the communities. In Colombia, PAs are represented by those located in terrestrial and marine realms; excluding Ramsar sites and one National Natural Park (NNP La Paya); there is no other mechanism to protect freshwater ecosystems and their associated biodiversity, neither in the Amazon or any other region of the country.

Successful conservation strategies also need to incorporate concepts such as, development and society, and to work from the basis of principles of integrity, co-initiatives between local communities and institutions, social functioning, existence of multiple environmental systems, recognition and valuation of different stakeholders, benefits of conservation in peace construction processes and protected areas systems (UASPNN 2001). To guarantee the sustainability and success, projects that work jointly with local communities and public and private organizations are vital. A key issue is incorporation of the already existing network of researchers, donors and the civil society. Many action and management plans can be written, but what matters is that their implementation takes place according to the social, economic, cultural and environmental drivers in the area. Appropriate implementation will ensure success of the strategies and will benefit not only the aquatic resources, but the men, women, elders and children of the area.

The information compiled in this chapter provides an important basis of the current status of the study area (territory, biological and cultural diversity). This information is needed for the formulation and implementation of conservation initiatives. Currently no conservation project or study has collated information about the whole area or considered identification of key conservation areas in freshwater ecosystems. For the identification of these key conservation areas (Chapter 5), high conservation values (HCV) including species and habitats (conservation surrogates) and other environmental services need to be identified (Chapters 3 and 4). However, social, organizational and economic elements shaped by historical events (Chapter 2) need to be understood and taken into account as well.

This chapter aims to describe the way the South of the Colombian Amazon Trapezium (land and aquatic realms) has been used and approached by local inhabitants and external stakeholders, and to give a brief description of how the division of the territory plays an important role within conservation and development strategies in highly dynamic areas like the one of this study.

2.2. Study area: General description

The southern part of the Colombian Amazon, known as the Amazonian Trapezium, is located between the rivers Putumayo and Amazon forming a trapezium shape between the territories of Brazil and Peru (Agudelo-Cordoba 2007) (Figure 1.1). The area of study corresponds to the southern part of the Trapezium shaped by a 116-km segment of the Amazon River and its wetlands systems. The site includes two important cities: Leticia and Puerto Nariño as well as 45 indigenous communities, grouped in 16 Indigenous Reserves, and the southern area of the National Natural Park (NNP) Amacayacu (Castellanos *et al.* 2009). The study area only represents 7% of the extension of the Department of Amazonas but holds 70% of the departmental population and 73% of these people live in the city of Leticia (Agudelo *et al.* 2000). The area is positioned within the High Amazon Basin and its ecological features correspond to those shared by nearby locations. It is located between 2.5 and 4° South and 68 and 71° West (Carrizosa 2004).

This area is characterised by tropical rainy weather over 95% of its jurisdiction; i.e. monsoon weather in the transitional zone of Amazon and Orinoco basins. The average temperature is around 26°C and it experiences 85% humidity. Precipitation varies from 42.5-55.9 mm during the dry season (June and November) to 760-3400 mm in the rainy season (December - April) (Figure 2.1) (Galvis *et al.* 2006, Munoz-Cordoba 2007, UNAL & Corpoamazonia 2007).

The Colombian bank of the River Amazon is mainly high land situated above the maximum levels of flooding (Galvis *et al.* 2006). The geology of the area is shaped by sediments from the Tertiary and Quaternary (mainly sands, limes and clays), which were deposited in fluvial and lentic systems. In some areas near Puerto Nariño, soil salinity can reach 6‰. These levels are caused by accumulations of calcium and gypsum from marine intrusion in some creeks and streams, benefiting the formation of "*salados*" or salty environments used by some terrestrial

species to meet their regular nutritional needs. These areas represent important hunting places for local communities (Galvis *et al.* 2006, UNAL & Corpoamazonia 2007).

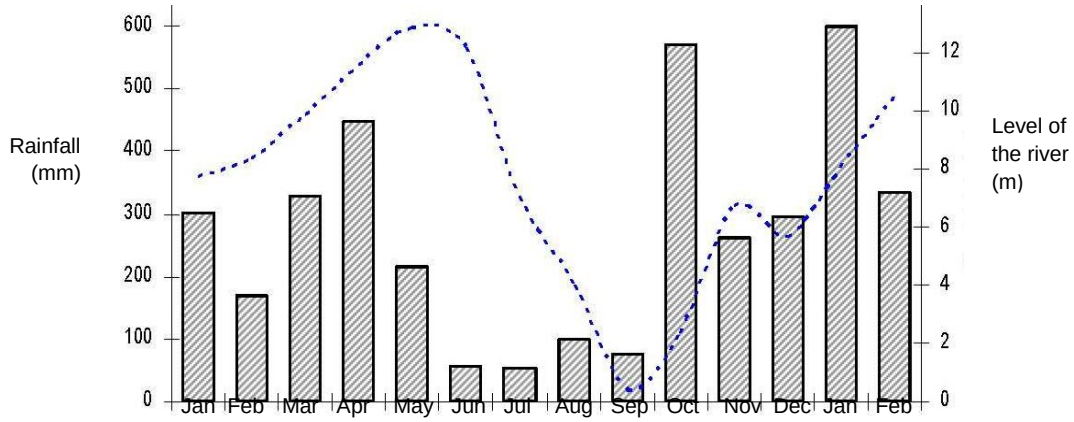

Figure 2.1. Seasonal rainfall and river levels. Bars: Monthly average rainfall (mm). Dotted line: Average Amazon River level in the Study area. Source: Bonilla (2006).

The fluctuation in the river level and the seasonal rain regime shape the physical and biotic Regarding the aquatic ecosystems of the study area, the principal lotic environment is represented by the River Amazon, with an average flow of 19,417 m³/s near the community of Nazareth (04°08'S - 070°01'W).

Other rivers of importance are the Amacayacu, the Loreto-Yacu and Atacuari, and creeks such as Yahuarcaca. The main lentic bodies are the Tarapoto Wetland system (03° 54' y 03° 12' S and 70° 17' y 70° 42' W) (Trujillo 1997, García 2005, UNAL & Corpoamazonia 2007) and Yahuarcaca Wetland system (04° 11' S and 69° 57' W) (Prieto-Piraquive 2006) (Figure 2.2). The limnological behaviour of the different lakes of the sector depend on hydrological fluctuations of the River Amazon, which at the same time depend on the Andean fluvial systems and on a rain regime that registers a monomodal behaviour resulting in periods of low (dry season: June – Nov - when the Inter-tropical Convergence Zone (ZCIT) is located to the north of the country) and high precipitation (rainy season: Dec - April).

characteristics of the aquatic ecosystems and at the same time the livelihoods of the communities in the Trapezium (UNAL & Corpoamazonia 2007). The creation of habitats during the floods is vital to increase freshwater habitat heterogeneity and to support important elements of the biodiversity as well as ecological processes.

Limnologically, three types of water can be found in the area. 1. White waters corresponding to those rivers with their origins in the Andean mountains and present a high level of nutrients generating an environment for fish production and floodplain replenishment (Amazon River). 2. Black waters; corresponding to those rivers or water bodies with their origins in the Amazonian plains, which have a greater transparency and higher concentrations of organic acids such as

humic acids, from where they take their blackish colour and which causes very low productivity (Tarpoto Lakes System and Yahuarcaca Wetland System – during the low water season). 3. Clear waters - those with highly acid pH, high transparency and low productivity. This last type is not found in this particular area but is common in other areas of the basin (Sioli 1968).

Some authors describe waters formed by the mixing of white and black waters, producing an optimum type of water for primary productivity (Ruiz *et al.* 2007, UNEP & ACTO 2009). These are mostly found in the confluences of rivers or during rising water periods when the white waters of the river mix with the black waters of lakes and tributaries.

2.3. Political and Administrative division of the territory

2.3.1. Department of Amazonas – Municipal Districts of Leticia and Puerto Nariño

Within the Colombian Amazon, the Department of Amazonas covers an area of 109,655 km², being the larger political-administrative division in the country. It represents 9.6% of the national territory and 27.2% of the Colombian Amazon. It has a population of 72,000 people, of which 43.4% are indigenous (DANE 2010). The Department preserves 99.91% (10,859,95 ha) of its ecosystems in natural conditions, with only 0.09% (9662 ha) transformed (SINCHI 2007).

The Department of Amazonas is divided into the Municipal Districts of Leticia, its capital, and Puerto Nariño; the *corregimientos* (townships) of Tarapacá, Pedrera, Arica, Puerto Santander, Miritί, El Encanto, La Chorrera, Puerto Alegría, and La Victoria; and the *police inspections* of Santa Sofía, Atacuari, Santa Isabel, Calderón and 93 hamlets.

The city of Leticia is located 1100 km south of Bogota (capital of Colombia), and it is only accessible by air, thus remaining isolated from the rest of the country because of the large distances and an impenetrable rain forest. It has a population of 32,450 (Ruiz *et al*. 2007) bordering the Tarapaca region in the north, Brazil in the east, Brazil, Peru and the Amazon River in the south, and the municipal district of Puerto Nariño in the west.

Leticia's rural area constitutes 25 indigenous communities (5 on the Leticia-Tarapaca Road, 18 within the Municipality's territory and 2 belonging to the TICOYA Reserve of Puerto Nariño but located within Leticia's boundaries) and a National Park (NNP Amacayacu). Its rural area is considered National Forest Reserve, and it also possess an urban suburban sector (117,000 ha) (PBOT Leticia 2002).

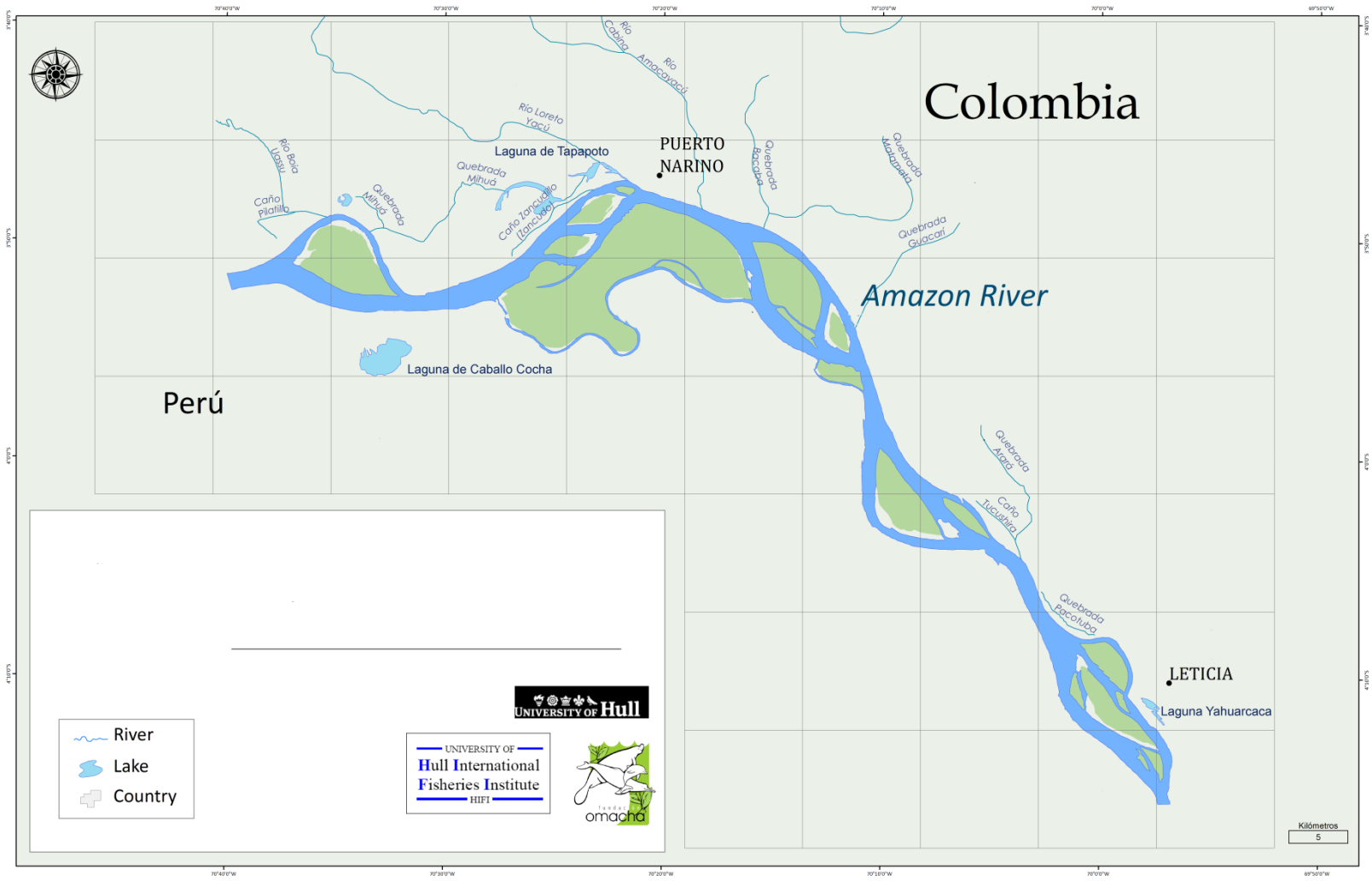

Figure 2.2. Rivers and lakes of the South of the Trapezium, Amazonas, Colombia.

Leticia is considered a sovereignty core, based on the presence of mostly governmental institutions, the army and security forces. It is a border city, municipal district and the headquarters of the Departmental Government.

Puerto Nariño is the second municipal district of importance within the Department. Its population is about 7190 (Ruiz *et al.* 2007). It is politically divided in an area of urban occupation that corresponds to the town of Puerto Nariño and a rural territory that holds the Indigenous Reserve TICOYA (Ticuna, Cocama and Yagua) composed of 20 indigenous communities and part of the NNP Amacayacu. The territory is divided into areas of protection and special management (indigenous reserves and communities) that cover 145,781 ha; 98.83% of the municipal district. The remaining 1.17% (1719 ha) are urban and rural areas (UNAL & Corpoamazonia 2007).

The economy of both districts is based on activities of extraction of natural resources in which different social and economic sectors from the three countries participate: businessmen, fishermen, loggers, tradesmen, transporters, members of governmental institutions and locals.

2.3.2. Territorial Zoning Plan – Land Use

According to Law 99 of 1993 and Law 388 of 1997, environmental planning in the territory is the duty of the State, and it regulates and guides processes related to the design and division of the territory and its renewable natural resources to guarantee their optimal exploitation and use (PBOT Leticia 2002). According to Law 388 of 1997, it is compulsory for every municipal district to formulate and implement a Territorial Zoning Plan (POT[1]), and with it to regulate the different uses of the soil in urban and rural areas, to optimize the use of available land and to coordinate the different national sectoral plans with their national development policies, with the metropolitan and departmental development plans to account for environment protection and historic-cultural traditions of the area (Mesa *et al*. 2000). These plans are formulated for a 12-year period.

Metropolitan and Municipal POTs, regardless of the legal framework behind them, are very weak in their implementation and local community participation in their formulation. The articulation of these POTs with the different protected areas, areas of special management, indigenous territories or other conservation frames has never worked, especially in the study area. According to Mesa *et al*. (2000), the formulation and implementation of these plans have ignored areas, are weakly integrated to the central power, and do not understand the social dynamics of localities populated by groups of indigenous peoples, peasants and *colonos.* The Colombian Amazon is a clear example of where the social organization of indigenous groups clashes with the territorial division of the municipalities of Leticia and Puerto Nariño.

The study area has complex territorial division and is therefore complex to manage. Besides the State, a series of actors have the duty to care for the territory as well as for its inhabitants. In the

[1] Plan de Ordenamiento Territorial.

south of the Colombian Amazon Trapezium, the territory and its management are the responsibility of the following stakeholders: City Council of Leticia, City Council of Puerto Nariño, Especial Administrative Unit of Natural National Parks (UAESPNN), Indigenous Associations (ATICOYA and ACITAM), Ministry of Environment, Housing and Territory Development (MAVDT), regional environmental authority Corpoamazonia[2], and private land owners (EOT 2007).

Besides the two urban centres, the territory is divided into areas of management such as Indigenous Reserves, National Natural Parks, Forest Reserves and Private Reserves. Each of these areas has its own legislation and stakeholders who have their own rights and duties to the territory. In some of these areas conflicts arise because of overlap of land, actors and duties, as is the case of the National Natural Park Amacayacu (Leticia/Puerto Nariño) and the Indigenous Reserve TICOYA (Puerto Nariño). Overlap of lands and competition are common and bring problems among stakeholders in their management and use of the resources held within these conservation areas (Corpoamazonia 2002, Riaño- Umbarila 2003, Ruiz *et al.* 2007).

Clashes among decision makers, managers and the communities compromise the role these conservation areas are playing in the protection and conservation of a large percentage of the territory. Correct management of these areas and improving understanding among their users and managers is key to their success. Lack of clarity in the definition of capacities and motives of each stakeholder involved in these processes is also risking the integrity of the territory and its ecosystems (Ochoa *et al.* 2006).

It is important to understand that the Department of Amazonas is a strategic territory for biodiversity for the Government, but it is also classified as a non-homogenized territory in which development models set by the central government are not viable. To better understand the complexity of the territory and its management in the study area, a brief description of each of the management components is presented.

Protected Areas (PAs)

In the 1960s, the Government of Colombia declared Protected Areas as a conservation tool to guarantee preservation and conservation of its natural resources. More recently, in line with the CBD and the Colombian Biodiversity National Policy, Colombia created the National Protected Areas System (SINAP) representing geographically defined areas that have been assigned or regulated and managed with the aim of reaching conservation targets set in these policies (Ruiz *et al*. 2007). The SINAP is one of the Colombian strategies to reach its conservation commitments, allowing it to integrate different stakeholders within the territory and thus involve different sectors of society in management and policy making, ensuring more effective actions

[2] **Corporación Autónoma del Sur de la Amazonia**. Important note: In 2011 the president of the Republic of Colombia Juan Manuel Santos issued a Decree to modify the Environmental Regional Authorities (CARs). These started to be re-structured, and their names and areas of influence have changed. For the South of the Colombian Amazon, the new Regional Environmental Authority is the **Corporacion Autonoma Regional del Rio Amazonas**, however in this dissertation the Corpoamazonia (former name) is referred to as the Regional Environmental Authority.

to solve territory issues at national, regional and local levels. It also has the purpose of protecting biological and ecosystemic diversity and supporting ecosystem services and the cultural and natural patrimony of the country (Legal Resolution 0061 of the 27th of March 2008). Regional Protected Areas Systems (SIRAP) exists within the SINAP, and these act at a regional scale. The Amazon and Orinoco PAs are managed by the same SIRAP.

The National Natural Parks are found within the National Protected Areas System managed by the Special Administrative Unit of Natural National Parks (UASPNN); at the regional scale are the Reserves of Natural Renewable Resources and Especial Management Areas managed by the Regional Autonomous Corporations (CAR or Regional Environmental Authorities – Corpoamazonia for this area of the Amazon), and at the local level is the Department or the City Council or RESNATUR (National Civil Society's Reserves Network) that manage private protected areas (Ruiz *et al.* 2007).

The Administrative Special Unit of the National Natural Park (UAESPNN) has the duty to manage and co-ordinate the National Natural Parks System and the SINAP.

Indigenous Territorial Entity (ETI) and Reserves

In 1991 by the National Constitution the Colombian State created a new territorial division, the Indigenous Territorial Entity (ETI). Indigenous authorities are responsible within their Reserves (*resguardos*) to look after these Territorial Entities. Indigenous Reserves are common property to the indigenous communities that constitute them. This Territorial division was created due to the important role of indigenous reserves in the protection of biological, cultural and ethnic diversity and to support their autonomy and own forms of legislation (Mesa *et al.* 2000).

The Reserves are held in perpetuity by the indigenous peoples and cannot be sold according to Articles 63 and 329 of the National Constitution. They are also a legal and socio-political institution with a special management constituted by one or more indigenous communities, with a collective ownership title. The rights and duties attached to the land and its communities are enforced and enhanced by an inner autonomous organization and its own legal system (PBOT Leticia 2002).

These indigenous reserves have an equal status to municipalities (Article 357, Political Constitution 1991), and as such are entitled to receive state payments (*transferencias*) for health, education and social programs, and to meet their local governance responsibilities through the *Sistema General de Participaciones* (General System of Participations) (WWF 2005).

A total of 162 Indigenous reserves exist in the entire Colombian Amazon covering 51.6% of the region and protecting an important portion of the biodiversity of those only 121 have been legally recognized (WWF 2005). According to their regulations, these territories, as common property, have a social and ecological duty, based on the uses, cultures and beliefs of their

communities. Local communities have set up their own Life Plans where it is stated the way the environment and its natural resources as well as the territory should be managed.

These Reserves are key elements for the conservation and sustainable use of the biodiversity due to their extension, the presence of a variety of natural ecosystems, the ancestral management given by the communities to their resources and the recognition of indigenous communities as an administrative organization and their role as environmental authorities.

The territory for the indigenous communities is the basis of their existence and social organization (Ruiz *et al.* 2007). These communities recognise, extraction areas, conservation sites and a series of sacred areas mostly associated with mythical heroes and legends in their territory; most of these sites correspond to aquatic water bodies (especially lakes and creeks). The protection of their cultural richness as a principle of diversity is the basis of nationality given to the diverse expressions of culture, equality and dignity of all these indigenous peoples (Mesa *et al.* 2000). Twenty six indigenous reserves are recognized by the Department of Amazonas, with 16 containing 45 communities and the NNP Amacayacu covering 70% of the area in the south of the Colombian Trapezium (Riaño–Umbarila 2003, DANE 2007).

Indigenous Communities

The indigenous communities are managed by the *Cabildo* (council), which has a Governor or *Curaca* or Captain who represents them. In the Trapezium area the principal authority is called *Curaca.* The communities are organized through weakly consolidated Indigenous Associations.

Two associations are established along the Amazon River; ATICOYA (Ticuna, Cocama and Yagua Association) in the Municipal district of Puerto Nariño with 20 communities (plus 2 located within the Municipality of Leticia) and ACITAM (Indigenous *Cabildos* of the Amazonian Trapezium Association) in the Municipality of Leticia with 18 (Appendix 1). The five communities based on Leticia – Tarapaca road (km. 9-11) are under the management of AZCAITA (Traditional and Ancestral Indigenous Authorities of the Amazonian Trapezium Zonal Association) (Riaño – Umbarila 2003, Ruiz *et al.* 2007) (Figure 2.3)

National Natural Parks (NNP)

At least 10% of the Colombian territory is now protected by the National Nature Parks System. All the ecosystems of the country are protected within this system and only the dry forest and the savannas are the least represented (CBD 2010).

The Colombian Government has created 10 National Natural Parks that cover 5.518.380 Ha and 2 National Natural Reserves (RNN) in the Colombian Amazon, occupying 14.7% of the Amazonian area. The study area includes one NNP, the NNP Amacayacu created in 1975 and currently with an extension of 293,500 ha. This NNP is located between the municipal districts of Leticia and Puerto Nariño (Vásquez & Serrano 2009).

The west area of the park overlaps with the Indigenous Reserve TICOYA, allowing the presence of people in the overlapping area of the park. The presence of people is not allowed in the rest of the territory because of its status as a National Park and the role that it plays in the conservation and protection of the natural ecosystems of the Colombian Amazon (UAESPNN 2005). All activities undertaken in the area are conducted in consultation with local communities to ensure their commitment and acceptance of the terms and decisions made for the proper use of the resources within the overlapping area and the buffer zone of the park.

Amacayacu is recognized as an important area due to its cultural and archaeological value and is protected by the National Government and the International Scientific Community; it was declared in Resolution 283/1975 – and increased in extension in 1987 through Resolution 10/1988 (PBOT Leticia 2002) to preserve a representative sample of tropical rainforest and conserve the species diversity inside the park focusing on those that represent something to local communities or those threatened by human activities (Ruiz *et al.* 2007).

National Forest Reserves of the Amazon (RFNA)

This management and protection category was created by Law 2 of 1959. This aimed to improve the development of the national economy and protect the soils, waters and wildlife of this important region.

Since 1990, land has been removed from this Forest Reserve to address human colonisation processes as well to create the Amacayacu National Natural Park and for the legal constitution of Indigenous Territories. A total of 61,000 ha of land have been taken out the area of Puerto Nariño and Leticia to allow people from other areas of the country and from different ethnic backgrounds to settle. This colonization process has allowed the fragmentation of a series of patches of forest for agricultural expansion and village settlement (PBOT Leticia 2002, UAESPNN 2005, Ruiz *et al.* 2007).

Private Reserves of the Civil Society

These correspond to an initiative taken by a group of people and non-governmental organizations (NGOs) who are owners of land with well preserved natural ecosystems and interested in their protection and conservation. Law 99 of 1993 recognizes these reserves and gives them the right to be used for development activities with possible economic benefits. Some of the private reserves in Colombia are managed by the UAESPNN and others by RESNATUR[3] (National Civil Society's Reserves Network).

[3] Currently RESNATUR counts with 314 associates spread all over the country, of which 264 are Natural Reserves, 12 are NGOs, 31 local environmental groups called '*herederos'* and 7 are Honorary Associates. The Network counts with approximately 73.000 ha of protected territory (www.resnatur.org)

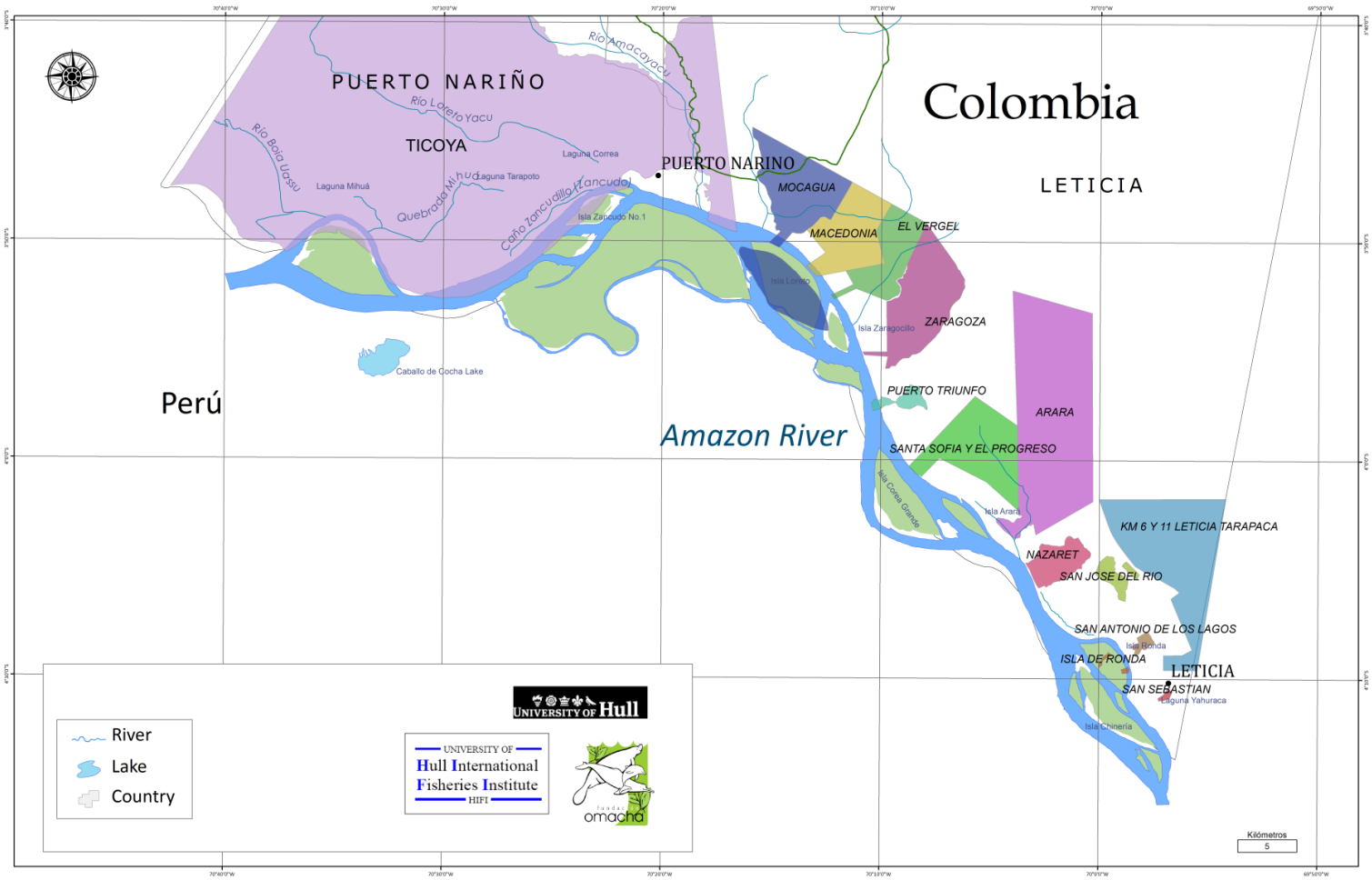

Figure 2.3. Indigenous Reserves of the South of the Amazonian Trapezium. The NNP Amacayacu is limited by a thin green line. The white parts within Leticia correspond to the National Forest Reserve of the Amazon (RFNA).

Across the country the reserves are gathered in 'cores' according to the region where are established. In the Amazon region, the core *Enraizados* comprises nine reserves located in the Municipal district of Leticia and located on the Leticia-Tarapaca way and Los Lagos (The Lakes) area.

A private reserve of the civil society conserves and protects units of natural ecosystems, functional units composed of biotic and non biotic elements of the environment. These have evolved naturally and maintain the structure, dynamic composition and its ecological functions, and are managed under sustainability principles. Areas where timber is industrially exploited are excluded and only those using wood for domestic purposes, always under sustainability parameters, are admitted (PBOT Leticia 2002). In some municipalities (not within the study area) the Government rewards the owners of these reserves with extension of their land (property) taxes (Mesa *et al*. 2000).

Private Reserves do not have to focus all their activities on conservation; they can also develop the following:

- activities aiming to preserve, regenerate and restore the ecosystems, such as isolation, protection, control and restoring of native plants' communities;
- actions conducted to the conservation, preservation and recuperation of the native fauna;
- domestic use of wood and sustainable use of non-wood resources;
- environmental education;
- recreation and tourism;
- basic and applied investigation;
- building capacities;
- production or generation of environmental services direct to the Reserve and indirect to its influenced areas;
- construction and recuperation of social networks and communal organizations;
- Permanent settlement.

The sum of these conservation elements makes the south of the Amazonian Trapezium the area in the country with the most diverse land conservation strategies.

2.4. Conservation components for strategic freshwater ecosystems

Although the conservation components described above consider protection of freshwater systems within them, they were not established to protect them specifically. However, in Colombia a series of specific management categories have been created to protect these systems. Reserve areas for fishing resources and integrated management of hydro-biological resources, which guarantee the protection, propagation and breeding of hydro-biological species and Fishing Reserves where it is forbidden to exploit determined species (Decree 2256/1991 – Article 120), are two examples. None of these reserve areas are established in the study area. The creation of these areas in collaboration with local communities could protect

key areas for fish production, where proper use of fishing gears and restrictions on fishing areas and seasons are mandatory.

The creation of new management and conservation frameworks for fresh waters needs to be made according to the already existing frameworks for terrestrial ecosystems, although these struggle to co-exist. Freshwater resources in the area are common property but also belong to more than one country. Lakes and water bodies within the boundaries of Indigenous reserves are the responsibility of the communities settled nearby making their management less complicated, but those water bodies outside the reserves are the responsibility of the State and less control is given to their protection and surveillance. It is important to understand that in this part of the country the spatial organization is also cultural, social and political and empowers local communities with management and construction of their territories. As Mesa *et al.* (2000) stressed, the resurgence of local autonomies, the processes of decentralization and the search for territorial control by the local indigenous communities, are examples that prove that the territory is defined by interactions between the local and the global.

2.5. Biological, Social, Cultural, Legal and Economic dimensions

2.5.1. Environmental and Ecological dynamics

Colombia is recognized as a mega-diverse country and together with a few other mega-diverse countries contains at least 40% of the total species on earth. Colombia occupies first place on species richness per area unit. Its continental extension of 1,140,000 km² (0.7% of global land mass) is home to almost 14% of the biological diversity described in the world (Ruiz *et al.* 2007). Of the total extension of its territory, 53,200 km² are covered by natural forest; 21,600 by other types of vegetation in savannas, deserts and wetlands; 110,000 km² by inland waters, snow peaks and urban settlements and at least 384,000 km² are under agricultural use and colonization processes (MMA 1996).

Colombia is host to more than 40,000 plant species, over 1800 bird species (19.5% of the total bird species found in the world, making it the country with the highest number of bird species), 9.8% of the mammals of the world, 7.3% of the reptiles and over 580 amphibian species (13.8%) (Samper 1998, Ruiz *et al.* 2007). The inland waters of Colombia are home to two thirds of the 3000 fish species described in South America (Ruiz *et al.,* 2007), and the two species of river dolphins of the continent. It has being estimated that at least 700 species of marine biodiversity are found in the reefs of the Caribbean and Pacific waters (MMA 1996). Colombian biodiversity is so great, that few ecosystems of the world are not represented in the country.

Colombia's mega-diversity is not only because of its biological diversity. Colombia's social diversity also gives it that status. There are 87 different ethnic indigenous groups, 3 well-differentiated afro-Colombian peoples and a Romani group. In addition, 64 different languages are spoken (DANE 2007).

Focusing on the Amazon region, this part of the country comprises 41.8% of the Colombian land surface (UNEP & ACTO 2009) and contributes 50% of the diversity present in the country (Ruiz *et al.* 2007). The area holds 68.7% of the natural ecosystems of the nation (IDEAM *et al.* 2007, IAvH 2008) and supports an important social and cultural diversity. Dinerstein (1995) and Mittermeier *et al.* (1999) recognized the western Amazonia, and especially the areas close to the Andean foothills, as the most biodiverse hot spot on earth. A total of 3219 species have been registered for this part of Colombia (von Hildebrand *et al.* 2001). The Colombian Amazon has a population of approximately 1,029,000 people (DANE 2010) and hosts 52 different ethnic groups who speak 52 different languages and a further 10 that have not been classified. Within the Department of Amazonas, 22 different indigenous groups are present (Andoke, Barasana, Bora, Cocama, Inga, Karijona, Kawiyarí, Kubeo, Letuama, Makuna, Matapí, Miraña, Nonuya, Ocaina, Tanimuka, Tariano, Ticuna, Uitoto, Yagua, Yauna, Yukuna, Yuri), and from these 6 can be found in the south of the Amazonian Trapezium (Ticuna, Yagua, Cocama, Uitoto, Ocaina, Bora). The territory is shared with non indigenous people (*Colonos*) and indigenous peoples from other areas of Colombia, Brazil and Peru (Riaño- Umbarila 2003, Ochoa 2008).

According to the Diagnosis of the Biological and Cultural Diversity of the South of the Colombian Amazon and the National Biodiversity Policy (MMA 1996, Ruiz *et al*. 2007), the cultural and biodiversity of the region is the result of evolutionary, bio-geographical and ecological processes that involve areas of the Guiana Plate, the Amazonian central floodplain and the Andean piedmont. In the Colombian Amazon it is possible to find important terrestrial formations that depend on the soils and their capacity to retain water. These are mainland forests, permanent flooded forests, seasonal flooded forest affected by white waters (*Varzea*) or black waters (*Igapo*), Amazonian savannas and rocky outcroppings (Ruiz *et al.* 2007).

The presence of freshwater ecosystems depends on the availability of water and on the physiographical and weather (seasonal) conditions. The dynamics of these ecosystems, their productivity and ecosystem services and societal benefits are related to the hydrological cycle. During the rainy season vast areas along the rivers are flooded forming seasonal habitats that can be additional to the permanent water bodies (rivers, creeks and lakes), incrementing the heterogeneity of the environment and its diversity (Junk *et al.* 1997, Ruiz *et al.* 2007). During the dry season a variety of new habitats such as beaches and rocky formations arise, making new habitats available for different local biota.

2.5.2. Social and cultural dynamics in the Trapezium

The word “biodiversity” is something new, incomprehensible and unknown to local communities in the Trapezium. This concept comes from the western world and its culture. The species, populations and biological communities are not conceived independent or separated from each other and much less from the history and lives of the human communities. The communities have always known and lived the concept of biodiversity, but it has not been until recently where the concept was integrated into their lives by research and outsiders.

Most of the communities in the area are immersed in the tropical rainforest and their settlements are located on the banks of the rivers and other water bodies. These peoples depend on what nature provided and this dependency was not a problem until a series of political and socio-economic events started to take place in the beginning of the last century (rubber extraction (1900-1945), animal trading (1930s-1970s) cattle ranching, cocaine processing (1970s-1990s) and fishing extraction (1990s- present), as well as the redefinition of international boundaries in 1932 due to the Colombo-Peruvian conflict, and the legal recognition of Indigenous Territorial Entities in 1991; events that began to shape the lives and ways of living of the peoples in the Colombian Amazon and particularly in the study area. These situations, together with the biological diversity of the area, have shaped the way the environment was exploited in the past and the way it is now managed and exploited.

The environmental situation faced in the Amazonian Trapezium is related to four main socio-cultural aspects (Munoz-Cordoba 2007).

1. Processes of occupation of the territory. Most of the cases are generated by economic booms, promotion of processes of colonization or as a consequence of population migration from other regions of the country.
2. Processes of deterioration of habitats and the environment, a consequence of the interaction between humans and their surroundings.
3. Pressure over water resources, either from changes in land use, direct use of the resource for development of productive and human activities (e.g. agriculture, settlements, industries) or because water bodies have been used as solid and liquid wastes receptors.
4. Weaknesses in knowledge of the integrity of the natural resources and their status and potential. This has undermined processes of conservation and sustainable use of the terrestrial and freshwater resources.

To understand why local natural resources are used and exploited, it is necessary to understand the processes that have occurred in the area and the relationships between locals and their environment. Originally local communities in the Amazonian Trapezium area were classified as nomads, and as they moved to find new areas to grow food and to hunt, they left areas to let the soil and resources recover and with this they contributed to restoring the natural dynamics and resilience of the environment. With the Spanish and Portuguese conquest and post colonization, a drastic reduction in the indigenous population took place. After Catholicism was introduced by the Spaniards these groups were forced to settle permanently in villages. This process forced these peoples to change their exploitation of the natural resources and to adapt their lives to particular and specific locations. Their behaviour changed to extraction of the surrounding natural resources and promoted activities involving extensive use of a nutrient-poor soil as well as hunting and fishing activities in the areas surrounding their villages. These approaches became aggressive and harmful to the environment. After a few centuries of these activities and the constant migration of peasants and people from different ethnic backgrounds to and from the region, the uncontrolled use of natural resources has become of concern.

The south of the Amazonian Trapezium experienced a completely different development compared with the rest of the country, and its dynamics have been driven by the availability of certain natural resources that have been used in both legal and illegal ways. The events that changed the perception of the use of natural resources started with the Spanish and Portuguese conquest and colonization and were followed by periods involving human trade, when indigenous people were sold as slaves or recruited to serve in the Brazil/Paraguay war in 1860, the rubber and quinine booms from 1900 to 1945, illegal hunting of species such as jaguar (*Panthera onca* (Linneo)) and giant otters (*Pteronura brasiliensis* (Gmelin)) for the fur trade between the 1930s and 1970s, illegal logging and oil exploration periods and the establishment of the Jose Francisco de la Cruz movement, which imposed Christianity as the main religion on the local peoples and made them change and abandon their own ancestral beliefs. All of these events were followed by use of illegal crops between 1970 and 1997, which involved local people in the chain of drug-trafficking, the implementation of productive agricultural systems not suitable for the environmental conditions and finally uncontrolled fishing have marked important changes in the way local communities have used and approached natural resources (Agudelo *et al.* 2000, Riaño-Umbarila 2003, Muñoz-Cordoba 2007, Ruiz *et al*. 2007).

In the last 20 years has been a shift towards fishing in the fresh waters. Fishing is the most important activity for the local and regional livelihoods and economy. Dependency on this activity is huge, it supports the livelihoods of around 1000 Colombian families along the Amazon River, which according to Agudelo *et al.* (2000), consume around 200 kg of fish per year per person and a minority of these families supply the national fish market with 8600 tonnes per year, representing 37% of total freshwater fish production in Colombia. According to Riaño-Combarila (2003), this activity is part of the local people's daily routines as one of the most important activities conducted by these groups. Fishing gives them the chance to bring food to their families and to sell the remainder, and with it buy basic goods for their homes.

Commercial fishermen (only a minority in the area) support an important part of the local economy (Agudelo-Cordoba 2007). Almost 100 fish species are exploited because of their abundance, demand or cultural preference. The region (south of the Amazonian trapezium), and especially the city of Leticia, also acts as a trading centre for the rest of the country and region, rather than as a fishing area itself. Almost 90% of the fish passing through this port comes from Peru and Brazil to be sold and traded within Colombian territory.

The fisheries in the area have not been managed to the extent they deserve. Over the last 30 years, different institutions have been in charge of their management: Inderena (1968 – 1993), INPA – National Institute of Fisheries and Aquaculture (1993-2005), INCODER - Colombian Institute of Rural Development (2005-2008), ICA - Colombian Agropecuary Institute (2009) and then back to INCODER in 2010, creating confusion among the sector and actors involved. In 2012 the Government will create a brand new Fisheries Agency with total financial independence and autonomy. These changes have led to a disruption in different activities, as well as implementation and regulation of policies. Fishermen have been neglected by society

and the government by not recognising the importance of fisheries or supporting the welfare of the community, despite the importance of fisheries to the economy of the region.

Currently, Colombia does not have either a defined policy on fisheries and aquaculture development or strategic guidelines to manage artisanal fisheries. For the Amazon region only a few regulations banning fishing at certain times or fishing gears, minimum capture sizes and restricted fishing areas have been expedited. Legal frameworks do not match the social, economic and environmental dynamics of this complex region, and the low budgets assigned to implement management strategies (normally lower than required) means little can be done to management the fisheries effectively. Furthermore, lack of professionalism of the fishing authorities to enforce policies or implement conservation strategies to improve the resource and the livelihoods of the users is an issue shared with the nearby Peruvian and Brazilian's fishing authorities (Agudelo *et al.* 2009).

In addition, indigenous fishing communities not only depend on the fresh waters as their main source of food, they also depend on them to conduct their daily activities. Freshwater ecosystems provide services and benefits to these communities which range from the storage and provision of clean water and flood or erosion control, to wood and timber to build their houses and boats, and aquatic and semi-aquatic species to complement their daily diets and household incomes. Freshwater ecosystems also provide spaces and landscapes suitable for tourism and leisure activities. Tourism activities conducted on lakes, flooded forests and the main river include dolphin watching, kayaking and landscape contemplation.

Dependency on freshwater ecosystems and their resources is, in part, the reason for deterioration of the habitats, and the loss of biodiversity (Millennium Ecosystem Assessment 2005). Also historical, political and economic processes described earlier, have shaped people's lives. Contact with external cultures, access to markets, the implementation of national programmes of education and the globalization have been powerful forces that have altered this culture and environment (Trujillo 2007). Nowadays, this area cannot be thought of as an isolated area, its connectivity to the market and global systems and the migratory dynamics of its people connect it to events happening in other parts of Colombia and other countries of the Amazon River Basin.

Most of the problems that the Amazon region faces currently are not Amazonian but have their origins further afield. Violent situations in other regions of the country have made Colombia second in the world for numbers of displaced people. These migrations sometimes occur with the government's support and at other times not; internal conflicts happening in distant areas are leaving millions of families with no land and are contributing to degradation of the peasant culture. This degradation added to environmental degradation caused by physical, economic and social impacts is crossing boundaries and exacerbating poverty. There is also a different case of migration happening in the nearby areas of Peru which is risking conservation of the aquatic and terrestrial ecosystems. The "Israelis of the New Universal Pact" (*Israelitas del Nuevo Pacto Universal*) are a religious group who come from Peru and move across the region,

settling in the area carrying out agricultural and cattle ranching activities, devastating 4 ha of forest/family/year and using inappropriate techniques for the Amazonian ecosystems (Rios-Zumaeta *et al*. 2002), as well as increasing hunting and fishing activities with no respect for traditional ways.

All these activities and dynamics threaten the freshwater ecosystems, but the key problem has been a lack of congruency between the threats and the activities conducted to prevent or counteract them. Conservation programmes to mitigate threats and disturbances, as well as to provide alternative livelihoods, must be conducted together with educational programmes and supported by policies (International, National, Regional and Local) regarding the use and management of natural resources and their enforcement. Planning is very important in freshwater ecosystems and should be done as it is for terrestrial realms.

The indigenous reserves, the private reserves, the NNP Amacayacu and the territorial division previously mentioned are fundamental for the establishment of a system of protected areas where freshwater ecosystems can be managed and protected. Aquatic ecosystems are briefly mentioned within the Management Plans of the components of this system of PAs, with the exception of the Life Plans of the indigenous territories, where these environments are considered sacred (UNAL & Corpoamazonia 2007).

2.5.3. Legal and stakeholder situation

As mentioned previously, Colombia being as a recognized mega-diverse country forces it to have a strong National Biodiversity Policy (on paper) and to follow up commitments under the CBD, CITES and Ramsar, concerning conservation of its biodiversity (ecosystems, species and genes) and important ecological processes. Among the actions proposed in the National Biodiversity Policy is the identification of new areas of high environmental value where both biodiversity and ecological processes are highly represented. For the central government, protected areas are considered a very effective conservation tool. Any initiative or strategy including the identification of key conservation areas or the creation of PAs will ensure conservation of national biodiversity, mainly terrestrial and marine, as well as the cultural diversity and the associated services (Castaño–Uribe 2006). These strategies will also have to consider the direct and indirect threats to the areas identified and to their biodiversity, as well as the multiplicity of stakeholders and ecosystem users, to ensure appropriate management and planning of the areas. However, for many years these requirements have not been taken into account because of low interest in freshwater resources. This can be explained because of the general perception that water is abundant in the Amazonian countries. Over the past few years this perception has been changing and the Colombian environmental authorities as well as private environmental organizations are now focusing their efforts on conservation of freshwater systems and their most representative elements. Things are starting to change and the support and persistence of NGOs, research institutes and universities are making the government and its organizations focus their efforts on the Amazon region and on its people. However, there is still something broken along the command line between the Central and the Local governments

that makes all that effort and interest from the central government disappear when it gets to the local governments.

Due to the location and isolation of the study area, there is lack of governmental presence, unclear policies and appropriate investment of public financial resources. The Department of Amazonas and the Amazonian Trapezium are one of the poorest regions in the country, facing not only environmental but critical social problems. The area has heavy military presence. The national army, navy and police have constant presence in the area and as a border territory they are in charge of protecting national sovereignty. Within their duties is the protection of the natural resources through enforcement of the law, which is weak and or nonexistent. Overcoming this situation to improve the region rural livelihoods and exploitation of the natural resources is a challenge. It is easy to say that the answer to this problem is in the hands of the governors and the people who make and enforce the law, but changes can be made if local stakeholders work together with local communities and come up with conservation strategies that will benefit everyone.

Formulation of conservation strategies, management and conservation plans, fisheries agreements, educational programmes among others, to protect the aquatic biodiversity and its habitats are the first step to changing people's minds and behaviour. Strategies taking into account the motives, interests and values of all users and stakeholders and not simply averaging their position are key for their success.

For several years the area has been studied from different perspectives; scientific research has been done in different freshwater ecosystems - lakes (specially the Tarapoto and Yahuarcaca Lakes' systems), creeks and rivers have been sampled and information about their species composition and ecology is available. The constant presence in the area of a series of institutes and organizations has made this possible, and has helped to create a series of bonds between the organizations and the local communities improving confidence and trust between the two parties. Entities such as the Sinchi Institute, the National University of Colombia (Amazonian campus), Inderena – Institute of Natural Resources (1968-1993), SENA (National Apprentice Service), the NNP Amacayacu, Corpoamazonia, Department of Amazonas' Education Secretary, Foundation Omacha and Foundation Natutama, have been based in the area for several years, and together with other institutes not based in the region, National University of Colombia (Bogota and Medellin), Universidad de los Andes, Universidad del Cauca, Universidad Distrital de Bogota, Universidad Industrial de Santander, Pontificia Universidad Javeriana (Bogota), Universidad Jorge Tadeo Lozano, Universidad del Magdalena, Universidad Pedagogica Nacional, Universidad del Valle, Ideam (Institute of hydrology, meteorology and environmental studies of Colombia), Tropenbos International and international organizations such as the Ramsar Convention, International Organization for Migration (IOM), Organization of American States (OAS), Wildlife Conservation International, The Nature Conservancy (TNC), the city council of Vila-Real, Castellon (Spain) and many other more, have been involved in scientific, conservation, social and development programmes.

A lot of research and information has been obtained for the area by these organizations. However, this information in most cases has ended up on the library shelf or an office drawer and only a few studies have included the area and its entire extension (south of the Colombian Amazonia Trapezium – from Leticia City to the Atacuari area). According to Ruiz *et al.* (2007), 164 documents have resulted from research conducted in the area and can be found in databases and libraries in Colombia; 35% of them are dissertations mostly from undergraduate programmes followed by Masters and 2% are doctoral studies; 22% are technical reports, and 18% correspond to conference presentations and scientific papers. The studies involving freshwater issues cover five main categories: 44% of the studies are about aquatic biota, 42% about physico-chemical characteristics of the water, 7% on the use and management of the aquatic systems, 4% on fluvial aspects, 2% on the alteration of aquatic environments and only 1% on studies with an integrated character. Many other studies have also been on social, cultural and economic aspects of the communities in the area.

To summarize:

- The South of the Amazon Trapezium is divided in a series of territorial frames for management and conservation purposes making it diverse in terms of stakeholders, legislations and social and economic dynamics.
- Indigenous territories constitute an important part of the dynamics and characteristics of the Colombian Amazon. Indigenous people have strong bonds to their territory and this has defined their relationships with their surrounding resources.
- Understanding the relationships between people and their territory constitutes an important step to formulate better and more accurate conservation initiatives.
- Territorial planning has been seen as an important way to protect biological, environmental and social assets in terrestrial ecosystems, for this reason planning should be also done for freshwater ecosystem conservation.
- Strengthening the stakeholders' network, clarifying their roles and areas of jurisdiction is a key step to improve their work towards successful freshwater conservation and their relationships with local communities.
- To contribute to regional planning, the following chapters will provide the basis for the identification of key conservation areas for the local and regional freshwater biodiversity (Chapter 5). The brief social, cultural, legal and economic panorama presented in this chapter constitutes the basis to understand how the selection of conservation surrogates – species and habitats- (Chapter 3) and the identification of ecosystem services and human activities threat to these services (Chapter 4) are essential steps for the selection of conservation areas and consequentially the formulation and implementation of a management plan or strategy for these areas and their resources (Chapter 6).
- This research is the first local initiative regarding this subject. This initiative puts together information about freshwater biota, ecosystems, human activities, economic dynamics and cultural traditions, presenting a general panorama or 116 km of Amazon River and its surroundings.

CHAPTER 3

AQUATIC BIODIVERSITY OF THE SOUTH OF THE COLOMBIAN AMAZON: DYNAMICS, MAJOR COMPONENTS AND THEIR ROLES AS SURROGATES OF CONSERVATION

3.1. Introduction

Colombia's strategic geographical position and a series of evolutionary, bio-geographical and ecological processes involving areas of the Guiana Plate, the Amazonian central floodplain and the Andean piedmont have created conditions to sustain almost all the ecosystems found in the world, only a few are not represented in the country (Ruiz *et al.* 2007). Colombia is home to almost 14% of global biological diversity. With a continental extension of 1,140,000 km² (0.7% of the globe's territory), Colombia has the highest species richness per unit area. It is also second to Brazil in South America in terms of number of species (Ruiz *et al.* 2007). This complexity in biodiversity contributes to ecosystem resilience and stability, enabling large adverse changes in the ecosystems to be regulated and ensuring the provision of vital ecosystem services and societal benefits (Mertz *et al.* 2007). For the Colombian Amazon region these important goods, ecosystem services and societal benefits range from food and building materials, to water filtration; flood and erosion control, cycling of nutrients and flow of energy (Millennium Ecosystem Assessment 2005).

The contribution of Colombia to the rest of the Amazon River Basin is enormous, despite only representing the 7% of the basin. Notwithstanding, biological, environmental, social, economic, cultural and politic dynamics and events in Colombia will affect and drive events and activities in the freshwater ecosystems of the rest of the Amazon region. Connectivity of freshwater ecosystems in the region remains mostly intact compared with fragmented terrestrial ecosystems within the Amazon, but pressures are risking the stability of these systems and accelerating the loss of the aquatic biodiversity. This is already having an impact on local communities' livelihoods.

The Colombian Amazon is highly diverse, with different characteristics across the region, thus, making it impossible to manage the region and its problems as a whole. Colombia's historical events have shaped this region, and as one of the most isolated and troubled areas in the country, the attention paid to it has been intermittent and almost non-existent regarding environmental problems. Social issues have been addressed by decisions made by a central government completely alien to the people's needs and requirements.

The South of the Colombian Amazon, known as the Amazonian Trapezium, is currently going through a series of rapid changes that include escalating tourism and expansion of Leticia the Amazonian capital city as the most important fishing port (including servicing nearby cities in Brazil and Peru). The city also acts as the headquarters of most Colombian government institutions, and is considered a key point in a complex tri-national area.

The Trapezium comprises a variety of aquatic ecosystems ranging from complex habitats associated with the main channel of the river, permanent lakes with herbaceous and bush vegetation, permanent lakes with arboreal vegetation, temporal swamps, tributaries originating in the Andes, and permanent and temporal creeks (Ruiz *et al.* 2007). These aquatic environments are embedded in the regional hydrological cycle and their dynamics are influenced by: hydrological fluctuations of the River Amazon which at the same time depend on the Andean fluvial systems and a rainfall regime that registers a *monomodal* behaviour resulting in a period of low precipitations (dry season: June – Nov) and a high precipitation period (rainy season: Dec - April). These dynamics create and alter a variety of habitats that allow the undertaking of subsistence activities such as fishing, farming and tourism. The dependency of local communities on these resources and the importance of fishing as one of the main income and supportive activities make the interactions between local communities and the aquatic system critical.

Studies on Colombian freshwater ecosystems, and especially in this area, have been linked to the lives and behaviours of the local people and resource users. The southern Amazonian Trapezium is inhabited by indigenous communities, which exploit their territory according to their own cultural and social believes and needs, and also according to what national and international markets dictate.

Locally, pressures on the freshwater systems include expansion of agriculture, creation and expansion of human settlements, misuse of fishing gears, overfishing, illegal hunting and deforestation, water pollution, unregulated tourism and poor policy and regulation enforcement. Local indigenous communities are now exposed to part of the dynamics of industrial economies. This has changed their interests and perception of their environment. Exploitation rates have escalated to fulfil market and trading patterns; nowadays the conservation of freshwater resources must be approached from a multi-disciplinary perspective where the local, national and regional economies are examined and considered as important drivers to aquatic biodiversity deterioration.

Rural community welfare plays an important role in the conservation of the local biodiversity. Weak education and health systems are responsible for poverty and low social wellbeing, although people in the study area do whatever is possible to improve their livelihoods and provide better opportunities for future generations. Indigenous people, especially the young generations, are shifting towards a western life style and this is disrupting supporting ancestral traditions with new cultural and social patterns.

In summary, Colombian Amazonian biodiversity is threatened but also the culture and survival of the communities that depend on it. Urgent and new conservation alternatives must be sought to prevent their deterioration and eventual disappearance.

Currently conservation surrogates are used by conservationists and managers to monitor anthropological disturbances, population trends or to locate areas of high biodiversity (Caro &

O'Doherty 1999). In this document these surrogates are divided into fine filter targets (single species) and coarse filter targets (those units of biodiversity that capture many other elements – habitats/environments), and considered a robust method of representing local, regional or even global biodiversity (Roux *et al.* 2008). The representation of a full variety of biodiversity within a single species or type of habitat has proved effective in ecosystem-based conservation strategies. Conservation surrogates are also useful in the identification of areas of high environmental value and in areas proposed for special protection (National Parks, Reserves, Freshwater Protected Areas and so on) (Caro & O'Doherty 1999). This strategy is useful in areas as complex as the Amazon, where understanding of the species, their habitats and dynamics is poor. The Colombian conservation goals set in the National Policy of Biodiversity aim to identify these elements of the biodiversity and set up strategies that can prevent their disappearance.

Over the last 10 years, international non-governmental organizations (NGOs), such as The Nature Conservancy (TNC), The Wildlife Fund for Nature (WWF), Conservation International (CI) and IUCN, have developed methodologies to evaluate biodiversity at the level of species and ecosystems in terrestrial, marine and freshwater ecosystems, and with them have proposed a series of criteria to identify those elements key in the representation and conservation of biodiversity. This information provided by these methodologies has being adapted and collated according to the needs of this research and the situation experienced in the South of the Trapezium.

This chapter aims to identify targets for conservation that represent the local freshwater biodiversity in the Colombian Amazonian Trapezium as well as those that characterise proper functioning of ecological processes that support local biodiversity and ensure provision of ecosystem services and societal benefits that have been sustaining the lives of millions in and around the region. Identification of these conservation surrogates is the first step within this research to identify key conservation areas in the freshwater ecosystems of this part of Colombia. They will also serve as an input to other stakeholders and decision makers in their process of building a more sustainable and equitable Amazon.

3.2. Methods

3.2.1. Data collection

A literature review of species, ecosystems and their ecology and biology was conducted. Articles, scientific and technical papers, undergraduate and graduate dissertations, reports and educational material were gathered and examined to identify the most important elements and dynamics of the aquatic ecosystems of the Colombian Amazonian Trapezium.

Two field trips to the study area were carried out to complement this information. The first took place in July 2009 and the second in March 2010. During both trips, the entire study area was visited; photographs of ecosystems, species and indigenous communities were taken together with casual conversations conducted in different communities throughout the Trapezium. During

these casual conversations, the current environmental, economic, social and cultural realities were discussed, as well as perceptions about the local and regional development and the needs and requirements of the local communities (Appendix 2).

Institutions and stakeholders were also visited. Informal discussions were held with key stakeholders where their perception of the current environmental and social situation in the area and the role of their institutions in solving environmental problems were discussed (Appendix 2). The discussions were not recorded (taped) but notes were taken and further communication was maintained via email.

3.2.2. Assessment of aquatic biodiversity (species and habitats) and identification of conservation surrogates

According to WWF and TNC, conservation surrogates, such as certain types of freshwater habitats, species and processes, may exercise a powerful influence on the composition, structure and ecosystem function, and consequently on biodiversity (TNC 2000, Abell *et al.* 2002). Based on the literature reviewed and the methodologies for the identification of fine and coarse filter targets proposed by WWF, CI and TNC (TNC 2000, Abell *et al.* 2002, CI 2008), a series of species and habitats were chosen as candidates to be surrogates of conservation. This approach has proven effective and is recommended as the most robust method to find elements to represent the local or even regional or global biodiversity (Lombard *et al.* 2003).

Selection of fine filter targets (fft) (Species)

A list of all aquatic vertebrate species registered in the study area was compiled. The list gathers the scientific name, taxonomic authority, conservation status (global and national) and the special features (endemic, migratory, with special habitat requirements or in a special category: umbrella, flag, keystone species) of every species, where the information was available. Data on invertebrates were not considered because few records exist for freshwater ecosystems in the area. The long list found highlighted the impracticality of trying to protect every single element and the importance of identifying a few species to be used as conservation surrogates that represent the almost 1000 species present in the area.

The criteria established to identify fine filter species for aquatic ecosystems of the Colombian Amazonian Trapezium were the following (Caro & O'Doherty 1999, Abell *et al.* 2002, Almeida *et al.* 2003, Coppolillo *et al.* 2003):

- Status of conservation, importance or vulnerable at a global or national level;
- Species with a visible ecological function (e.g. top predators), specific habitat users or habitat dependants;
- Species of cultural and/or mythical importance;
- Species of socio-economic importance;
- Species representing special features - endemic, migrant, flagship or umbrella species.

i. **Status of conservation or vulnerability**. Species classified in any category of threat according the IUCN Red List or the National Red Books. Endangered Species generally owe their status to changes in the environment, mostly provoked by anthropogenic activities that have changed the acceptable patterns of natural resources' extraction and use of land. Species catalogued as endangered or threatened best exemplify the current and changing conditions of the environment because of their sensitivity to these changes (Lambeck 1997).

ii. **Ecological function - top predators - specific habitat users**. The ecological role(s) of a species within a natural ecosystem is sometimes more visible than others. Top predators tend to concentrate in important biodiversity hotspots (Worm *et al*. 2003). It has been established that top predators and larger vertebrates are disappearing rapidly in most aquatic ecosystems as human activities fragment and transform natural habitats and deplete populations of vulnerable species through overexploitation (Abell *et al.* 2002). These species also have strong effects on the structure and function of natural ecosystems, controlling the abundance and composition of prey communities (Coppolillo *et al.* 2003). Normally top predators require large habitat areas which motivate large conservation areas projects (Aldeman & Fagan 2000). Other species not considered as top predators might use particular habitats to perform specific activities during their life cycles, becoming habitat dependants. The use of particular habitats (beaches or floating meadows) and their dependency on them make these species important conservation surrogates, especially when those habitats are threatened too.

iii. **Cultural/Mythical importance**. Wildlife may serve as a cultural icon, forming a significant portion of people's diets, rituals and/or believes (Bodmer *et al*. 1997, Coppolillo *et al.* 2003). Most of the indigenous communities' cosmogony is based on the way nature functions and on how they as humans fit within their surroundings. For these communities the presence of wildlife species within their environment has a meaning and each species has a particular role vital for the functioning of the planet. Fear, respect and admiration for these species in most cases address the way they exploit or approach the species. Species considered important to local communities must be protected on behalf of the preservation of native communities' cultures.

iv. **Socio-economic significance**. Freshwater resources, especially fish, provide an important income to local communities, as well as a vital source of protein. Other species used as tourism attractions, such as river dolphins and birds, are nowadays gaining more importance and consideration. Improving local people's livelihoods should also be the aim of all aquatic resources conservation scheme by implementing new activities bringing alternative income opportunities, and where the use of the resource is done on a sustainable basis. Carried out properly will take the pressure off currently bad-managed and collapsing aquatic biodiversity.

v. **Special features.** Characteristics presented by migratory, flagship (species with substantial public appeal), or umbrella species (those which by using large areas of habitat, by default, are protecting many other species) demand particular area attributes and environmental features such as habitat heterogeneity and large geographical areas. In

most cases, meeting the needs of these species will provide substantial protection for other cohabiting species (Caro & O'Doherty 1999, Hess *et al.* 2006). According to Abell *et al*. (2002), in large rivers such as the Amazon, aquatic mammals, reptiles and even migratory fish with sizable habitat requirements are considered good focal species for the identification of key areas. Species with a wide distribution ranges can be useful to examine links between sites making them part of a geographical net of key conservation spots, including those areas serving as geographical and ecological corridors between key spots.

Selection of Coarse Filter Targets (freshwater environments)

Eight main freshwater environments were identified in the area of which six were selected as coarse filter targets. The selection of these habitats, as well as the species selected as fine filter targets constitutes the first step to represent the extensive local and regional biodiversity and a starting point in the identification of key conservation areas in the region. According to Smith *et al.* (2008), the finest scale used as an object of conservation is the macro-habitat scale. Lakes and segments of river and creeks that are easily represented on maps and have been classified according to local environmental factors (Groves *et al.* 2000), are the best for conservation surrogates. The definitions of environments used in this research (Table 3.1) were adapted from Trujillo *et al.* 2010.

Table 3.1. Aquatic habitats identified in the study area (adapted from Trujillo *et al.* 2010).

Freshwater environments	**Definition**
Main River	White water rivers of Andean and Guyanese shield origin, typically turbid, brown-yellow in colour with low transparency, basic pH and sediment-rich (Sioli 1984). At least 400 m in width and classified as a basin or sub-basin.
Confluences	Intersection areas of the main channel with other channels or rivers. Confluences maintain connection during all hydrological periods and may or may not present a mix of white and black waters.
Lakes	Bodies of water enclosed by land. River lakes are those located within the floodplain and subject to constant filling by depositional processes of the river, An oxbow lake, is a lake which is formed when a wide meander from a stream or a river is cut off to form a lake. They are called "oxbow" lakes due to the distinctive curved shape that results from this process (Welcomme 2001).
Channel	Water courses no more than 300 m wide, generally associated with island and main river systems. Navigability is limited depending on rainy seasons.
Island Pools	Waters adjacent to land bodies in the water course of main rivers with vegetation that may appear or disappear due to hydrologic dynamics. These areas present pools (stream pools) of low currents and are known locally as *remansos,* and are especially located on the end of the islands.
Beaches	Mostly associated with islands, this habitat is an accumulation of sediments coming from upstream areas and conditioned by several processes, including the hydrodynamics of the basin (Petermann 1997). This habitat is only available during the low water period.
Flooded Forests	Extensive lowland areas covered by forest, bordering the main river and its tributaries and are subject to annual flooding with the consequent soil enrichment. The local names *varzea*, given to areas influenced by white waters, and *igapo,* to areas influenced by black waters (Junk 1997).

Floating vegetation	Macroscopic forms of aquatic vegetation including macro algae, a few species of mosses and ferns adapted to the aquatic habitat as well as angiosperms. Patches of this vegetation freely float and are not rooted to the substratum. Its emergence is conditioned by changes in river level and the nutrient flow of the aquatic bodies (Petermann 1997).

These eight freshwater environments are among the categories proposed by the Ramsar Convention for Wetlands. For the Convention, wetlands are defined as: "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt ..." (Article 1.1) as well as areas incorporating "...riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands" (Article 2.1, Ramsar 1971).

After this first selection, five criteria for the selection of final Coarse Filter Targets were identified for aquatic ecosystems in the South of the Trapezium following the protocols of Abell *et al.* (2002), Groves *et al.* (2000) and Smith *et al.* (2008).

i. **Heterogeneity and uniqueness of the habitat.** Heterogeneity of a habitat is related to the variety of niches and physical spaces that it provides for the performance of a series of life cycles (Agudelo *et al.* 2000). The disappearance of the habitat will compromise existence of the species that depend on it and the provision of vital services and benefits. This criterion is useful to guide selection of individual reserve units and as a defining point when a more than one area is being considered as reserves (Roberts *et al*. 2003).
ii. **Productivity (primary production and fish biomass).** High levels of phyto and periphyton will determine the structure of the food web and with it the complexity of the habitat. High or moderate fish biomass support local or regional fisheries constituting an important cultural and economic feature for local and regional communities.
iii. **Level of knowledge.** The availability of the information about the ecology of the habitats as well as the species that use those habitats plays an important role in the identification and selection of coarse filter targets. The more information available the more resources can be used in the selection of conservation targets and in the implementation of proper conservation measures. A habitat with little information available will be poorly assessed and strategies implemented for its conservation can be inadequate for its needs and functioning.
iv. **Role as biodiversity protector.** Those sites with dynamic and diverse ecological processes supporting and protecting vulnerable stages of certain elements of the biodiversity. This criterion is important in any site-based conservation initiative that would make a significant contribution in the improvement of any species' global status (Eken *et al.* 2004).
v. **Level of threat.** The threats and exposure that habitats have to harming and uncontrolled human activities put at risk their stability as well as their elements and components (species and ecological processes). Habitats identified to be at risk must be prioritised and included in any freshwater biodiversity conservation initiative.

3.2.3. Mapping

To map (according to the literature) the areas of presence of the species and habitats selected as conservation surrogates (Tables 3.2 and 3.4), the study area was divided in 10-km grids (Figure 3.1). One or more grids represent specific geographical spaces containing different water bodies' types (tributaries, lakes, islands systems, fragments of the main river). Maps were created using ArcGis 9.3.

3.3. Results

3.3.1. Fine Filter Targets (FFT) (species)

Applying the criteria from section 3.2.2 to the former list of freshwater fauna resulted in 25 species being selected as fine filter targets (Table 3.2). To make sure the species selected were appropriate to achieve conservation goals to address some of the environmental and social issues taking place in the region, each species was analysed based on its natural history and its current role within the local social and cultural situation.

Nine groups of species were considered as fine filter targets to represent the local freshwater biodiversity (river dolphins, black caiman, manatee, river otters, river turtle, commercial fish, subsistence fish, pirarucu and birds). Fish were grouped into three categories: scale fish, those important for local consumption, including one species, the Arawana, important for ornamental fisheries, and commercial fish, the latter represented by big catfish of high economic importance. These fish are exported out the region to the main cities of Colombia and support an important part of the local economy. And the pirarucu (*Arapaima gigas*) was placed in a single category because of its cultural and economic importance as well as its threatened status.

The distribution of each of the 9 groups of selected fine filter targets is shown in Figure 3.2. Each grid has been given a particular colour according to the number of groups that it contains. There is a homogenous colour pattern in the west part of the Trapezium. However, the grids located in the east end close to the city of Leticia where more people have settled, more boat traffic is recorded and disturbance to the natural environment takes place, portray fewer elements of the local freshwater biodiversity. Justification for the selection of these species as fine filter targets is summarised in Table 3.3. This table should provide concrete information for conservation and management purposes.

3.3.2. Coarse filter targets (CFT) (habitats)

Six freshwater habitats were selected after applying the criteria identified in section 3.2.2, (Table 3.4; Figure 3.3 for location). The habitat 'Channel' will be considered in this research as part of the main river system, and the habitat 'Lakes' are identified as key conservation areas (Chapter 5) rather than single habitats or coarse filter targets. Justification for the selection of these habitats as coarse filter targets is summarised in Table 3.4, which with a condense explanation

of the main features of each habitat (ecology), their threats and cultural importance provides supporting information for conservation and management purposes.

3.4. Discussion

3.4.1. Conservation surrogates analysis

The large number of aquatic animal species found in the Trapezium area exemplifies the complexity and diversity of aquatic systems in the basin. Evolutionary processes and geological, environmental and human-induced changes have shaped the freshwater ecosystems, their components, dynamics and status. Currently, local ecosystems are intertwined with human activities in the area and beyond the Trapezium borders. The use of these resources and particularly their uncontrolled exploitation is now endangering the sustainability of the processes and dynamics that for so long have maintained healthy plant and animal communities. The social benefits and services provided by these ecosystems are innumerable and most of them invaluable.

Nowadays, conservation programmes should focus on the preservation of the benefits and services to ensure and improve livelihoods of the local people. The Colombian Amazon represents a critical point within the region connecting the ecosystems in the high and low Amazonia, as well as the location where three important Amazonian national jurisdictions (Brazil, Peru and Colombia) meet. Sharing the aquatic resources, their management and threats among these three nations is complicated and puts Colombia in a position where it needs to come up with sensible and effective conservation strategies and social programmes to deal with problems arising from the misuse of its shared resources.

The aquatic species of the area have a series of needs and ecological features that must be fulfilled by the habitats where they are found. To protect them and ensure their continuity in time, conservation and maintenance of their habitats is mandatory. Unfortunately it is impossible to protect every species of the Colombian freshwater biodiversity, so it is necessary to solve the dilemma by selecting a few iconic species. The group of 25 species identified previously were selected to meet this goal and represent the many thousands of species found in the Colombian aquatic biodiversity. The cluster of freshwater species and habitats selected as conservation surrogates are considered to best represent local environmental complexity. These species and habitats together support and maintain vital ecological processes and ensure provision of goods and services key to the survival of the Amazonian peoples.

Table 3.2. Fine filter targets: selection criteria, conservation status and local distribution. ♦ Transnational migratory fish.

Fine Filter targets	Criteria of selection	Conservation Status	Local distribution/Grids (See Figure 3.2)
River Dolphins			
Inia geoffrensis	i – v	According to the IUCN Red Book, both species are considered Data Deficient (DD) in South America while they are consider Vulnerable (VU) in the Red Lists of all South American countries where the species are found. This change of category within the IUCN Red List from Vulnerable to DD is now under re-evaluation and discussion because of the conservation implications that this can bring to these species. The species is included in Appendix II of the CMS (Convention on Migratory Species) and in Appendix II of the CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora).	Amazon, Atacuari, Loreto Yacu, Amacayacu and Mata Mata Rivers, Tarapoto and El Correo Lake System, Yahuarcaca Wetland System. Caballo Cocha Lake (Peru). Confluences Amazon- Atacuari, Amazon-Loreto Yacu. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 36, 46, 47, 58
Sotalia fluviatilis	i, ii, iv, v		
Black Caiman			
Melanosuchus niger	i, ii, iii	The species is currently classified as Lower Risk/conservation dependant (LR/cd) in the IUCN Red List and listed under Appendices I of CITES. In the Colombian Red Book of Reptiles the species is classified as Critically Endangered (CR).	Loreto Yacu and Atacuari Rivers, Tarapoto and El Correo Lake System *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 49, 58, 59
Amazonian Manatee			
Trichechus inunguis	i – v	The IUCN has classified the species as Vulnerable (VU) but in Colombia it has been catalogued as Endangered (EN). The species is included in Appendix II of the CMS and in Appendix I of the CITES.	Tarapoto and El Correo Lake Systems, Confluence Amazon-Loreto Yacu. Patrullero Island. *Grids:* 3, 12, 13, 14, 15, 22, 23, 26
River Otters			
Lontra longicaudis	i, ii, v	The species is in the category of Data Deficient (DD) within the IUCN Red List and to be considered Vulnerable (VU – A2cd+3cd) within the Colombian Red Book of mammals. It is also within the Appendix I of CITES	Tarapoto and El Correo and Soco Lakes. The Amacayacu and Atacuari Rivers. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 49, 59

Pteronura brasiliensis	i, ii, v	The species is considered globally and locally as Endangered (EN A3cd and EN A2acd). It is also within the Appendix I of CITES.	Fewer individuals have been seen in the last decade as a consequence of its overexploitation during the 70's *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 49, 59
Giant River Turtle – Charapa			
Podocnemis expansa	i, iii, iv	According to the IUCN, globally the species is considered in Lower Risk/conservation dependent (LR/cd). In the Colombian Amazon the species is considered Endangered (EN). The species is included in Appendix I of the CMS and in Appendix II of the CITES.	Tarapoto and El Correo Lake System, Mocagua and Patrullero islands. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 49, 58, 59
Fish: Commercial fish - leather fish			
1. *Pseudoplatystoma fasciatum* (Pintadillo)♦ 2. *Pseudoplatystoma tigrinum* (Bagre rayado)♦ 3. *Brachiplatystoma filamentosum* (Lechero - Pirahiba) 4. *B. rousseauxii* (Dorado) 5. *B. vaillantii* (Pirabuton)♦ 6. *Zungaro zungaro* (Amarillo)♦ 7. *Goslinia platynema* (Baboso) 8. *Calophysus macropterus* (Mota)♦	ii, iii, iv, v	Within the National Red list of endangered fish, the species 1, 2, 3, 5 and 6 are catalogued Endangered (EN)	Amazon River, Lakes and main tributaries *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 36, 46, 47, 49, 58, 59
Subsistence fish: scale fish			
1. *Osteoglosum bicirrhosum* (Arawana) 2. *Colossoma macropomum* (Gamitana - Tambaqui) ♦ 3. *Brycon sp.* (Sabalo) 4. *Cichla ocellaris* (Tucunare) 5. *Piaractus brachypomus* (Paco) 6. *Prochilodus nigricans* (Bocachico) 7. *Potamorhina sp.*(Braquinha) 8. *Psectrogaster sp.* (Braquinha) 9. *Mylossoma duriventre* (Palometa)	i -v	Within the National Red List of endangered fish the Arawana is considered Vulnerable (VU A2d).	Tarapoto and El Correo Lake System, Yahuarcaca Wetland System, Caballo Cocha Lake, Amazon, Atacuari, Loreto Yacu, Mata Mata and Amacayacu Rivers. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 36, 46, 47, 49, 58, 59

Arapaima gigas	i -v	According to the IUCN Red List, the species is catalogued as DD however in the Colombian Red Book for freshwater fish the species is considered Vulnerable (VU A1d, A2d). The Pirarucu is part of the Appendix II of CITES since 1975 though juveniles are still traded as ornamental species.	Tarapoto and El Correo Lake System. Soco Lake off Loreto Yacu River. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 36, 46, 47, 58
Birds			
Birds	ii, iv, v	14 aquatic bird species are under any category of risk according to the Red Book of the birds or Colombia. Two species (*Crax globulosa* and *Netta erythrophthalma*) are under the Critically Endangered (CR) category; seven species under the category of Endangered (EN) (*Anas cyanoptera*, *Anas georgica*, *Harpyhaliaetus solitarius*, *Hypopyrrhus pyrohypogaster*, *Oroaetus isidori*, *Tinamus osgoodi* and *Touit stictoptera*) and five are Vulnerable (VU) (*Ara militaris, Galbula pastazae, Grallaria rufocinerea, Leptosittaca branickii* and *Pipreola chlorolepidota*). From all bird species identified for the area, 58 are included in the CITES lists; five within the Appendix I, 47 in the Appendix II and six in the III.	Yahuarcaca Wetland System, Mocagua Island, Amacayacu NNP, Tarapoto and El Correo Lake System. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 36, 46, 47, 49, 58, 59
References: Tirira 2001, Castaño -Mora 2002, Mojica *et al.* 2002, Rengifo *et al.* 2002, Rodriguez-Mahecha *et al.* 2006, Ruiz *et al.* 2007, Rodriguez & Rojas-Suarez 2008, Aliaga-Rossel 2009, IUCN 2009, IUCN 2010, CITES 2011.			

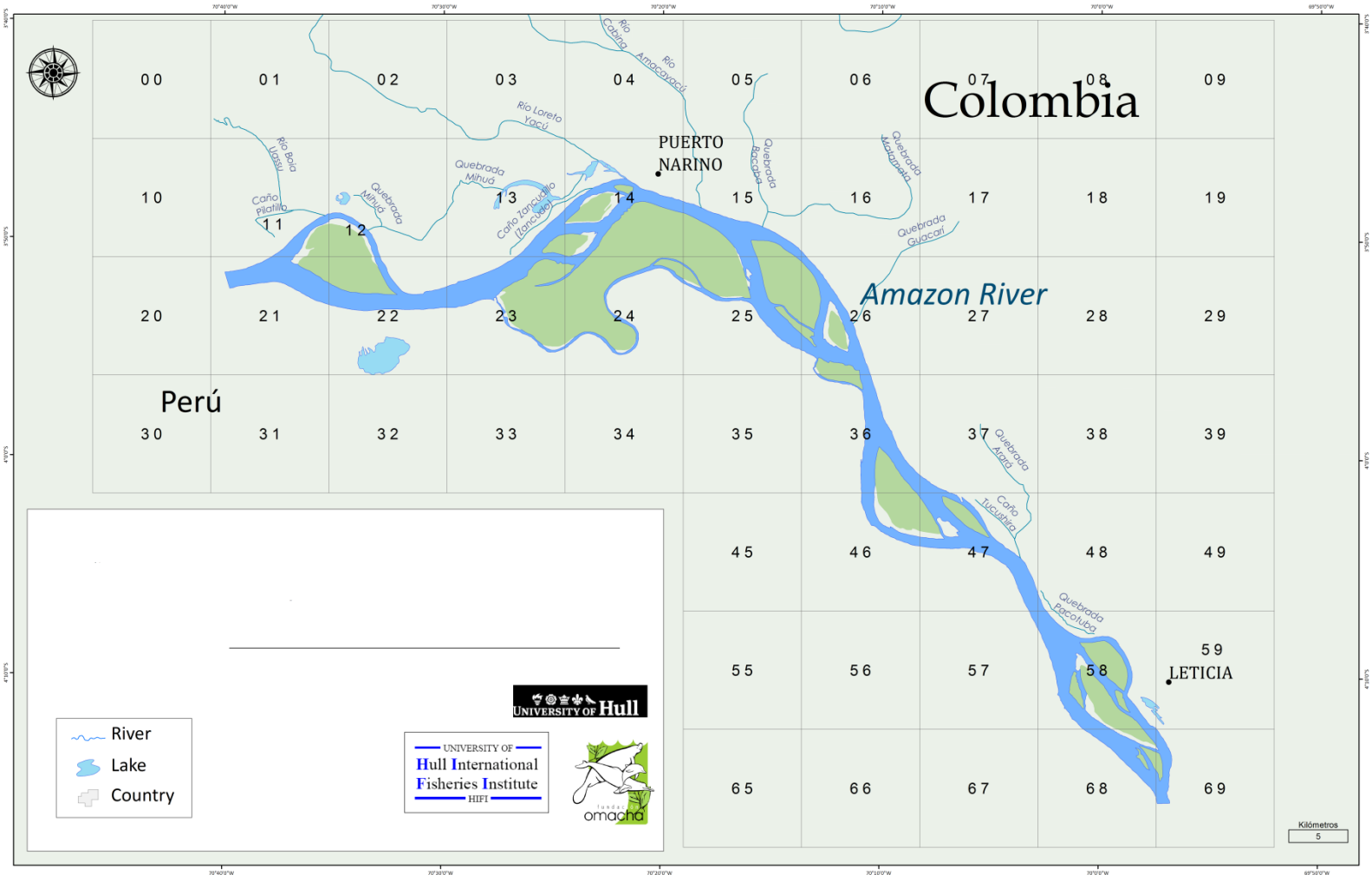

Figure 3.1. Base map of the study area used to locate the distribution of species and habitats. For geographical context see Figure 1.1.

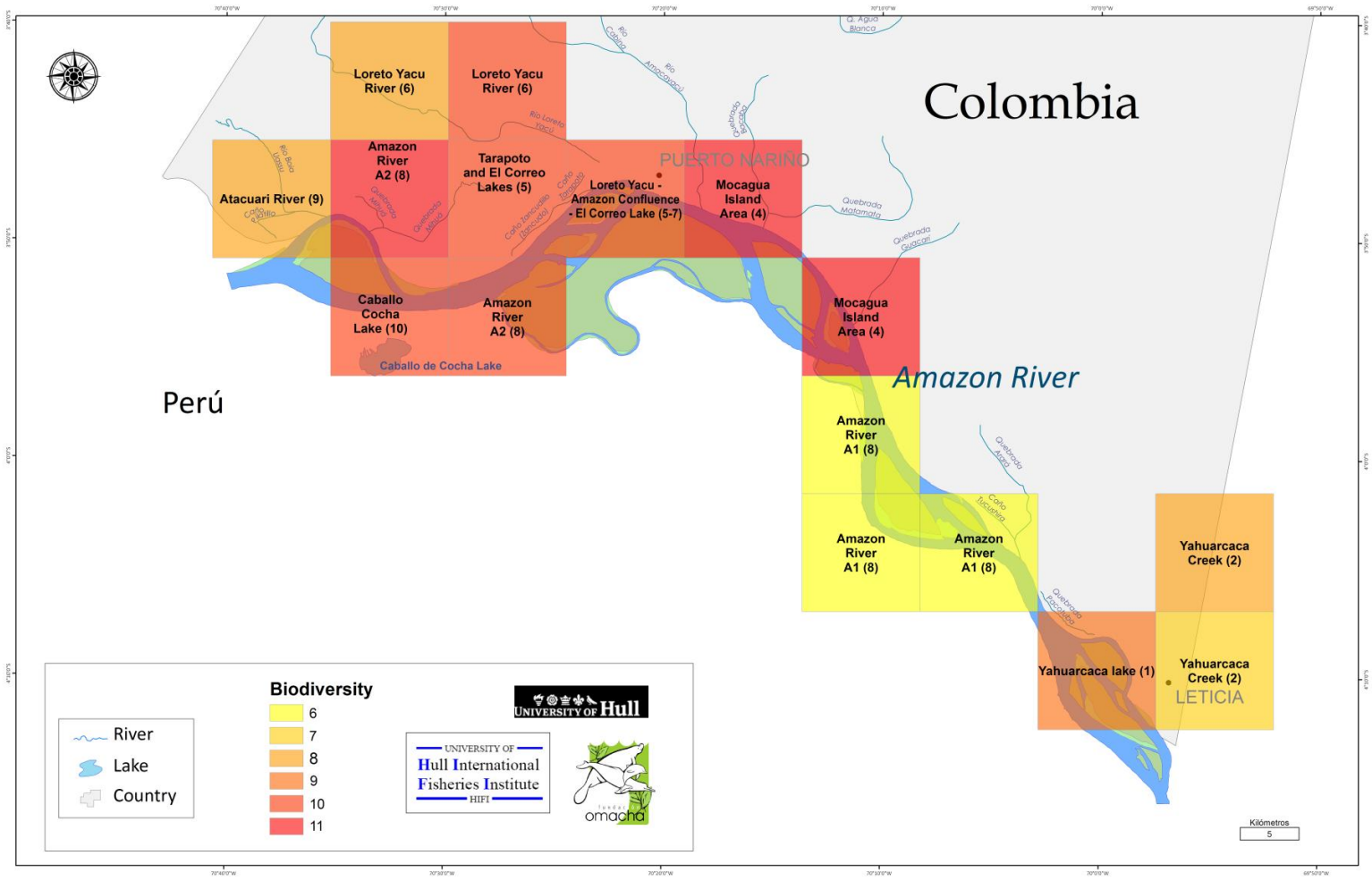

Figure 3.2. Distribution of Fine Filter Targets in the Study Area. Numbers (6-11) represent the groups (FFT) present in each grid. For detailed information of each grid see Table 3.2.

Table 3.3. Fine Filter targets: ecology, threats and cultural importance.

Scientific name	Ecology	Threats	Cultural importance	References
River Dolphins				
Inia geoffrensis- boto, bufeo, bugeo *Sotalia fluviatilis* - tucuxi	Being top predators makes them good indicators of the presence of fish, a functioning food web and appropriate habitats where fish can breed and feed. They use a wide range of habitats including: flooded forests, lakes, river banks, river mainstreams, beaches, confluences and low current areas. They are therefore directly affected by any changes in the ecosystem. They move and migrate long distances based on changes in the river level, or the creation and destruction of available habitats.	Overfishing, misuse of fishing gears, habitat pollution and fragmentation, uncontrolled touristic activities, population growth, human migration, lack of law enforcement and direct killing as fishing competitors or for the case of *Inia* for fishing bait to catch the catfish mota (*Calophysus macropterus* – Lichtenstein).	Part of the cosmogony of the indigenous communities. Stories and legends encourage locals to respect and fear dolphins. They are considered charismatic, flagship and attractive species, and play an important role in the local economies through dolphin watching activities and handicraft manufacture.	Ruiz *et al.* 2007 Gomez *et al.* 2008 Trujillo *et al.* 2010 Smith & Reeves 2011
Black Caiman				
Melanosuchus niger	As a top predator contributes to the energy flow chain within the system. It regulates prey populations (insects, amphibians, fish, aquatic birds and mammals), and the dynamics of abundance and richness of other aquatic populations. Removing the species from the system can cause a decrease in	Overfishing, accidental entanglement in fishing nets; as with dolphins, caiman flesh is also used as bait to catch the scavenger catfish mota; deterioration and habitat loss, lack of knowledge about the biology of the species.	It contributes greatly to local culture and economy throughout tourism. Indigenous communities use its meat as a source of protein and economic income, as well as its liver oil, for its medicinal properties. It is recognized as a sacred species, and claimed to be the owner of the water and lakes.	Fittkau 1973 Medem 1981 Ross 1969, 1995 Peres & Carkeek 1993 Rodríguez & Wilches 1999 Castaño-Mora 2002 Ruiz *et al.* 2007

	the number of some fish species when the flow of nutrients generated by the caimans' faeces is interrupted as well as the proliferation of micro-algae and zooplankton. It is found in lentic systems (especially on the shores), meanders, and low deep lakes, flooded forests and aquatic macrophytes. These habitats confer an abundance of aquatic vegetation which permits the proliferation of other aquatic species. Beaches as nesting areas are a key issue to the survival of the species.			Trujillo *et al.* 2008[a] Castellanos *et al.* 2009
Amazonian Manatee				
Trichechus inunguis	As a large herbivore it regulates and controls the populations of floating meadows and also contributes with nutrients in its urine and faeces to phytoplankton, which is the base of the aquatic food chain.	Hunting, occasional entanglement in fishing nets and domestication as pets. The species is also under threat from bioaccumulation of organ chloride pollutants and heavy metal from agriculture in the food web; reduction in macrophytes caused by pollution; underwater noises and boat collisions.	It is part of the local folklore. For several years it provided protein and monetary income to dozens of families. Currently, extensive work on environmental education is been undertaken with local communities and there has been no report of hunted animals since 2004 reflecting changes in the perception of indigenous communities about the species and its importance within the freshwater ecosystem and their cultures	Best 1981 Chiarello *et al.* 2008 Kendal *et al*. 2008
River Otters				

Lontra longicaudis - nutria or lobo de rio and *Pteronura brasiliensis* - perro de agua or lobo	Rare species in the Trapezium found in tributaries and more pristine areas indicating the good environmental health of the water and abundant fish resources because they are at the top of the food chain. The species are currently used as water quality indicators.	Overexploitation and continuous colonization, as well as mercury pollution from gold mining and bioaccumulation through fish and the food web. They are also exploited for the pet trade, and adults are commonly killed to capture the cubs and to sell them in local black markets.	For local communities, they are considered their ancestors. Many of their stories about the origin of their communities or even the origin of the world stress how river otters are the origin of their families and peoples. For local communities river otters maintain the balance in the aquatic world by taking out of the system poorly and contaminated fish.	Donadio 1978 Schenck 1999 Trujillo *et al*. 2008a. Portocarrero-Aya *et al*. 2009
River Turtle				
Podocnemis expansa - charapa	It is the largest river turtle in the world and has an unique spawning method due to the specificity on the selection of beaches and the large amount of eggs laid each time (100 -120 eggs). As a migratory species, is conditioned to the availability of the habitats created by changes during the hydro-climatic periods. The species uses different aquatic habitats to fulfil its needs during its life cycle. It is associated with large, medium and small rivers, to white or black waters, lakes or oxbows and beaches or banks. It is a great component of energetic chains in freshwater ecosystems, playing major roles in the cycling of energy and nutrients, riparian vegetation dispersion and in the maintenance of water quality.	Hunting of individuals for meat or pets, collection of eggs, habitat modification and deterioration, tourism, human settlements, deforestation of riparian forests in the headwaters, result in floods and the loss of nests and hundreds of eggs along the rivers and climate change when the sex ratio of hatchlings and the structure of the population are modified by an increase in soil temperatures.	It is an important source of protein for local communities and contributes to the income of a small portion of the society which subsists from the exploitation and illegal commercialization of the species' products (eggs, meat). More than 18 different uses are given to the species, making it an important asset to the communities. The species is also associated to different myths, legends and stories within the different indigenous communities.	Pritchard & Trebbau 1984 von Hildebrand et al. 1997 Castaño-Mora 2002 MMA 2002 Moll & Moll 2004 Ruiz *et al*. 2007 Portocarrero-Aya 2008.
Fish : Commercial fish - Leather fish (catfish)				

Pseudoplatystoma fasciatum (Pintadillo) *Pseudoplatystoma tigrinum* (Bagre rayado) *Brachiplatystoma filamentosum* (Lechero - Pirahiba) *B. rousseauxii* (Dorado) *B. vaillantii* (Pirabuton) *Zungaro zungaro* (Amarillo) *Goslinia platynema* (Baboso) *Calophysus macropterus* (Mota – Piracatinga)	Ones of the most important migrant species groups on the continent. Fish migration optimises the use of resources in temporally and spatially heterogeneous environments by investing energy in movements that bring larger energy returns. The species have particular habitat needs at different life stages and have specific spawning locations; this involves temporal and location-specific elements. Catfish populations are tightly associated with the estuary (Brazil) where they grow in size and mature, to the main channel of the river (Brazil) where they feed, to the rivers from the high Amazonia and close to the piedmont (Colombia, Peru and Ecuador) where they reproduce. As depredators, they control prey populations, allowing the balance of the structure and functioning of the ecosystems.	Misuse of fishing gears (fibre synthetic gill-nets), overfishing, deforestation, habitat degradation and modification, changes in the land use, pollution; e construction of dams, gold mining, climate change, water abstraction, and human population growth. Lack of policies enforcement and governmental presence as well as conflicts arising among fishers from Colombia, Peru and Brazil. Lack of homogenous legislation and fishing conservation strategies among countries. Lack of a homogeneous protocol for the extraction of ornamental species.	Only a few fishermen are dedicated to this fishery, but an important number of families get benefits from the income provided by the different steps comprised in the activity (fishing, selling, processing and distribution). 14 species of catfishes are commercialized from the city of Leticia to the interior of Colombia. Of those, 10 species are responsible for91% of the fish moved from this port, representing annually US$9 million. Leticia is the main catfish supplying port for the region, covering areas from the city of Iquitos (Peru) located 500 km west to the city of Leticia and from the city of Tefe (Brazil) located 1000 km downstream to the city of Tabatinga (Brazil).	Lowe-McConnell 1986 Barthem & Goulding 1997. Junk 1997 Agudelo *et al*. 2000 Abell *et al*. 2002 Durrance 2003 Junk *et al*. 2007 Hall (1972) In Castello 2008 Martel *et al*. 2008 Agudelo *et al*. 2009 MAVDT & WWF 2009
Fish: Subsistence fish -Scale fish				
Osteoglosum bicirrhosum (Arawana) *Colossoma macropomum* (Gamitana - Tambaqui) ♦ *Brycon sp.* (Sabalo) *Cichla ocellaris* (Tucunare) *Piaractus brachypomus* (Paco)	Important role in seed dispersal and plant distribution. They are also migratory performing spawning migrations, where the species move from the floodplain (feeding area) to the main river to spawn; and up river movements, which occur when the river level begin to		The main source of animal protein for the local communities. The selection of the species is based on local beliefs, tastes and flavour preferences, showing the predilection of scale fishes over catfishes for subsistence consumption. The Arawana (*Osteoglosum bicirrhosum*) is responsible for one	

*Prochilodus nigricans (*Bocachico) *Potamorhina sp.*(Braquinha) *Psectrogaster sp.* (Braquinha) *Mylossoma duriventre* (Palometa)	decrease and the fish leave the floodplain and tributaries and move to upriver areas with better oxygen conditions. Fish need an immense variety of habits, and depend on the continuity and connections among them.		third of the total individuals moved from Leticia, the main port of distribution of ornamental species in the area, to Bogota. This represents annually between US$ 200,000 and US$300,000 making it one of the more appreciated commercial species for the Colombian Amazon.	
Arapaima gigas –Pirarucu or Paiche	Top predator regulating prey populations. Its lateral migration from and into the flooded forest and from and into the lakes confines them to particular areas and specific environments on which they depend. Its presence in these areas confirms the presence of prey, suitable areas for spawning and nesting and the presence of key habitats to conduct its life cycle. Representative of one of the oldest fish lineages, as one of only seven species in the family Osteoglossidae and the monotypic genus Arapaima. Features like breathing air help the species survive in deoxygenated lakes and channels during the low water season while other species have to move to river channels where fishing activity is concentrated.	Overfishing has reduced its populations, the occurrence of large individuals and its genetic variability; habitat fragmentation and deterioration, and lack of policies enforcement.	The species has historically been part of the local communities' diet. Its meat is very valuable and highly sort in the local markets, making it an important element within the local economy. For Amazonian people the species has very important cultural and symbolic meaning. The species considerable size (up to 3 m of length) and because it is endemic to the basin make it part of the history, traditions and culture of the region.	Hrbek *et al.* 2005, 2007 Castello 2008 Lopez-Casas 2008 FAO 2009
Birds				
Birds *Phalacrocorax brasilianum* (Humboldt, 1805) *Anhinga anhinga* (Linneaus, 1766)	Seed disseminators and plant biodiversity controllers. Piscivorous birds help in the	Habitat deterioration and disruption by settlements and logging, touristic	Few species are used as a source of protein, but their meat and eggs are highly prized among the locals. The	Caro & O'Doherty 1999 Gomez & Tabares 2007

Butorides striatus (Linneaus, 1758) *Casmerodius albus* *Ardea cocoi* (Linneaus, 1766) *Mycteria Americana* (Linneaus, 1758) *Mesenbrinibis cayanensis* (Gmelin, 1789) *Anhima cornuta* (Linneaus, 1766) *Cairina moschata* (Linneaus, 1758) *Neochen jubata* (Spix, 1825) *Netta erythrophthalma* (Wied –Neuwied, 1833) *Anas cyanoptera* (Viellot, 1916) *Pandion haliaetus* (Linneaus, 1758) *Porphyrula martinica* (Linneaus, 1766) *Aramides cajanea* (Muller, 1776) *Heliornis fulica* (Boddaert,1783) *Eurypiga helias* (Pallas, 1781) *Jacana jacana* (Linneaus, 1766) *Charadrius collaris* (Viellot, 1818) *Tringa solitaria* (Wilson, 1813) *Actitis macularia* (Linneaus, 1766) *Sterna superciliaris* (Viellot, 1819) *Phaetusa simplex* (Gmelin, 1789) *Rynchops nigra* (Linneaus, 1758) *Opisthocomus hoatzin* (Muller, 1776) *Ceryle torquata* (Linneaus, 1766) *Chloroceryle Americana* (Gmelin, 1788) *Chloroceryle amazona* (Latham, 1790) *Chloroceryle inda* (Linneaus, 1766) *Donacobius atricapillus* (Linneaus, 1766) *Crax globulosa* (Spix, 1825)	maintenance of fish populations and are considered important predators within the local food web. Indicators of habitat deterioration, especially aquatic and semi-aquatic birds using beaches and river banks as sites for breeding and nesting.	developments and agricultural expansion, the use of agro-toxic compounds, indiscriminate hunting, and the collection of nests and living individuals to be sold in black markets.	targeted species are ducks, ibises and members of the Cracidae group which nest in trees of the flooded forests. Birds are also used in rituals, dances and for the manufacturing of handicrafts. Touristic attractions include bird-watching, a lucrative activity to locals.	Mejia *et al*. 2007 Ruiz *et al.* 2007 IAvH 2008

Table 3.4. Coarse filter targets: criteria of selection, ecology, threats, cultural importance and distribution.

Habitat	Criteria of selection	Ecology	Threats	Cultural importance	Local distribution/Grids (Figure 3.3)	References
Main River	i, ii, iv, v	Migration pathway and biodiversity corridor. Changes in water level are responsible for the hydrological structuring of different aquatic environments (Flood Pulse Concept) within the main stem: islands, beaches, channels, meanders, pools and confluences. Its chemical constitution influences processes like photosynthesis, and nutrient, CO_2 and O_2 cycling, and from that point the complexity of the food web and the resource use activities are shaped. Flow in the main stem of the river regulates erosion and deposition processes and transports sediments from the upland areas to the floodplain, which are influenced by human activities along its extension .It is a buffer to the impacts of human activities both on land and in the water.	Environmental disturbances, habitat fragmentation, logging, pollution, infrastructure development, up and downstream. Changes in the river's capability to regulate processes and to maintain the complex biodiversity. Lack of knowledge and policy enforcement mean they are not considered as ecological units performing important environmental processes and biodiversity supporters.	Commercial fishermen depend on the good health of the river and its proper functioning to ensure the success of the activity. Rivers constitute the largest communication and navigation network of the continent.	River Amazon – Mainstem *Grids:* 14, 15, 22, 23, 25, 26, 36, 46, 47, 58	Petts 1984 McCain 2001 Junk *et al*. 2007
Confluences	ii, iv	Zones characterised by variations in geomorphological and hydrological processes caused by entrainment of flows, and different types of water. Each confluence has its own characteristics and will possess different levels of productivity and biodiversity. Fish schools coming from the tributary into the river and vice versa, either in the day or the night time, use the confluences as gathering areas providing fishermen a	Boat traffic, pollution, overfishing, misuse of fishing gears, vegetation removal, changes in land use.	Important places to spot dolphins thus are important areas to develop touristic activities. Tourism, together with fisheries is a key economic activity in the Trapezium.	Loreto Yacu – Amazon; Atacuari – Amazon *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 36, 46, 47, 58	Rosales *et al*. 2007

		place to fish and predators, such as river dolphins, otters and caiman, a place to find abundant food.				
Island pools - *Remansos*	i, ii, iv, v	Found in sites surrounding islands and in meanders allowing species to save energy. During the low water season, pools located especially at the end of islands serve as refuges for manatees that migrate from lakes to the main river when the river level drops. During this particular time of the year, these pools constitute an important area for dolphins, manatees and fish.	Boat traffic, overfishing, misuse of fishing gears, changes in land use, expansion of agriculture, tourism	Constitute important dolphin watching spots as well as fishing areas during the low water season.	Areas surrounding the Islands of Mocagua, Patrullero and Vamos. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 36, 46, 47, 49, 58, 59	Herbert 2008
Beaches	iv, v	Beaches are only found during low water periods. They are essential breeding areas for reptiles, especially caimans and turtles, and birds.	Habitat degradation and modification, human settlement and infrastructure projects, expanding leisure and tourism activities	Leisure areas.	Beaches present in the Islands Mocagua, Patrullero and Vamos *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 36, 46, 47, 49, 59	Pettermann 1997
Flooded Forests - *varzeas* and *igapos*	i - v	Oscillate between terrestrial and aquatic phases, creating suitable environments for aquatic and terrestrial organisms, especially for fish, as well as provide opportunities for the performance of different aquatic and terrestrial activities. It is considered key land reserves for agriculture, animal husbandry and forestry, as well as for human colonization. They enhance biological production and maintain a large amount of biodiversity. Extremely important as refuges and feeding areas for fish, especially during the first year of life and more vulnerable larval stages of catfishes.	Logging, tourism, changes in land use, human settlement, population growth.	They provide local communities with the resources to support most of their daily and annual economic and cultural activities The majority of fish harvested in the area obtain nutrition in flooded forests or from organic matter derived from floodplain algae.	Flooded forests along the Amazon river (varzeas) and its tributaries (Atacuari, Loreto Yacu, Amacayacu Rivers and the Yahuarcaca creek - Igapos). And the flooded forests surrounding the Yahuarcaca Wetland System, the Tarapoto Lake System and the Caballo Cocha Lake (Igapos). *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 36, 46, 47, 49, 58, 59	Davis & Walker 1986 Bayley 1995 Daily *et al*. 1997 Junk 1997 Melack & Forsberg 2001 Abell *et al.* 2002 Agudelo *et al.* 2009

		Flood controller and nutrient recycler through sediment deposition in an area where the soils are very poor. Floodplains are the most fertile soils in the Amazon, and the processes maintained by the ecosystem ensure good health of the environment.				
Floating vegetation	i - iv	It provides shelter and food for fish and herbivores. These patches create a very dynamic and diverse habitat that plays a key role within the food web in the river. It is the principal source of dissolved organic carbon (DOC) for bacterial communities and ensures the maintenance of the chemical dynamics of these waters.	Vegetation removal, pollution, changes in land use.	Key habitat for subsistence fisheries.	Patches arising in the lakes, tributaries and main river, especially during the transitional water period. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 36, 46, 47, 49, 58, 59	Junk 1986 Melack & Forsberg 2001

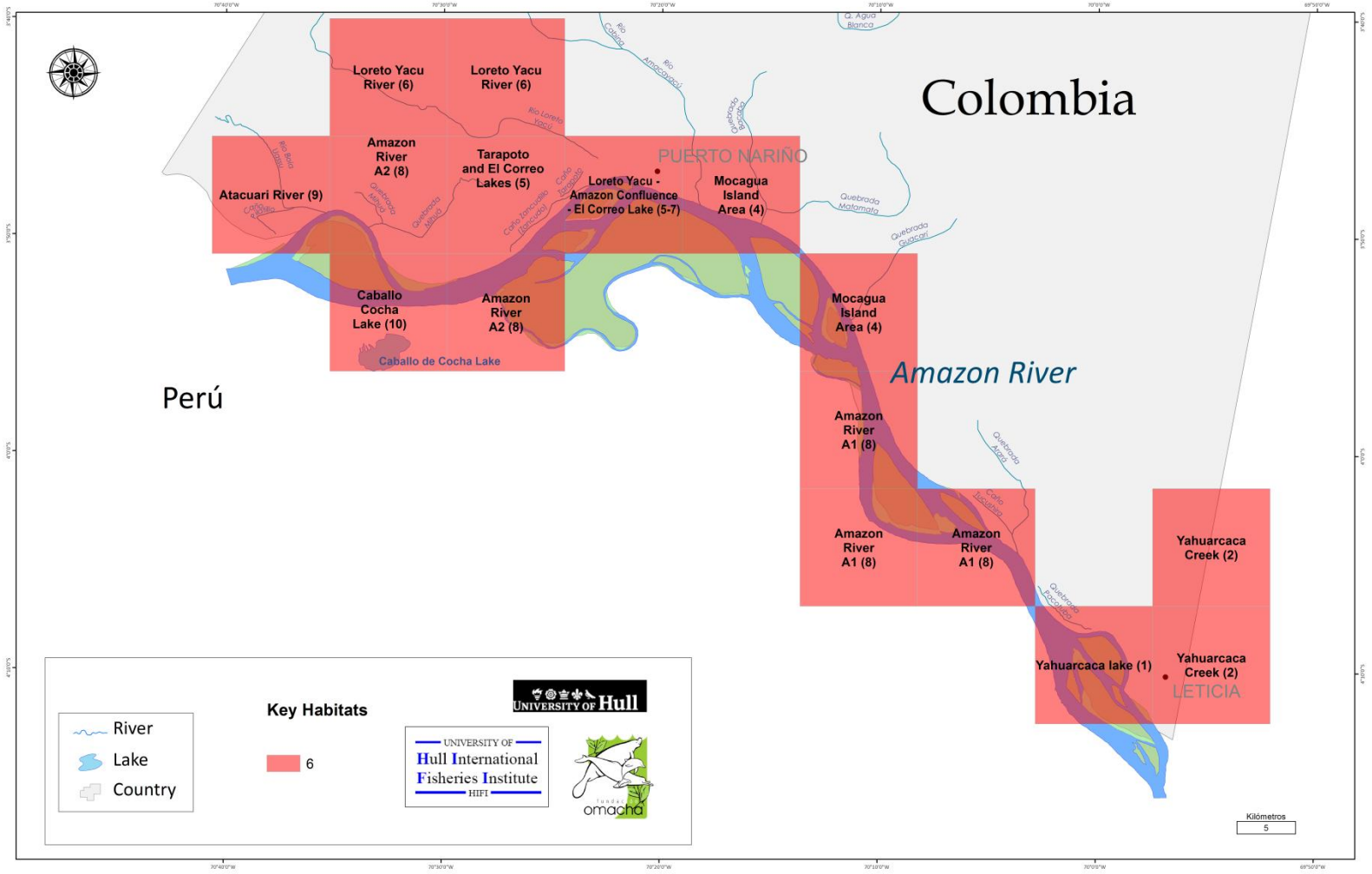

Figure 3.3. Distribution of CFT in the Study Area. The numbers (6) represent the number of key habitats (CFT) present in each grid. Details can be seen in the Table 3.4.

Using more than one species as a conservation surrogate is considered a multi-species approach. This method gives stronger criteria for selecting key areas, as well as defining ecosystem conservation strategies. Single species or habitats selected as surrogates for conservation are unlikely to succeed and effort will be wasted because of the complexity of the ecosystem and interaction that must be considered. Individual species surrogates will require a huge array of actions to achieve the overall conservation goals, therefore selection of groupings of target (surrogate) organisms or habitats for conservation is considered fundamental to addressing this problem (Caro & O'Doherty 1999).

3.4.2. Fine and coarse filters targets of the South of the Colombian Amazon

The study area can be considered as an exemplar of the biological, ecological and social reality of the Amazon. This area comprises 116 linear km of river, adjacent lakes and tributaries, and represents the complexity of interactions among species and their habitats in the Amazonian aquatic ecosystem, and the benefits and services that support entire communities within and outside the area.

The relationships among biodiversity elements is key to understanding the dynamics of the system and together with the interactions between these elements and their users, will provide opportunities developing for successful conservation strategies, especially those regarding the creation or implementation of areas of special protection (Embling 2010) (Figure 3.4).

According to Aldeman & Fagan (2000), surrogate species must spatially co-occur with a large proportion of other species in the area of interest. The maps (Figures 3.2 and 3.3) show species and habitat distributions, illustrating how both groups of conservation surrogates spatially overlap. Thus protection of either species or habitats will support protection of all ecosystem elements. However, protection of both Fine Filter and Coarse Filter Targets needs to be tightly linked to the maintenance of local ecological processes and the regulation of impacting anthropological activities (Abell *et al.* 2002). Whilst the maps provide elements for decision makers regarding the identification of key conservation areas, they also need to be integrated into environmental, social and economic impact assessments, as presented in Chapter 5.

Of the Fine Filters, river dolphins can be thought as a species that best represent other freshwater elements of the area, and as surrogates for the identification of key conservation areas that can be promoted as protected areas. Initiatives in Asia (China, India, Pakistan, Indonesia and Bangladesh) (Kreb *et al.* 2010) are using river dolphins as flagship species and with them are exposing the world to the threats and pressures that are risking the sustainability of the freshwater ecosystems in this highly populated countries. River dolphins are amongst the most charismatic species and conservationists have used this feature to attract funding for their protection. This strategy saved the panda in China when they were about to become extinct. Efforts conducted by WWF using the panda as its logo raised the attention of people worldwide. River dolphins in South America are in better conservation status than populations in Asia; for example the Baiji (*Lipotes vexilifer*) was recently declared ecologically extinct in China with only

a few individuals, insufficient to maintain a population, being sighted (Turvey *et al.* 2007). To prevent further extinctions in freshwater ecosystems, global and local efforts are now in motion; Asia and South America are working together and sharing their experiences in freshwater's conservation. The formulation of 'The Action Plan for South American River Dolphins 2010-2020' (Trujillo *et al.* 2010), is the result of years of research and work in the Amazon and Orinoco basins. The success of this type of strategy depends on collaboration between stakeholders. Joint work among countries, researchers, institutions and governments must be done when shared resources need to be protected. Cooperation with local communities is essential; their participation in conservation programmes is the key to success as primary users of the system and as major stakeholders affected by drivers and pressures generated by local, regional, national and global developments.

River dolphins are now used as indicators of water pollution by mercury and DDT (dichlorodiphenyltrichloroethane) (Lailson-Brito *et al*. 2008, Torres *et al.* 2009); revealing the impact that activities like gold mining and non sustainable agriculture have on the freshwater ecosystems, their top predators and humans. Dolphins are also indicators of the struggle that fishermen have to experience everyday when they go fishing. The decline in numbers of fish and changes in the composition of their communities due to bad management of the resources and the weak role of the local fishing and environmental authorities are driving fishermen to use more aggressive techniques (bigger fishing nets, use of toxic substances, fishing bans and regulations not obeyed), including the killing of dolphins as they are perceived direct competitors for the resource. Dolphins and humans share the same fishing areas and both have now to deal with years of overexploitation and habitat degradation.

In the area, river dolphins are active users of the flooded forest during the high water period. The flooded forests constitute one of the most complex and productive environments in the basin. The interactions among its components (animals, plants and ecological processes) make this a valuable and indispensable habitat for not only river dolphin conservation but for the entire Amazonian freshwater system. In the Trapezium, flooded forests are present mostly along the Amazon tributaries and the lake systems. Riparian habitats, especially those associated with flooded forests and floodplains, are known to have high species richness (Aldeman & Fagan 2000) and are therefore effective surrogates (these habitats can be considered as umbrella due to their role in protecting communities of species and other micro-environments). However, along the river, the flooded forest is highly fragmented because of the presence of human settlement and alteration of land use to pastures. These forests associated with lakes and tributaries that are better preserved. The Trapezium possesses three main lake systems: the Yahuarcaca lakes system near the city of Leticia, Tarapoto and El Correo lakes near the city of Puerto Nariño and Caballo Cocha Lake in the Peruvian village Caballo Cocha. These areas are considered essential for the maintenance of the freshwater biodiversity as well as the existence of the local communities. These lakes are used by dolphins, especially females and calves, as nursery and feeding areas. They are present throughout the year, and only leave when the level of the river drops to the point where the lakes get disconnected from the river. Lakes also are

the home of big pirarucu. This emblematic species is mainly sedentary and uses the lakes and the flooded forests as reproductive and feeding areas. In addition, turtles, birds, caimans and the Amazonian manatee use these systems as feeding and refugee areas. Lakes are less disturbed than the river, and their size provides refuge and allow them to escape human interventions. Manatees need areas of a certain depth and where their food, aquatic macrophytes, is available. This drives the species movements and makes them habitat dependant and vulnerable. When water levels drop, this species moves to the main channel of the river, where pools or *remansos,* provide refuge and food as other habitats dry up. These lateral migrations twice a year (during rising and falling water level seasons) expose the species to hunters, boats and fishing nets. As manatees move between the river and the lakes, they pass a complex trail of tributaries and confluences that are heavily used by boats, e.g. the Tarapoto Lake – El Correo Lake - Loreto-Yacu River – the Loreto-Yacu-Amazon confluence - and finally the Amazon River. This type of journey highlights the importance of protecting all the different and heavily used habitats. The main river is, however, sometimes forgotten, yet it provides a variety of critical habitats, but being the main artery is heavily impacted by human activities. In the Trapezium, the river is an ecological unit that is home to dolphins, manatees, birds, caimans, otters, turtles and fish. The river is critical pathway used by the species to move between habitats, but also provides islands, beaches, channels, pools, meanders and floodplains that are crucial for maintaining the functioning of the system and providing ecosystem services.

Coarse filter targets (habitats) should not be considered as independent units, they must be used as a group when conservation strategies to protect a particular area, species, service, process or the entire watershed are formulated. Species selected as fine filter targets must also be grouped if better and more successful conservation initiatives are to be achieved. Thus, both fine and coarse filter targets are required as part of any freshwater conservation strategy.

This is further warranted because not all Amazonian freshwater species can be considered charismatic like river dolphins. The lack of appeal of some threatened species is an impediment to attracting the attention of people and getting support from funding agencies and local communities for conservation. Species considered dangerous and with little charismatic appeal, like the black caiman, or cryptic species such as catfishes, do not always get the attention needed for their protection. Fortunately these species embrace features that make them essential for ecosystem functioning and survival of local people. For example, local people are aware of the importance of the black caiman and the way it controls the dynamics, stability and health of the system and are thus respected within ancestral believes. Unfortunately, the species have been pushed into less populated areas with little human disturbance. These areas represent key areas that will complement any strategies implemented for river dolphin's conservation. Black caiman as well as river turtles and some aquatic birds also use beaches and sand banks created during the low water periods for breeding, and their presence suggests these areas are in good ecological condition. Destruction of these habitats will lead to local extinctions of the species, despite conservation efforts focused on the flooded forests,

confluences or lakes. It should be noted that fishes in general are not considered important for the functioning of the systems or as key elements supporting the food web that supports other species. Fish are considered as an aquatic resource that provides benefits only to humans. Regulations and conservation strategies have always been focused on the economic role of these species. Fishing is one of the most important activities conducted in the area. Commercial fisheries even though not contributing much to the national economy, are part of the dynamics and essence of the region. It was not until recently that fish were seen as species that need to be protected to ensure the existence of those species that feed on them, e.g. river dolphins, otters, caimans, birds, but also as the main source of protein for local communities. The depletion of fish stocks by commercial fisheries and local consumption will force other species to change their distribution to areas where fish is available. Such changes will change the dynamics of local communities that are dependent on both the fish and conservation species. Conservation strategies in the Colombian Amazon have been led to protect commercial species and with it local and national markets, but they have not been formulated or created to protect the food security of hundreds of Amazonians that play an important role within the Colombian social diversity. To protect the fish communities and stocks in the Trapezium, it is crucial to protect all the freshwater environments used by the species, and this is best achieved using more visible conservation surrogates to attract people's attention.

This multiple perspective approach must consider the group of species, their needs and importance for local environments as well as the interactions among them to characterize the local freshwater biodiversity. Birds have been already used as conservation surrogates in the identification and creation of three Important Bird Areas (IBAs) in the study area (IAvH 2008). The Yahuarcaca Lakes System, Mocagua Island and the PNN Amacayacu were chosen as IBAs using the concept of coarse and fine filter targets (for location, Figures 2.2 and 2.3).

Using habitats, and specially species, to locate areas of conservation importance is a strategy to attract public attention and obtain funds to change social patterns that will in time protect the ecosystems and the local livelihoods. To achieve this aim, there is a need for information on the species and habitats to give a clear characterization of the area. Despite being heavily studied in the last couple of decades, further research is needed in the Trapezium to understand the linkages among the ecosystem components and ecological processes that support and maintain the wide biodiversity, especially regarding phytoplankton, zooplankton and macro invertebrates in white water systems, but this information needed must not be an excuse for not implementing conservation initiatives based on knowledge of surrogate species. Immediate action for the coarse filter species proposed will, for example, help protect the 23 species of amphibians found in the *varzeas* of the Trapezium about which little is known. Such a strategy will also help protect species that have societal and ecosystem benefits (vector controllers, pharmaceutical value and nutritional benefits), but about which there is little known at present.

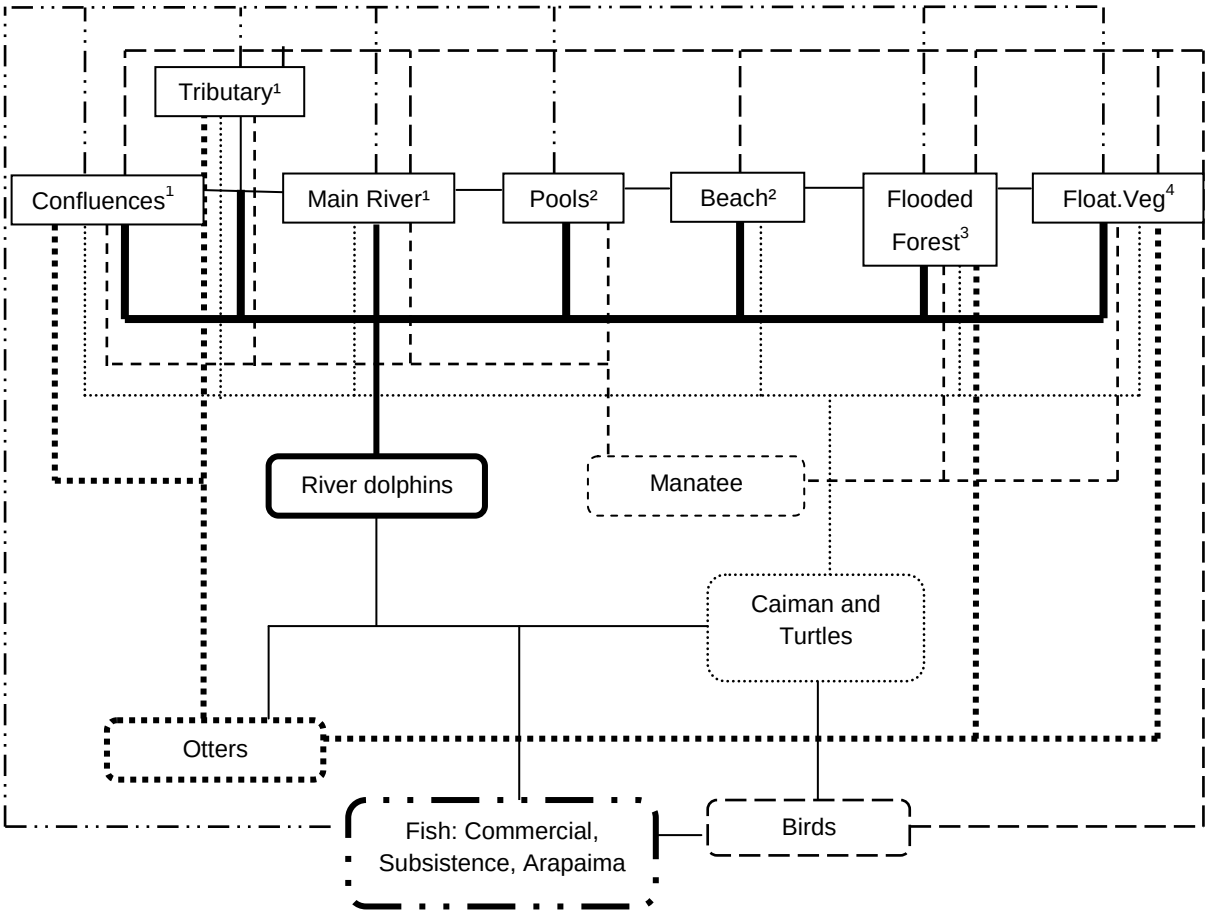

Figure 3.4. Diagram showing the interaction among fine and coarse filter targets in the Trapezium. [1] habitats available all year; [2] habitats available during low waters; [3] habitat available during high waters; [4] habitat available during transitional waters.

3.4.3. Colombian conservation strategies for the Amazonian freshwater biodiversity

In Colombia, environmental policies have been formulated to meet international agreements and commitments (CBD, Ramsar, OTCA, OMS and CITES). Current environmental policies aim to protect the national biodiversity, species and ecosystems, as well as to protect the local communities' traditional knowledge and livelihoods by ensuring the maintenance of key areas, key species and strategic ecosystems and watersheds. The National Biodiversity Policy is the tool that guides the way Colombian biodiversity is managed and protected currently and for the foreseeable future. The main objective of this policy is the conservation and sustainable use of the biodiversity as well as the fair and equitable distribution of the benefits resulting from its use (MMA 1996). This is achieved by characterising all the components of the national biodiversity and strengthening and disseminating the knowledge and traditional practises of Colombian indigenous, peasant and afro-Colombian peoples (Ruiz *et al.* 2007).

The policy is implemented through a series of legal instruments and tools formulated under each government in power, as a way to guide its management and conservation actions throughout the time of governance. These tools act at national, regional and local levels, covering different aspects regarding the use of the territory, the natural resources and the

development of its peoples. These legal instruments were created to enforce joint work among different development sectors of the country and environmental institutions to find a balance between economic development and the use and conservation of its biodiversity. The National Biodiversity Policy instruments are: at a national level the National Development Action Plans (one Action Plan for every presidential term), and for the Amazonian Region, the Triennial Action Plan for the South of the Colombian Amazon – Corpoamazonia – PAT (2007-2009), the Regional Environmental Plans for the South of the Colombian Amazon – Corpoamazonia - PGAR 2002-2011, Territorial Zoning Plans (POT – Planes de Ordenamiento Territorial) for the Department of Amazonas, the Life Plans for the Indigenous Peoples of the South of the Colombian Amazonian Trapezium, Agenda 21, and the Development Forestry Plan for the South of the Colombian Amazon. However, these policies, legal frameworks and tools do not assure conservation objectives are met, especially in countries with such biological and social complexity. Different approaches must be implemented to help the country achieve these goals. No specific methodology about the use, management and control of aquatic ecosystems in the Amazonian region have been implemented to date, and until now the few existing policies and regulations are focused on improving fisheries and aquaculture, ignoring the rest of the freshwater resources.

To contribute to the implementation of these national conservation objectives at the local level, different stakeholders have implemented a series of management plans and strategies to focus on local resources, their users and their dynamics. The National Conservation and Management Programme for manatees in Colombia (Caicedo-Herrera *et al.* 2004), the Action Plan for South American River Dolphins (Trujillo *et al.* 2010), the National Action Plan for aquatic mammals (MAVDT in press), the Book of Endangered Aquatic Fauna in the Colombian Amazon: Analysis and Conservation Proposals (Trujillo *et al.* 2008a), and agreements for responsible fishing in the Tarapoto Lakes (Trujillo & Trujillo 2009), are examples of local and regional initiatives to help the country achieve its commitments. Actions proposed in these plans and programmes have been slowly implemented but there is still a long way to go to accomplish their objectives. Cooperation among stakeholders is vital to implement the actions; these plans need to be used by not only the people that formulated them, but by others to guideline future conservation projects.

Environmental policies in Colombia also need to be encapsulated in the formulation of educational, development and health policies. The causes of biodiversity loss and habitat degradation involve deeper social problems that can, in part, be overcome through better education and health programmes as well as sustainable economic strategies.

3.4.4. Conservation within multi-jurisdictional territory

Municipal districts, urban centres, indigenous reserves, indigenous communities, protected areas, forests reserves and private property constitute the management divisions of the territory in the Trapezium area. Each has its own management regulations as well as stakeholders assigned to ensure its proper use, development and conservation. The variety of legal

territories, which in some cases overlap with each other, need special attention when conservation actions are sought. Each management division comes with a variety of stakeholders that act according to their own desires and interests, which in some cases do not meet local people needs and conservation priorities. Inconsistencies like this cause problems and misunderstanding in any conservation or social campaigns or programmes planned and implemented.

Freshwater resources are the responsibility of the State; public waters belong to the nation and no one can possess them or act on them as an owner. Free use and access to rivers and lakes make them a common property. In this part of the Colombian Amazon, the freshwater ecosystems inside the TICOYA Reserve are managed by the communities settled within them. This includes the Tarapoto and El Correo Lake System as well as the Atacuari and Loreto-Yacu tributaries and their wetlands. Any conservation initiative forwarded by any NGO, institute, university or even the environmental authorities must be authorised by the Reserve's authorities. Wetlands inside any other indigenous reserves along the Amazon bank and river (e.g. Mocagua Island wetlands) are managed by these communities.

In the rest of the study area, aquatic ecosystems inside the Amacayacu NNP are managed and protected by the National Natural Park System (UAESPNN) and those beyond their boundaries are the responsibility of the state. The north half of the Amazon River and the Yahuarcaca Lakes System are also the responsibility of the Colombian government. The southern half of the river is Peruvian territory. In this area there are no boundaries and the river is shared, used and managed according to verbal agreements between users from the two countries.

Although exploitation activities need to comply with conservation strategies applicable to the area where they are being applied local people (e.g. fishermen, hunters, loggers or just civil people, indigenous or otherwise) do not necessarily alter their behaviour to comply with the regulations. Most conservation programmes fail on this aspect because local communities have not been consulted or been direct involved the formulation process. In future, all stakeholders should be engaged in the development of conservation strategies. They should recognise that the conservation of local freshwater species and habitats is the responsibility of every stakeholder present in the area regardless the wider area in which the elements of biodiversity occur. The Government strategy to empower local leaders and institutions in activities of surveillance and control of their own resources unfortunately has not been successful because of failure by national and local institutions to play their part as environment authorities (Ruiz *et al.* 2007). Local empowerment is potentially a good strategy to manage and use freshwater resources properly, but this strategy needs to be closely accompanied and guided by local and national authorities.

Finally the conservation surrogates selected could be a basis for the regional environment authority (Corpoamazonia) to establish environmental indicators, which by law must be established in every region of the country through the Territorial Zoning Plans (PBOT). Currently neither the PBOT of Leticia or the EOT (E for Scheme) of Puerto Nariño, mention or include any

environmental or biological indicators in their proposed conservation and planning strategies. However, the Development Plan for Puerto Nariño 2008-2011 has among its objectives the participative formulation of environmental, socio-cultural and economic indicators to improve the touristic potential of the municipal district. Environmental indicators selected by the Municipalities will become conservation surrogates and will be considered a complementary conservation strategy in the area.

3.5. Conclusions

- The Amazon basin has always been considered as a whole system, including terrestrial and freshwater realms. Terrestrial ecosystems can be interrupted or disconnected from each other with minimum impact, but freshwater systems are a continuum and maintaining connectivity between the myriad of habitats across the Trapezium is essential for any freshwater biodiversity conservation strategy. Maintaining this connectivity (between aquatic ecosystems, within the riparian zone and floodplain and with subterranean systems) will ensure the maintenance of species that depend on them, especially those selected as fine filter targets, as well as ecological processes and with it the provision of social benefits and services.
- The habitats and species availability across the territory are conditioned to the hydrology of this part of the Amazon basin (western Amazonia). The River Amazon and its water level changes condition the rest of the aquatic environment's chemistry and heterogeneity, as well as the daily and seasonal human activities in the area.
- Protecting all elements of regional, national or local biodiversity is impossible. Freshwater species are not easy to study because they are highly mobile and not visible, complicating efforts to estimate their abundances or understand their population dynamics, habitat use or conservation status. For this reason many management efforts have been postponed because of a lack of knowledge. Consequently, it is important to identify representative elements (species and habitats) of the biodiversity to address conservation initiatives to ensure the protection of other elements of the biodiversity, ecological processes and human livelihoods. It should be noted, however, that lack of knowledge should not be seen as an excuse not to implement conservation strategies, as the precautionary approach to protection should be invoked in these circumstances.
- Twenty five freshwater species (fine filter targets) and six habitats (coarse filter targets) were selected as conservation surrogates for the Colombian Amazonian freshwater biodiversity. The species selected represent specific characteristics and environmental features that must be available to meet their needs and those of other less-visible species that share similar habitat needs (Lambeck 1997).
- Considering habitats as conservation surrogates is a strategy to capture the wealth of aquatic biodiversity of the area (TNC 2000). A habitat supports both the target species as well as the ecological processes maintaining these species. Habitat in good condition is reflected in its proper functioning as well as in the presence of a healthy food web. In general, for freshwater species, the presence of a diversity of habitat may be more important

than the extent of key habitats, especially to those species that require markedly different habitats during their life stages (Abell *et al.* 2002).

- Together the freshwater species and environments cover a wide distribution. The sum of the areas needed by the species shape an important and vital space for the local and regional freshwater biodiversity (Sanderson *et al.* 2002). The sites covered by these habitats provide different benefits to the system and its inhabitants, and the Coarse Filter Targets support the life cycles of the species selected as fine filter targets (Goulding 1980, Coppolillo *et al.* 2003).
- The implementation of actions to address aquatic species' conservation is also key to success. Conservation of Amazonian freshwater systems and their elements (including human populations) is not possible without local communities and stakeholders working together. Ancestral knowledge combined with scientific information must be the basis for policy makers to drive their policies, regulations and interests to a point where sustainable life patterns begin to happen.
- The use of conservation surrogates as a conservation tool is only useful when it is part of a wider conservation strategy, considering social, cultural, economic and historical perspectives. Mapping species and habitats is an indispensable tool to identify areas with key species and habitats, areas with a special use and areas that need special attention and management by locals and authorities. However, participation of local communities is essential for the formulation and implementation of conservation initiatives. Conservation surrogates must, therefore, be selected to support conservation of not only biotic elements of the systems, but also to help improve the livelihoods of aquatic resource users.
- Freshwater conservation initiatives must have an ecosystem vision where the conservation of ecological processes (important evolutionary phenomena and communities' assemblages) and of single species and habitats are planned together. Conservation programmes in the area must also consider the jurisdictional issues and the multiplicity of stakeholders in the Trapezium.
- Colombian environmental legislation should be powerful enough to enable protection of freshwater biodiversity and ecosystems. Deficiencies in enforcing legislation and capacity of the local authorities are allowing the regulations to be bypassed.
- The Colombian government needs to find a way to harmonise legislation regarding fish, not only as an exploitable resource but as an element of the aquatic national biodiversity. Better and more rational regulations regarding fisheries must be formulated in association with the fishing authorities of Peru and Brazil.
- Information provided in this chapter will provide a framework for coordinating new and existing initiatives for biodiversity conservation at the local and regional levels.

CHAPTER 4

DIAGNOSIS OF THE ECOSYSTEM SERVICES AND SOCIETAL BENEFITS PROVIDED BY THE FRESHWATER ECOSYSTEMS IN THE SOUTH OF THE COLOMBIAN AMAZONIAN TRAPEZIUM AND HUMAN ACTIVITIES (DRIVERS) IMPACTING ON THEIR PROVISION

4.1. Introduction

The Amazon River basin is threatened by an array of activities that could jeopardize the ecological integrity and conservation of one of the largest freshwater systems on earth as well as the lives of the entire humanity. The basin supports 50% of global biodiversity and discharges into the Atlantic Ocean 20% of the fresh water delivered to the oceans by rivers (McClain *et al.* 2001). It has more than 1000 tributaries, three of them longer than 3,000 km (Madeira, Purús and Yurua rivers) and also supports about 39 million people, including more than 420 indigenous groups (ACTO 2004). The South of the Colombian Amazon is characterized by a great representation of regional freshwater biodiversity. The freshwater ecosystems in the area offer a series of heterogeneous and complex environments suitable for maintaining hundreds of species supporting the ecological processes that underpin a dynamic and complex aquatic environment.

As with many other civilizations and cultures, the proximity to water bodies has characterized the evolution and development of the Amazon people. The dynamics of the river, its annual hydrological changes and variation in habitat availability provide and sustain important biodiversity and services that range from animal species to ecological processes that regulate global climate. These localised ecosystems and species and their interactions provide a diversity of underestimated and understudied ecosystem services. They range from food and raw materials, residential and industrial water supply to flood and erosion control, biological mediated habitat, nutrient cycling, climate regulation and culture identity.

Apart from the evolutionary processes that have been driving geomorphological patterns, ecological processes and environmental gradients in the freshwater ecosystems of the Amazon basin (Groves *et al*. 2000), social and economic development activities taking place in and outside the region are responsible for negatively impacting and modelling these ecosystems and the behaviour of their users.

Global trends drive global, national, regional and local economies and with it the way resources are used. In the Amazon region, people have always depended on the freshwater resources. The exploitation of the local resources has always been according to the needs of the local communities and their perception of their surroundings according to ancestral believes and culture. Nowadays local people do not only use and exploit the environment to fulfil their own needs but do so to support regional, national and global markets and economies, providing societies beyond the Amazon with important elements to meet their needs and desires.

For instance, the study area was shaped and influenced by a series of economic booms that drove local people to exploit their resources to fulfil national and global market demands. From 1900 to 1945 the forest was heavily exploited during the rubber and quinine booms and between 1930 and 1970 three species currently considered highly endangered were exploited to the point of extinction. The fur markets almost extirpated the jaguar (*Panthera onca*), and giant otter (*Pteronura brasiliensis*), and the manatee *Trichechus inunguis* was hunted for its meat, considered one of the most palatable in the basin. Regulations imposed by the Colombian government banning hunting in the late 1960s, slowed down the disappearance rates of these species. This period was followed by a preponderance of illegal plantations between 1970 and 1997, the establishment of productive agricultural systems not suitable for the conditions of the environment, and finally uncontrolled fisheries that currently constitute one of the major threats to local resources and livelihoods (Agudelo *et al*. 2000, Riaño-Umbarila 2003, Muñoz-Cordoba 2007, Ruiz *et al*. 2007).

Local freshwater ecosystems are threatened as a result of internal and external drivers of a social and economic development for food, recreation, space for living, clean water and other basic human needs. Changes in social and cultural patterns are leading not only to a degradation of the environment but local indigenous communities are putting at risk their heritage.

According to Chopra *et al.* (2005) economic growth has enhanced the demand for and consumption of freshwater services. The integration of local communities to global economic markets has decreased dependency on the environment (as a share of household income) but increased the extraction of forest and aquatic products in absolute terms. Trujillo (2007) also stressed that increases in total household income are thus associated with both more market income and more income from natural resource extraction. As markets open and household incomes increase, pressures on environmental resources are also likely to increase. This is something currently happening in the study area, and indigenous families are even more dependent on the environment and markets demands.

Maintaining healthy freshwater ecosystems and ecological processes is vital for the proper functioning of any economy and it must be acknowledged by national authorities who keep pushing national and regional development without understanding the direct connection among the natural's capital, people's welfare and the country's economic development (TEEB 2010).

In addition, external drivers that have put pressure on the freshwater ecosystems and local drivers aiming to fulfil the same need for food, space and clean water, are exposing the area to changes leading to habitat and cultural degradation and biodiversity loss. Local pressures range from water abstraction for domestic, industrial and agricultural use, effluent disposal, mining, dams and hydro-ways, to over exploitation of fish stocks, wrong use of fishing gears, hunting, logging, aquaculture farms and navigation. It has been estimated that the availability of water in the region has been decreasing as a consequence of a series of human actions related to the increase in agriculture, the destruction of highland ecosystems and recent climate alterations

(Ruiz *et al.* 2007). These pressures are the result of activities taking place both on land and in the water, shaping the functioning and components of these aquatic habitats and with it causing changes in local peoples' lives, economies and traditions. Nowadays the Amazonian peoples are considered to be influenced by an impoverished western urban culture that has changed the authenticity of their cultures and traditions.

The South of the Trapezium is inhabited mainly by three indigenous ethnicities: the Tikunas, the Yaguas and the Cocamas. [Non indigenous or *colonos* (settlers) constitute only 1.11% of the population of the study area (Riaño-Umbarila 2003)]. As the majority of the population in the area are indigenous, and in accordance with the National Constitution of 1991 (Articles 246, 286, 287, 329, 330) these communities have organized their territory in Indigenous Reserves. They hold autonomy over decisions about using, planning, exploiting and managing the territory and its resources.

The territory has been legally divided into 16 Indigenous Reserves, one National Natural Park (NNP Amacayacu), a Forest Reserve constituted since 1959, two urban centres (Leticia and Puerto Nariño) and private land surrounding these urban centres. This variety of legal forms of land tenure deserves well formulated land use planning and management regulations. Conflicts or misunderstanding derived from confusing or inappropriate land use plans can be added to the drivers risking the freshwater ecosystem's functioning. In Colombia, Territorial Zoning Plans (POTs in Spanish) are mandatory for every municipal district in the country and aim to provide a series of political and administrative actions of concerted land use planning to guide the development, use, transformation and occupation of the territory. All this, in theory, using socio-economic strategies formulated in harmony with the natural environment and the cultural traditions of the people inhabiting the area (Mesa *et al.* 2000). Each Indigenous Reserve is considered within these POTs, but each reserve fits with a plan that states the regulation of the land, water and natural resources within its borders.

Although having autonomy does not mean they are not affected by Government development plans or conservation measures, which in some cases go against the conservation policies settled by the communities. Conflicts between indigenous communities and stakeholders regarding the use of the territory and its conservation cause problems at the moment of formulation and implementation of joint conservation initiatives to protect the natural resources and improve their own livelihoods.

In the area, conservation of the freshwater resources has also been influenced by a current lack of governmental presence, unclear policies and an incorrect investment of public economic resources, which have magnified the drivers and pressures on the ecosystems through unregulated and uncontrolled use of habitats and species. An example is how weak enforcement of the regulations regarding commercial fishing (minimum size, appropriate fishing gears and fishing areas) has contributed to the reduction in size and number of individuals traded, resulting in changes in fishing patterns, and shifts in targeted species and fishing areas

(Durrance de Obaldia 2003). These changes also result in cultural and social transformations while local communities adapt to changes taking place in the environment and vice versa.

To improve conservation strategies in the area, it is essential to move towards the identification and assessment of ecosystem services and societal benefits, and the link between these and the increasing internal and external drivers that are having an impact on them. Up to now, conservation initiatives implemented in the area have changed from protecting singles species to protecting the entire ecosystem by linking biodiversity, ecological processes and human activities. Conservation patterns have changed gradually and have tried to be implemented according to National and International conservation policies. However, there is still a lot of work to do with local communities and stakeholders to ensure success of these initiatives.

Current conservation initiatives need to be changed and reinvented at the same pace that economic and social activities are changing and degrading the Amazonian biodiversity. Conservation now requires a better understanding of each element that comprises the ecosystem: species, habitats and their interaction must be understood and included in every initiative proposed. At the same time these strategies need to be formulated in conjunction with the local communities considering their needs and cultural history, and must be acknowledged and endorsed by the national and local authorities. These authorities must formulate and enforce their policies in a harmonized way where environmental, economic and social activities complement each other towards a sustainable use of the freshwater resources and the improvement of local communities' livelihoods.

For this reason, this chapter aims to characterize the ecosystem services and societal benefits of the south of the Colombian Amazonian Trapezium as well as their relationship with internal and external drivers creating pressures on the whole freshwater ecosystem and risking its survival. The results of this chapter and those of Chapter 3 (Conservation surrogates – species and habitats) will provide the foundation to identify key conservation areas in the South of the Colombian Trapezium (Chapter 5) and to formulate a Management Framework for the Conservation of the local freshwater biodiversity (Chapter 6).

4.2. Methods

All ecological, biological and environmental research and documents were compiled and analysed to identify and characterize the components of the local freshwater ecosystems. At the same time a social, economic and cultural review of the study area helped to identify the human activities, their dynamics and pressures on the area. This was followed by a qualitative appraisal of the ecological and social values of the ecosystems' services and benefits rather than their economic or developmental value (TEEB 2010). These reviews identified and characterized the ecosystem services, societal benefits and the drivers and pressures putting them in risk.

The literature was confirmed during two visits to the study area in July 2009 and March 2010, when informal conversations and interviews with local stakeholders and members of the

communities were held (Appendix 2). Previous working experience in the area was also used for this characterization.

Finally, the study area was divided in 10-km grids to map (according to the literature) the areas providing key ecosystem services and those exposed to human threats. One or more grids represent specific geographical spaces containing different water bodies' types (tributaries, lakes, islands systems, fragments of the main river) (Figure 3.1 Chapter 3). Maps were created using ArcGis 9.3.

4.3. Results

Fourteen (14) ecosystem services and societal benefits provided by the freshwater ecosystems for the South of the Colombian Amazonian Trapezium were identified and classified (Table 4.1). It is important to recognise that the ecological and social processes taking place in the area have a spatial and temporal character, involving hydrological and climate cycles responsible of the provision of the identified ecosystem services. Consequently, inclusion of spatial and temporal thresholds in the implementation of management and conservation activities regarding provisioning ecosystems is critical for successful outcomes.

Twenty (21) threats were identified and linked to a series of different drivers (Table 4.2). The ecosystem services and threats identified were mapped (Figures 4.1 and 4.2), making easier the visualization of these elements within the study area. The maps highlighted that both ecosystems services and threats overlap in space, making it difficult to balance both. Ecosystem services, societal benefits and pressures are now co-existing and interacting in the same territory.

4.4. Discussion

Worldwide ecosystem services are being impaired and destroyed by a wide variety of human activities; the study area is no different. A connection between regional and national consumer tendencies and the Colombian Amazonian freshwater resources is risking the balance of the ecosystem, the supply of services, the cultural and social integrity of local indigenous communities and the sustainability of this major system.

The following sections will try to elucidate the different ecosystem services, their main features and how the threats identified have an impact on them.

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Table 4.1. A Summary of the ecosystem services and societal benefits provided by the freshwater ecosystems of the South of the Colombian Amazonian Trapezium.

Ecosystem services		**Societal Benefits**	**Location of the service/Grids (Figure 4.1)**	**Ecosystem processes, components or features involved**	**Outcome in terms of livelihoods.**	**Communities benefited**
Supporting services	Biodiversity maintenance	Biodiversity maintenance	Amazon river, Tributaries and Lakes' systems. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 36, 46, 47, 49, 58, 59	Primary productivity; complex food web; river level fluctuations due to the hydrologic dynamics of the basin; chemistry of the waters; heterogeneity and complexity of freshwater and amphibian habitats. Flow of energy and matter, nutrient recycling.	Food security, Well being, resilience	Local, Regional, National, Global
Provisioning services: Production of Goods.	Fisheries – Food provision	Sport & game fishing - catch and release	Not common. Tarapoto Lake and Loreto Yacu River. *Grids* 13, 15, 22, 26, 36, 46, 47, 49, 58, 59			Local, Regional, National, Global
		Local consumption fisheries	Yahuarcaca Lakes System, Tarapoto and El Correo Lakes System, Caballo Cocha Lake. Amazon River and its tributaries. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 36, 46, 47, 49, 58, 59		Food security	Local
		Commercial fishing	Amazon River especially in the segment between Puerto Alegria (Peru) and San Jose (Colombia). *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 26, 36, 46, 47, 49, 58, 59		Food security	Local, Regional, National
		Ornamental fisheries	Black water creeks and lakes. Yahuarcaca System.		Well-being	Local, National, Global
	Water supply	Water for human consumption	All lakes, creeks and tributaries. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 26, 36, 46, 47, 49, 58, 59	Nutrient recycling. Hydrology dynamics.	Well-being, resilience	Local
		Agricultural uses	Amazon river, tributaries and lakes' systems. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 26, 36, 46, 47, 49, 58, 59		Well-being, resilience	Local

	Transport	Transport/Navigation	All Amazonian rivers. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 26, 36, 46, 47, 49, 58, 59	Hydrological dynamics. Habitat availability.	Well-being	Local, Regional
Regulating services	Waste treatment	Waste deposition	Yahuarcaca and Caballo Cocha Lakes. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 26, 36, 46, 47, 49, 58, 59	Nutrient and pollutants recycling. Bacteria and Fungus and other decomposer and scavenger fauna diversity.	Well-being, resilience	Local, Regional
	Climate Regulation	Climate balancing and carbon sequestration	Tarapoto, Yahuarcaca and Caballo Cocha lakes. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 26, 36, 46, 47, 49, 58, 59	Carbon and Nitrogen treatment and recycling (especially in black water bodies). Food web – matter flow. Photosynthesis. Riparian forests and their role retaining humidity and maintaining soil structure.	Well-being, resilience	Local, Regional, National, Global
Cultural services	Cultural heritage and identity; Leisure and recreation; Cognitive values and aesthetic beauty.	Dolphin watching	Tarapoto and Caballo Cocha Lakes. All along the Amazon river and confluences. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 26, 36, 46, 47, 58	River Dolphins. Energy and Matter flows. Maintenance of food web.	Well-being	Local, National, Global
		Indigenous communities - handicrafts	Communities settled along the river. Mocagua, Puerto Nariño, Siete de Agosto Atacuari, 20 de Julio, are among the most representative. *Grids:* 2, 3, 11, 13, 14, 15, 26, 36, 46, 47, 49, 58, 59	Biodiversity maintenance.	Well-being	Local, Regional, National, Global
		Landscape viewing	The Amazon River, its tributaries and lakes' system. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 26, 36, 46, 47, 49, 58, 59	Habitat heterogeneity. Biodiversity maintenance.	Well-being	Local, Regional, National, Global
		Scientific and social research	The Amazon River, its tributaries and lakes' system. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 26, 36, 46, 47, 49, 58, 59	Availability of ecosystems and components.	Well-being	Local, Regional, National, Global

Table 4.2. Drivers, pressures/threats identified in the study area, their site of occurrence and the ecosystem services impacted.

Drivers	**Pressures/Threats**	**Site of occurrence/Grids (Figure 4.2)**	**How do these drivers and pressures impact. Short statement. Extended information in section 4.4.**
Need for food; Human population growth; Governance	Overfishing	Amazon River, its tributaries and Lakes' systems. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 36, 46, 47, 49, 58, 59	Overfishing of scale and leather species both for subsistence and commercial purposes will have an impact on biodiversity composition. Biodiversity loss can be expected. Changes in local feeding habits and species preferences can change cultural and ancestral patterns. Local communities depend enormously on fisheries for economic and survival purposes. The livelihoods of commercial fishermen and their families will be affected when their main source of income collapses. Overexploitation of ornamental species causes the destruction of their habitats and with it the depletion of species having an impact on the income of the small group of people involved in this activity. The presence of dolphins depends almost exclusively on the presence of fish. So changes in the composition of the fish fauna will be reflected in the presence and health of local dolphin populations. This will impact the dolphins watching industry growing in the area.
Need for food; Governance	Illegal use of fishing gears	Amazon River, its tributaries and Lakes' systems. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 36, 46, 47, 49, 58, 59	Impacts will be seen on changes in fish population structure, depletion of the main commercial and locally consumed species. Depletion of other aquatic species involved in bycatch can be expected. The misuse of fishing gears can cause water pollution, especially when *barbasco* and other toxic plants are used. Polluting water will generate health and social problems in an area that depends almost exclusively on the good quality of its water to drink, cook, bath, etc.
Need for food; Need for clean water; Human population growth	Water pollution	Yahuarcaca Wetland System. Caballo Cocha Lake. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 36, 46, 47, 49, 58, 59	Can affect habitats and species, depleting some and changing the balanced of the web trophic dynamics. Subsistence and commercial fish species can be affected by deoxygenated waters as a result of high amount of pollutants and the eutrophication of the water. Social and economic impact. The dependency of the communities on the quality of the waters can be put at risk, as well as their health and survival. The capacity of the water bodies to act as waste recipients will change making freshwater ecosystems no longer able to perform that service. This will have a

			consequence on the acceptable values of nutrients in water, soil and air. The capacity of lakes to act as carbon sequestrators and their role in climate balancing will be negatively affected. The tourism industry will be impacted when unhealthy ecosystems will be no longer attractive to visitors. Environmental and social degradation can be expected from high levels of water pollution.
Need for food; Need for alternative income options	Hunting (aquatic species)	Amazon River, its tributaries and Lakes' systems. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 36, 46, 47, 49, 58, 59	Impact on endangered species risking their survival. Biodiversity loss can be expected. Activities like dolphin watching will be impacted if dolphins disappear. Scientific knowledge will die with the species and valuable information for the conservation and medical fields can be lost. Cultural and ancestral knowledge can die with the species and with that part of the social and cultural diversity of the area.
Need for food; Need for alternative income options; Human population growth	Conflict between river dolphins and fisheries	Amazon River, Lakes' systems. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 36, 46, 47	It can increase overfishing and the misuse of fishing gears and their impacts on the ecosystem are stated above. It will also have an impact on dolphin populations when more dolphins are killed as a result of this conflict. The fishery of the mota *Calophysus macropterus* is already using 600 dolphins a year to support the market of this species. An increase or strengthening of this conflict will be perceived when dolphin numbers begin to drop. The tourism industry (dolphin watching) will be impacted. Cultural and ancestral knowledge on fish and dolphins will disappear with the changes in the interaction between humans and their environment.
Need for food	Abstraction of water for agriculture – irrigation	Amazon River, its tributaries and Lakes' systems. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 36, 46, 47, 49, 58, 59	Increase of water pollution, affecting the most important source of water for human consumption in the area, and an increase of agriculture and with that large-scale land conversion (deforestation, cultivation and urbanisation) can be expected. There will be changes in the quality and admissible levels of nutrients in water affecting the buffer capacity of the water bodies and their role in carbon sequestration. In a long–term scenario changes in agricultural patterns and water use can transform the landscape and affect the tourism industry.
Need for electricity; Human	Dams and flow	Amazon River in Brazil	Dam construction can cause habitat fragmentation, genetic isolation and the

population growth	regulation *		interruption of migration patterns of catfishes and dolphins. Regulated flows reduce flood levels and the amount of sediments deposited in the floodplain. This threat has an effect not only in its source, where also causes large-scale land conversion, but in far way upstream and downstream localities. Dams are also responsible for increased GHG emissions.
Need for recreation; Transportation	Boat traffic	Amazon River, its tributaries and Lakes' systems. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 36, 46, 47, 49, 58, 59	Increase water pollution and underwater noise will affect sensitive species like the endangered Amazonian manatee. Changes and migration of species to quieter areas can be expected affecting activities like fishing and tourism. Any harm to these activities will have large repercussions on the local and regional economy.
Economic growth	Hydro-ways	Amazon River (Brazil, Colombia and Peru).	Water-ways bring changes in the pulses of the river affecting the presence of beaches suitable for turtles and caimans to nest; they also modify the reproduction and spawning times of fish, which are activated according to changes in the river level. For the creation of a water-way the river must be modified to be fully navigable implying changes to its banks, sedimentation rates and flowing patters. Aquatic species dependant on fish and habitats like beaches, floating meadows and floodplains will be greatly affected.
Need for an income; Need for living space	Logging and deforestation	Riparian Forests covering the entire study area. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 36, 46, 47, 49, 58, 59	The removal of the riparian forest affects the dynamics of the system enormously by causing changes in river flooding dynamics, provoking the loss of key habitats (e.g., varzeas) for fish and other aquatic species, with the reduction of shelter and feeding areas. Deforestation also changes nutrients' cycling and the input of terrestrial allochtonous material into nutrient-poor black waters. Erosion and flooding episodes will be increased leading to biodiversity loss and forced human and animal migration.
Need for food; Governance	Lack of income alternatives. Dependency on aquatic ecosystems	Communities based along the Amazon River, its tributaries and lakes' systems. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 36, 46, 47, 49, 58, 59	Overexploitation of both fish and other aquatic species (turtles, manatees, dolphins, iguanas) will lead to biodiversity loss and structural changes in the trophic web, affecting the environment and the local and regional economy as well as the livelihoods of all families in the study area. Social problems are expected when local communities have to resort to illegal activities (poaching, illegal crops, and logging) as a result of the lack of legal income opportunities. Exacerbation of poverty reinforced by habitat deterioration and pollution.
Governance	Lack of enforcement of regulations and policies	Amazon River, its tributaries and Lakes' systems.	It will lead to the uncontrolled exploitation of the resources, to changes in land use causing pollution and deforestation.

		Grids: 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 36, 46, 47, 49, 58, 59	Social injustice, poverty and abandonment. This generates tensions between local inhabitants and governmental organizations. Lack of trust and cooperativeness will impact the performance of any conservation and social initiative impairing the environment and its users.
Political and financial instability; Governance	Failure of planning in rivers and lakes	Amazon River, its tributaries and Lakes' systems. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 36, 46, 47, 49, 58, 59	Habitat degradation, biodiversity loss due to the over exploitation of natural resources as a result of social dissatisfaction and discontent. Loss of confidence in the role of external organizations.
Governance	Problems of local communities with stakeholders	Communities based along the Amazon River, its tributaries and lakes' systems. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 36, 46, 47, 49, 58, 59	Habitat degradation, biodiversity loss due to the over exploitation of natural resources as a result of social dissatisfaction and the loss of trust on external organizations. Enhancement of the tensions among stakeholders. Lack of trust and cooperativeness will impact the performance of any conservation and social initiative impairing the environment and its users.
Need for an income; Governance	Border conflicts	Amazon River, Atacuari and Loreto-Yacu Rivers. *Grids:* 2, 3, 11, 12, 14, 15, 23, 24, 25, 26, 36, 46, 47	Biodiversity loss due to overfishing and poaching. Social problems that can interfere with international relationships in the area. If border conflicts escalate to a point when local authorities cannot control them, manifestations and violence could be expected.
Need for recreation; Economic growth; Governance	Uncontrolled tourism	Amazon River, its tributaries and Lakes' systems. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 36, 46, 47, 49, 58, 59	Noise and water pollution. Changes in species composition and distribution. Increase of collisions between endangered species and propellers. Social degradation due to the influence of the western culture on indigenous communities. Changes in indigenous communities' patterns and lives to satisfy visitors.
Human population growth; Economic growth; increases in demand for food, water and energy, and agricultural practices	Climate change	Amazon River, its tributaries and Lakes' systems. *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 36, 46, 47, 49, 58, 59	Changes in the hydrology of the area causing extreme erosion and flooding events, causing biodiversity loss and affecting agricultural practises. This will have an impact on the local and regional food security and will be responsible of long-term health problems, regional conflicts, human migration and political instability. Impact on ancestral practises dependant on ecological and hydrological cycles.
Need for living space; poverty; economic development; Governance	Human population growth	City of Leticia, Caballo Cocha and settlements along the bank of the Amazon River on the Colombian and Peruvian sides.	Rapid growth accelerates consumption and resource use intensifying resource scarcity therefore biodiversity loss. Expected large-scale land conversion (deforestation, cultivation and urbanisation), water pollution, human conflicts for land and resources,

		Grids: 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 36, 46, 47, 49, 58, 59	exacerbation of poverty.
Need for alternative income; Economic growth; Technological innovation	Mining*	Amazon River in Brazil *Grids:* 12, 14, 15, 23, 24, 25, 26, 36, 46, 47	Impacts on the source point are large-scale land conversion (deforestation and urbanisation), habitat degradation and water pollution. Socially, poverty is exacerbated leading to social degradation and violence. In a wider scale fish and top predators contaminated by mercury having an impact on human health.
Human population growth	Changes in sedimentation and erosion patterns.	Amazon river, its banks and islands. *Grids:* 15, 24, 25, 26, 36, 46, 47, 58	Reduction of freshwater habitats affecting the availability of space for fish to spawn and feed. Commercial and subsistence fisheries will be harmed and affected by a reduction of fish diversity and places to fish. Impact on local and regional economy. Increasing of human migration, establishment of new settlements deeper into the forest bringing with it deforestation and land conversation.
Need for a space of living; food; alternative income; human population growth; economic growth, and technological advancement	Changes in land use (including agricultural development)	All along the Amazon River bank *Grids:* 2, 3, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 36, 46, 47, 49, 58, 59	Changes in soil use due especially to agricultural development will cause soil and ecosystem degradation significantly and irreversibly reducing its natural production capacity. Increase of monocultures, reduction of biodiversity. Reduction of the area defined for conservation and especial protection purposes.

*These threats occur outside the Colombian Amazonian Trapezium but their impacts can be seen in the area.

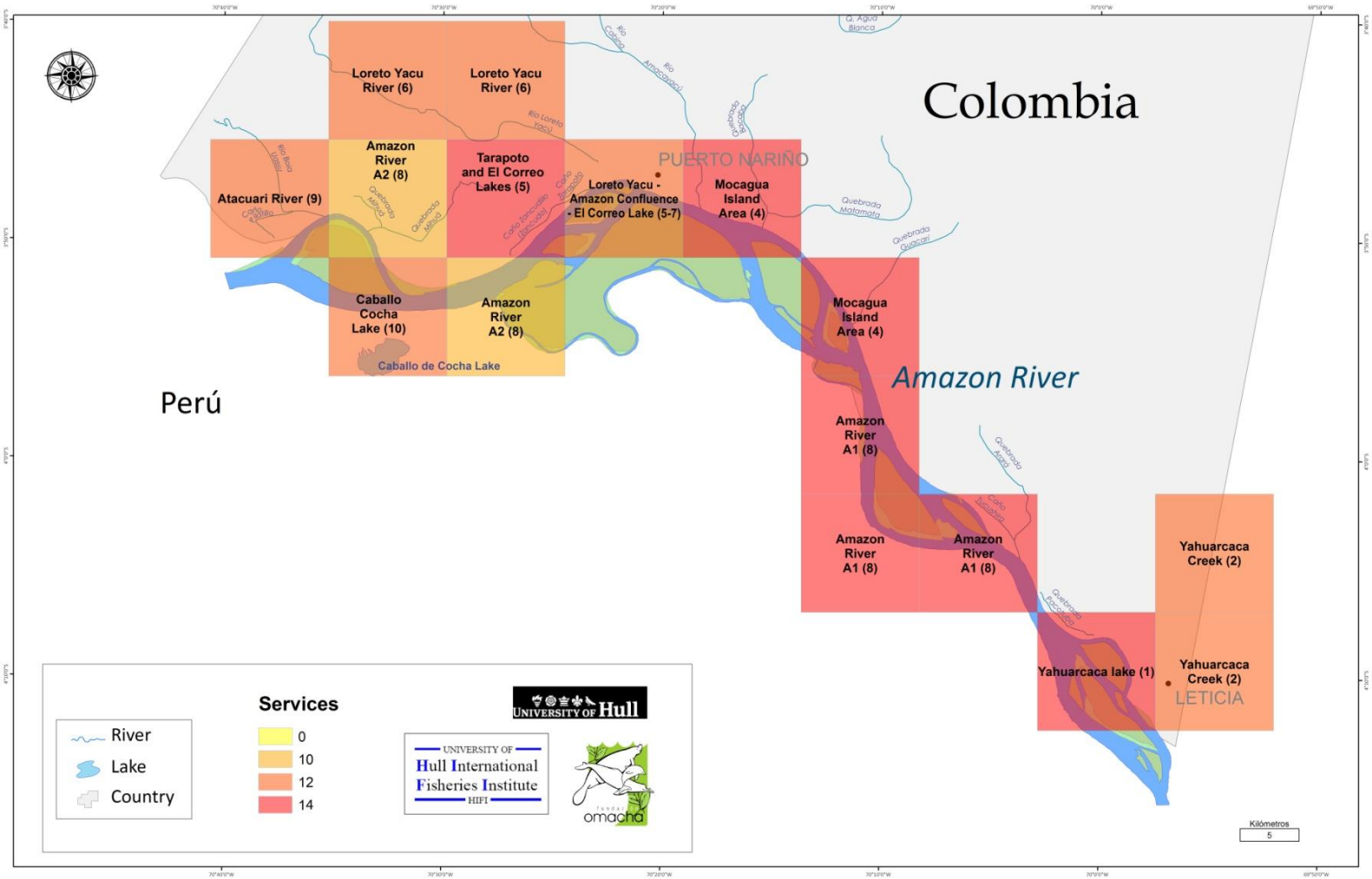

Figure 4.1. Distribution of the ecosystem, services and societal benefits in the study area. The numbers (0-14) represent the number of ecosystem services provided in each particular grid. The numbers in parenthesis in each grid represent the id. number for each site. For detailed information see Table 4.1.

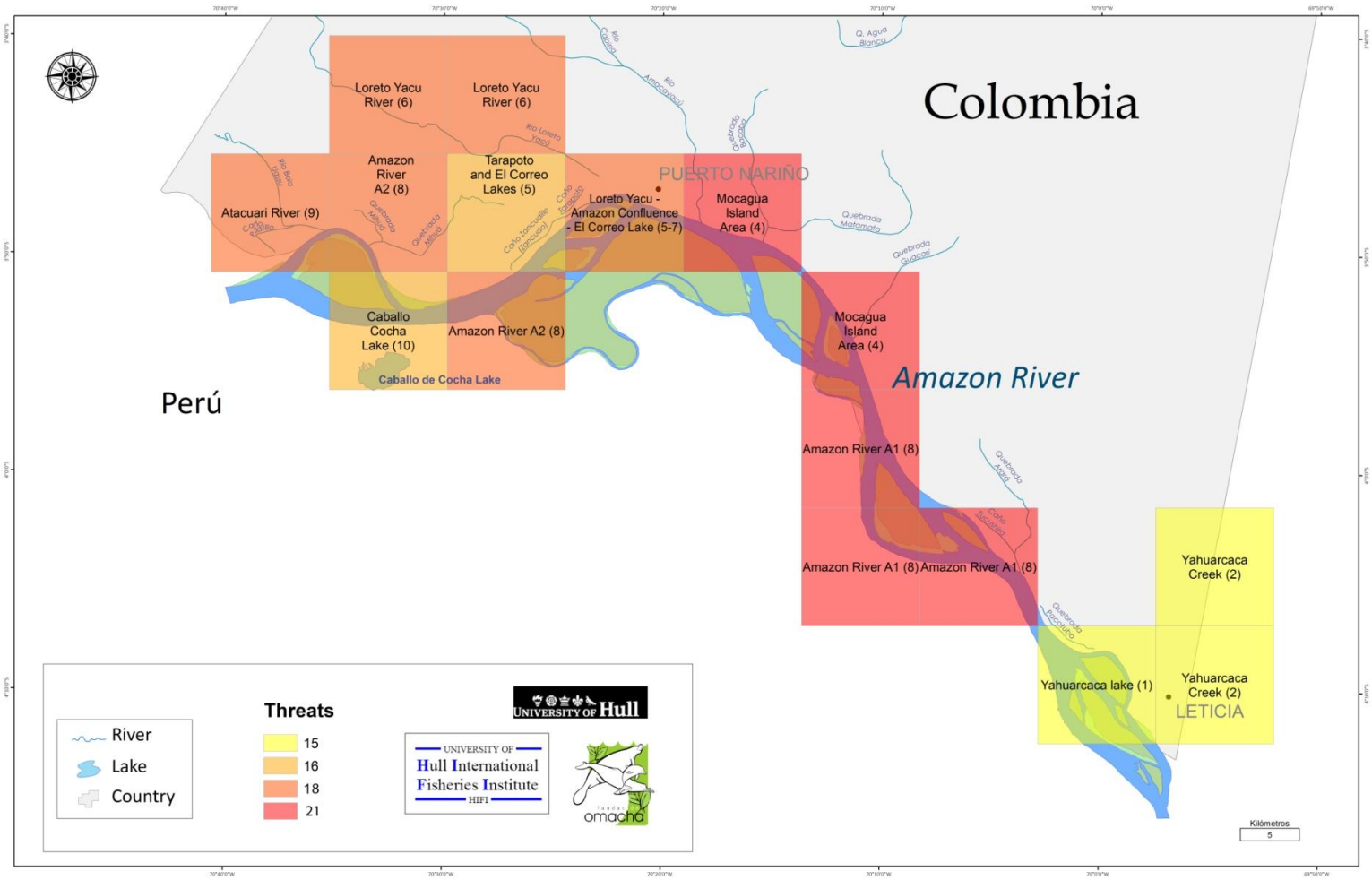

Figure 4.2. Distribution of threats in the study area. The numbers (15-21) represent the number of threats affecting each particular grid. For detailed information see Table 4.2

Biodiversity maintenance

The most irreversible of human impacts on ecosystems is the loss of native biodiversity. According to the National Research Council of the United States (2004) 'the maintenance of biodiversity is one of the less intuitive ecosystem services that have been recognized only as knowledge of the global ecosystem has evolved'. Extending the knowledge of the local freshwater biodiversity is a challenge as ecosystems are constantly adapting to their surroundings and to economic and social drivers. High levels of biodiversity are assumed to confer resistance and/or enhance resilience to the ecosystems, allowing them to adapt and transform other vital services in the face of disturbance (Folke *et al.* 2004).

Amazonian aquatic biodiversity is diverse and complex as a result of the diversity of habitats created by the dynamics of the river and its freshwater system (Chapter 3). Local peoples and societies beyond the Amazon region have derived key elements of their agricultural, medicinal and industrial enterprises from the presence of this biodiversity.

Certain taxonomic groups like macrophytes, algae, fungi and rotifer, have been researched in the waters of the south of the Colombian Amazon (Ruiz *et al.* 2007); but they remain poorly studied, in part because of the lack of taxonomic keys and catalogues, and skills to identify them. Biodiversity is also a provider of wildlife for non exploitive leisure; this service mainly contributes to tourism but has also shaped part of the area's cultural heritage and identity.

Nowadays almost all human activities taking place in the area are impacting the local freshwater biodiversity. Uncontrolled fishing activities are threatening to reduce important commercial fish stocks as well as species used in the daily diets of locals. Other harvesting activities like hunting to complement protein intake play an important role in local peoples' diets as well as in their cultural activities. The consumption of aquatic species such as turtles, caimans, iguanas and manatees is part of their cultural tradition. Uncontrolled hunting of these species arises when they are killed not for subsistence but to be sold in local markets. This type of trade is forbidden and according to the law must be prosecuted. The uncontrolled and indiscriminate hunting of aquatic species for commercial purposes will definitely cause the loss of important vulnerable and threatened elements of the local freshwater biodiversity. The loss of aquatic species has an impact on the local food web; top predators or herbivores play an active role in nutrient cycling processes and in keeping fish communities in balance.

The maintenance of biodiversity ensures the food security of the area. Freshwater resources are complemented by forests products. The health of the riparian forests is vital to maintain an innumerable number of species that depend on the floodplains and flooded forest. The v*arzeas* and *igapos* (forests flooded by white and black waters) are the food base of the area. Forests (flooded and non-flooded) support indispensable processes for human survival. Around 4650 plant species of which 1600 are used for medicinal purposes have been described for the Colombian Amazon (Ruiz *et al.* 2007). The removal of the riparian forest will affect the dynamics of the system enormously. It will cause changes in river flooding dynamics and provoke the loss

of key habitats (e.g. flooded forest) for fish and other aquatic species with a reduction in shelter and food for fruit-feeding species. It will also change the patterns of nutrient cycling and terrestrial inputs, and potentially increase light and temperature and change chemical composition of the water (Chapman & Chapman 2002). All these modifications can cause a disruption between freshwater and terrestrial ecosystems and also erosion and flooding processes. Deforestation is one of the major threats to the existence of the entire Amazon basin, thus for many years conservation efforts have been focused on reformulating the activity to make it sustainable and work within a defined legal framework. The market value of the timber is the driver of illegal logging. Issuing permits by the environmental authority (Corpoamazonia) takes a lot of effort that puts loggers off operating in a legal manner. Worryingly, illegal logging takes place inside the National Natural Park Amacayacu and the Indigenous Reserve Ticoya, that, because of their land size and in the case of the Park limited personnel, make it is hard to regulated logging and the extraction of the resources. Uncontrolled logging can be also seen on the southern bank of the Amazon River (Peru).

In the Amazon, the forest rainfall patterns will be disrupted if the forest cover is reduced. It has been established that the loss of this 'waterpump' could have an impact on the agricultural production in Argentina, Brazil and some of the Andean states (TEEB 2010).

Clearing forest areas to establish new settlements is prominent and linked to human migration processes. Social, political and economic problems affecting areas outside the study area encourage families to seek new income opportunities and security in the south of the Trapezium.

As in terrestrial habitats, freshwater ecosystem fragmentation is a serious threat to the maintenance of biodiversity. The disruption of the continuity of aquatic habitats is responsible for degrading environments and eventually will affect wildlife. Infrastructure construction, such as dams, is a serious risk to the Amazonian freshwater biota. Currently there are no plans for building hydropower dams in the Colombian Amazon, but there are plans for 45 dams in the Brazilian Amazon (Trujillo *et al*. 2010). The presence of these dams in Brazilian waters could have an impact on the Colombian freshwater biodiversity by affecting the migration patterns of fish and dolphins moving from the estuary and lowlands to the higher areas of Colombia.

Finally, an increase of boat traffic is also one of the threats to local biodiversity as a result of collisions with boats. Other problems relate to acoustic pollution produced by boat engines affecting communication processes of dolphins and possibly other species, and forcing species to migrate to more isolated and quiet areas. These disturbances have not been explored and require urgent attention.

Sport and game fishing

Catch and release sport fishing takes place mainly during August and September when water levels are low. Fish removal for food eventually takes place; however there is no control or data to know for certain how often this happens. The complexity of habitats provides a variety of

desirable species for fishermen from all over Colombia and the world. The activity takes place all along the River Amazon and the Yahuarcaca and Tarapoto lake systems. This activity only represents a small part of the income of tourist agencies and guides, mainly around Leticia and Bogota, although the area has huge potential for the activity (Agreda-Rudenko 2008). There are no clear regulations related to this activity and the country requires implementation of a code of practice to regulate any expansion.

Subsistence fisheries

This is probably the most visible service provided by the freshwater ecosystems in the area. The heterogeneity in the habitats contributes to supporting a major source of protein to local communities in the South of the Trapezium (500 g/day per family; Fabre & Alonso 1998, Trujillo & Trujillo 2009). Only in the city of Puerto Nariño,its 465 families eat 222,500 kg of fish per year (Trujillo & Trujillo 2009). Dependency on the river and this primary resource makes the communities highly vulnerable to changes in the fish species composition and to changes to freshwater habitats. According to Ochoa *et al.* (2006), there are not institutional data about the intensity of the activity and therefore there are no statistical data showing local aspects such as the amount of fish extracted and traded, fishing effort and the magnitude of pressure on the resources. However something is known about the species preferred by locals; selection depends on availability, taste and cultural preferences. Species like palometa *Mylossoma duriventri,* bocachicos *Prochilodus* spp., yaraquis *Semaprochilodus* spp., sabalos *Brycon* spp., piranhas *Serrasalmus* spp., paco *Piaractus brachypomus* and gamitana *Colossoma macropomum* constitute the main diet of the local communities (Agudelo - Cordoba 2007).

In the study area, all fisheries are artisanal and subsistence fishing predominates over commercial fishing (Ochoa *et al.* 2006). Fishing contributes 24% of local people's household income, second after 31% provided by *chagras* (agricultural family units) (Trujillo & Trujillo 2009), and is the main source of animal protein in the diets of local communities. Other sources of protein are the bush meet extracted from the forest, which is 4th place in the local communities' sources of income after timber and wood. Around Puerto Nariño 80% of the fish extracted contributes to local diets while 20% is traded in the market of Leticia, but the activity does not represent a major source of income (Ochoa *et al.* 2006), unlike around Leticia where the selling of these species in local markets is economically more important.

There is a general perception of decline of the fish stocks (Riaño-Umbarila 2003). Locals attribute this to bad fishing practises, misuse of fishing gears, not following fishing regulations, the use of *barbasco,* a natural poison (Castellanos *et al.* 2009), as well as river dolphins that have become 'enemies' of the fishermen. Both humans and dolphins are now competing for the same resource in an area that is now suffering the consequences of years of overexploitation.

Nowadays, it is common to hear from local people that they have stopped fishing because it requires a lot of effort and time. Declining catches are pushing the fishermen to either use more efficient fishing gears (bigger gillnets with smaller mesh size) or to stop fishing and start buying

fish from Peruvian fishermen (John J. Leon[1] pers. comm.). This situation is a threat to the culture of these fishing communities and will result in increasing fishing pressure by Peruvians who, as seen before, will exploit the Colombian area to meet the demand created by Colombian families and probably cause conflicts between the two countries. Ultimately this could result in a social crisis in the area.

Local fisheries are threatened and the lack of action by the fishing authorities is concerning. Fishing does not provide much to the national economy and consequently little attention is paid to the social, environmental and economic problems currently arising from overfishing. Subsistence fishing has saved the government millions of pounds in food support subsidies but facts like this are not always taken into account when the status of Amazonian fisheries is discussed.

Commercial fishing

Commercial fishing has supported the local and national economy since 1932, since the arrival of "cold rooms" (to store fish fresh) and airlines to accommodate supply of Amazonian fish to the main cities of Colombia (Agudelo *et al.* 2000). Around 95% of the fish traded in Leticia is shipped either frozen or dried by plane to Bogota where 67% is consumed; the remainder supplies other fish markets in Colombia (Ochoa *et al*. 2006). According to Ochoa *et al.* (2006), the demand for Amazonian fish increased 155% from 1977 to 2002; the fish shipped from Leticia to Bogota represents 30% of the total inland catches in Colombia. This tendency is putting increasing pressure on the environment.

This fishery catches about 50 catfish species, but only 13 are common and exploited (locally the species are called leather fish because of their lack of scales). The most representative species are pintadillos *Pseudoplatystoma tigrinum* (968.6 t/yr), and *P. fasciatum,* dorado *Bachyplatystoma rousseauxii* (848.34 t/yr), mota *Calophysus macropterus* (627.43 t/yr), baboso *Brachyplatystoma platynemum* (431.58 t/yr), lechero *Brachyplatystoma filamentosum* (376.93 t/yr), zungaro *Zungaro zungaro* (310.29 t/yr) and pirabuton *Brachyplatystoma vaillantii* (77.60 t/yr) (Alonso *et al.* 2000). Most of these species arrive in the area after a 3000 km migration from the estuary in Brazil. Management of fishing is complex because of its multi-species using a variety of fishing areas and gears (as a response to changes in the river level), and diverse social, cultural and economic dynamics. This complexity can risk the activity due to the fact that multi-species, multi-gear fish assemblages and fisheries in inland waters respond to heavy fishing and the use of illegal methods (Welcomme *et al.* 2010), therefore increases in fishing pressure (effort) will successively reduced and even lost larger individuals and species from the fishery until only the smaller species remain to form the basis for the fishery.

According to Welcomme *et al.* (2010), smaller species are generally more biologically productive, and for this reason the catch level will remain the same despite an increase in the

[1] Community leader: Macedonia Indigenous Reserve.

fishing pressure. For this reason the complexity of a multi-species fishery needs to be considered when assessing all fisheries in the South of the Trapezium.

The city of Leticia is the main catfish supplying port in the region covering areas from the city of Iquitos (Peru) located 500 km upstream, the city of Leticia and the city of Tefe (Brazil) located 1000 km downstream. Only 5% of the total landings comes from Colombian waters; 80% comes from Brazil and 15% from Peru (Ochoa *et al*. 2006). Although this activity is important to the local communities, its contribution to the National economy, is only 3.8% of GDP, but the calculation does not include the millions of Colombian Pesos resulting from packaging, public services, refrigeration, taxes and transportation included in other GDP categories (Ochoa *et al.* 2006).

This low contribution to GDP means the central government gives more attention to other sectors of the economy that have higher contributions. Commercial fisheries of the south of the Amazonian trapezium lack the attention and support of central government and its environmental and production institutions. Fishermen in the area complain about how risky the activity can be and how insecure they feel about being injured or killed whilst fishing. If the government does not change this attitude towards inland fisheries in the Amazon region, the whole fishery could collapse as happened in the Magdalena River Basin in Colombia. According to Galvis and Mojica (2007), in 1970 the total fish production was of about 80,000 tonnes per year, currently those fisheries produce only one tenth of that amount. The collapse of these fisheries have affected directly and indirectly the 80% of the Colombian population that live within the basin.

Currently fisheries can be seen as a threat, instead of being seen as a solution to manage properly the environment and to link important social and economic issues to the uncontrolled use of the freshwater biodiversity. The importance of fisheries should be reconsidered. The neglect in which they are positioned by the central government is possibly one of the few drivers causing excessive fishing. Overfishing and the incorrect use of fishing gears are now considered the main threats to the freshwater biodiversity of the study area, a situation enhanced by poor law enforcement and an absent and weak Fishing Authority.

Direct threats such as the use of gillnets to catch more fish in less time and the use of *barbasco* a toxic plant extract, are widely known and perceived as damaging by local fishers, despite being forbidden by law (UNAL & Corpoamazonia 2007, Trujillo & Trujillo 2009). Other threats to this service are the removal of the riparian forest, habitat degradation, dams and waterways.

There are also plans to build the *Hydro-way Putumayo-Amazonas* or *Axis Tumaco-Belem de Para* to connect the Atlantic Ocean with the Pacific. This is planned to take place within the South American Initiative of Regional Integration (IIRSA). This hydroway is thought to improve the economy and development of not only Colombia but countries like Brazil that will have the chance to trade their products and have a route to the Pacific Ocean. The hydro-way is planned

to cross part of the territory, as well as important extensions of Amazonian natural forests and the Andean piedmont (Killeen & Solorzano 2008, Ochoa *et al.* 2006, Leon Sicard 2008).

A major risk to fish stocks is habitat alteration or destruction through hydrological damage and deforestation (Junk et al. 2007). However, there is still time to reverse these threats with the implementation of suitable management practices, environmental education and the execution of co-management strategies and fishing agreements. Several initiatives of this type have taken place in Brazil, where lakes and fisheries have been managed throughout a community-based management approach. The total inclusion of local communities in the definition of rules, as well as in the monitoring and enforcement of regulations have worked, with its pros and cons, in lakes systems in the middle and low Amazon River (McGrath *et al.* 1993, Araujo-Lima *et al.* 2008, Silvano *et al.* 2009, Castello *et al.* 2011), A key element of this success is the degree of cooperation and social organization of the communities involved. However, the support and accompaniment of the Environmental authority (IBAMA), has been, regardless of many flaws, stronger and more permanent than the one provided by the Fishing Authority in the study area.

However, large scale threats like dams, hydro-ways and mining, might be harder to tackle. Brazil is currently number one in South America and second in the world for gold production (with 90% coming from informal mining). The use of mercury and manganese as chelating agent to extract gold (McCain 2001) is one of the most polluting and threatening activities to Amazonian freshwater ecosystems, and fish and human's health. According to Malm (1998), between the years 1550 and 1880, nearly 200,000 metric tonnes of mercury were released to the environment; he also states that during the past 2 decades at least 2000 to 3000 tonnes have been discharged into the Amazonian systems, with an annual average between 30 and 170 tonnes (Meech *et al*. 1997, Diaz 2000).

Mercury effects have been registered thousands of kilometres from the gold mines (Malm 1998), showing the extension of the threat. Meech *et al.* (1998) found higher concentrations of mercury in the tissues of black water fish not directly impacted by mining activities than in white water fish where the pollutants are normally dumped. Recent studies conducted in Brazil show high levels of mercury in the tissues of highly traded species like mota, *Calophysus macropterus.* Levels of 527.82 ng/g have been found, when legal acceptable values cannot exceed 500 ng/g (Leite *et al*. 2007, Beltran-Pedreros 2008, Beltran-Pedreros *et al*. 2008).

The threats mentioned above (mining, dams and hydro-ways) are not only specific to commercial fisheries, but are generic to all ecosystem services provided by the freshwater systems in the study area.

Ornamental fisheries

This service constitutes important income to local fishermen and traders. The Colombian Amazon, and more precisely the south of the Colombian trapezium, is the second most important region in the country for trade of ornamental fish; the Orinoco region being the most important. The main species traded are arawana *Osteoglossum bicirrhosum,* the Loricaridae

*Pterigoplichthys multiradiatus, Ancistrus sp.*and *Rineloricaria sp.*, and the cories *Corydoras arcuatus*.

The city of Leticia is the most important port of collection and export of these species, contributing 86.1% of the total production of the Colombian Amazon. Between 1995 and 2001, some 15.6 million units were shipped from this port to Bogota (Ruiz *et al.* 2007). Amazonian production contributes US$5.9 million annually to Colombia (Ruiz *et al*.2007). However, there are no consistent or clear regulations controlling this activity. Weak or almost non-existent organization of ornamental fishermen contributes to an unfair distribution of the benefits generated by this trade. According to Falla & Poveda (2008), the international market is responsible of modelling the activity with fluctuations in demand and prices having an impact on every step of the chain. Each element contributing to the performance of the activity, from the fisherman to the final recipient, needs to be properly articulated to ensure the continuity of a economically important activity to local communities and protection of the environment. Ornamental fisheries are the only ones dependent on survival of the species, thus health of the ecosystem and pristine fish habitats are crucial to the stability of this activity.

Water for human consumption

All 45 settlements (approximately 45,000 people) along the study area use water from nearby water bodies (black water lakes or tributaries) for domestic supply (Trujillo Osorio 2008). Rain water also makes an important contribution to the total water used by local communities. The city of Leticia, with approximately 32,450 people, depends on the Yahuarcaca Lake System for the provision of water to fulfil the city's needs. The water is not treated making it unsuitable for human consumption. People living in rural areas consume rain water or water from the lakes and tributaries with no purification treatment. Any change that negatively alters this quality will impair the health and lives of all locals.

As a basic and essential ecosystem service, the maintenance of clean water across the basin represents a challenge. It is critical to maintain ecosystem processes that provide and cleanse the waters, such as riparian forests, and thus activities such as logging and clearing need to be regulated to maintain this service. There are also many sources of pollution that need better control and management, such as mercury inputs (Villas Boas 1997) and wastes from cargo and recreational boats. In addition, sewage and solid waste discharges from the three main towns in the area - Leticia, Puerto Nariño (Colombia) and Caballo Cocha (Peru) - are a problem. Leticia's dump is located near the Yahuarcaca Creek and signs of water pollution have been reported (PBOT Leticia. 2002). Social campaigns regarding solid and liquid waste management are essential to stop and prevent further water contamination.

Sources of pollution also can come from upstream areas and include the use of pesticides (DDT is still used in some parts of Colombia) and chemicals such as sulphuric acid and acetone, used in illegal drug production (illegal plantations are not reported in the study area but are known to

be hundreds of kilometres upstream of the Amazon's tributaries in the Peruvian and Colombian territory).

Waste disposal

The lack of physical space, the proximity of water bodies to human settlements and the lack of waste treatment services inevitably results in wastes from housing, industrial and agricultural activities being deposited into the lakes and rivers. The buffering capacity of these ecosystems processes dilutes and assimilates certain levels of nutrients and pollutants coming from these activities. The proper functioning of the nutrient cycling, seasonal hydrological variations and reasonable discharges are necessary to support the provision of this service. Changes in these features, especially incremental loading of nutrients, will increase the productivity of the system towards eutrophication, and the ecosystems will lose their ability to maintain clean and functional habitats (National Research Council 2004).

Most families in the rural areas tend to burn their rubbish. In Puerto Nariño rubbish is collected and transported to a dump located miles away from the urban centre. The rubbish resulting from the 32,450 Leticia citizens ends up in an open dump located 300 m up the mouth of the Yahuarcaca creek. Water contamination is now perceived by locals and this is acknowledged by the Leticia City Council. It is estimated that 25,012 kg of solid wastes are produced daily by only 3203 citizens (PBOT Leticia 2007). Using this data it is possible to estimate a total of 253,399 Kg. of waste produced daily and 91,030 Tons of waste produced annually only by the inhabitants of the city of Leticia.

Population growth, incremental increases in the number of tourists together with weak solid waste management is degrading the freshwater ecosystems. The freshwater habitats as a whole perform their role of keeping the levels of organic and inorganic elements within ecological boundaries, but the threats to the freshwater ecosystem mentioned above, if not controlled, will take the ecosystem to a point where it will not be able to perform its basic processes to maintain the balance and proper functioning of the environment.

Climate balancing and carbon sequestration

Regional climate depends on the interaction of terrestrial and freshwater ecosystems in the Amazon through biochemical cycles. According to McCain (2001) the exchanges of bioactive elements between the river surface and the atmosphere takes the form of gases conditioning the basin climate.

As part of the entire river basin, the study area contributes to the regulation of the regional and global climate and provides important inputs to local, regional and global carbon and nitrogen fluxes; key elements in climate change. Another aspect controlling the Amazonian climate relates to the role of vegetation and soils in retaining water through evapotranspiration processes and allowing it to return to the water cycle balancing and contributing enormously to

the maintenance of the local climate. Inland Amazonia appears to receive about half of its rainfall from recycled water (Whitmore 1990, McCain 2001).

A way in which Amazonian processes also impact global climate involves freshwater discharge to the Atlantic Ocean, which enhances primary production in the ocean providing further carbon sequestration. The input provided by the river contributes to the fixation of N_2 allowing the sequestration of atmospheric CO_2 (Subramaniam *et al*. 2008).

Other forms of carbon sequestration occur, especially in black water tributaries and lakes in the high Amazon Basin. The productivity of these black water lakes and creeks is closely linked to fluxes of nutrients provided by riparian vegetation and can contribute enormously to the production of CO_2 to the atmosphere (Benner *et al.* 1995). In black water lakes and rivers of the High Amazon basin, the decomposition of leaves happens very slowly (Furch *et al.* 1989) reducing the rates in which the carbon is released to the atmosphere.

The study of this ecosystem service is now the focus of attention of many researchers in the region. The role of forests as carbon consumers and the rapid deforestation raise the need to find new carbon sinks or protect existing forests. Currently the Yahuarcaca Wetland System is being used to create a base of scientific and technical information to demonstrate the role of this system in the environmental service of carbon sequestration (Santiago Duque pers. comm.[2]). This project is the first in its kind developed in the Colombian Amazon.

Agriculture

Small scale agricultural practises take place in the Trapezium. Agricultural family units known as *chagras* constitute the core of every Amazonian family and are fundamental for economic subsistence (UNAL & Corpoamazonia 2007). The indigenous *chagra* in the Amazon is a farming system developed over the last 10,000 years to exploit the conditions of the soil, climate, vegetation and fauna of the Amazon (Rodriguez 2010). The *chagra* passes ancestral knowledge from one generation to the next and influences the way between 3 and 7 different products are cultivated in a plot of land (UNAL & Corpoamazonia 2007). Most families own two *chagras;* one in the highlands which depends on rain water and local humidity, and another on the floodplain. The latter is normally more productive and only active during the low water period. During the high water period the river floods the land with rich sediments fertilizing these plains for cultivation during the dry season. Women play a key role in this task, being responsible for the maintenance and harvesting of the crops. Men are normally involved in the preparation of the land for cultivation. The products are mainly for self consumption, but to increase income, women sell part of the harvest in local markets.

The *chagra,* its products, and the times of planting and harvesting are shaped by the hydrological cycle, the behaviour of the river and its seasonal dynamics. Changes currently seen in the patterns of rains and droughts (high and low water seasons) are worrying

[2] Professor Universidad Nacional de Colombia – Leticia. Director of the Amazonian Limnology Group associated to the same University.

community elders. Currently the practise is threatened because of abrupt changes in the hydrological climatic seasons. These agricultural activities have always been guided by local understanding of the hydrological cycle, but the unpredictable behaviour of the river has confused and worried the elders who no longer can rely on their inherited knowledge.

Another perceived threat is modification of these traditional agricultural practices by local market demands causing a reduction in diversity of products harvested and a tendency towards monoculture of manioc or cassava, which intensifies pressure on the soils and their low loading capacity. New practices involving soya plantations supported by the local government are also risking ecosystems stability where land areas are cleared for this purpose. Trujillo Osorio (2008) also stressed this can cause changes in local community diets threatening their alimentary tradition and changing their regular sources of proteins and minerals towards industrial processed food.

Transport/navigation

The Amazon River through the study region plays an important role in connecting two of the most important Amazonian cities of the high and middle Amazon: Iquitos (Peru) and Manaus (Brazil). The South of the Colombian Trapezium is considered an obligated passage for people travelling or trading goods across the basin (Ecuador-Peru-Colombia-Brazil). Lack of roads and other ways of access to communities within this area makes the river and its tributaries the only navigation pathways. The river is vital for local people to communicate and migrate, and to have access to other markets, villages and products, as well as access to medical support, education and entertainment.

This service might not be seen as threatened due to the immensity of the Amazon River, but increased erosion and sedimentation processes caused either by natural conditions or deforestation activities can change the river's shape and its navigability. Narrower streams will be impeded in providing this service if their forest cover is removed.

Dolphin watching

River dolphins can be considered the most emblematic species of the Amazon River basin. The waters of the Amazon are home to two species of river dolphins: the botos or pink Amazonian dolphins *Inia geoffrensis* and the Tucuxi or grey dolphin *Sotalia fluviatilis*. Over the last two decades, the dolphin watching industry in the Amazon and especially in the South of the Colombian Amazonian Trapezium has escalated to be one of the most important touristic attractions in the study area. Dolphin watching attracts thousands of visitors that arrive in Leticia every month (26,000 visitors per month in 2008 – DAFEC[3]). According to Hoyt and Iñiguez (2008), 22 tourism operators with 38 boats are registered in Leticia and conduct dolphin watching activities. Approximately US$8.5 million are spent annually by tourists on this activity. These same authors project a growth rate of 17.6% per year. The economic importance of this

[3] DAFEC - Administrative Department of Ecotourism Development, Leticia.

activity is, together with commercial fisheries and other types of tourism, supporting the livelihoods of dozens of families all along the area.

People come to the Amazon with the idea of finding pristine landscapes, amazing creatures and a tribal experience. The presence of dolphins as well as an attractive landscape depends on the health and proper functioning of the ecosystem. In the study area, key areas for dolphins have been identified: the Tarapoto and El Correo, Yahuarcaca and Caballo Cocha lakes, and the islands Ronda and Patrullero. In the last couple of years tourist operators have been trained to conduct the activity according to international whale watching protocols. These operators are aware that continuity of the activity will depend on two elements: the presence of dolphins and the proper operation of the activity. Currently, more and more tourists going to the Amazon request totally eco-touristic practises, including respectful approaches to wildlife and their ecosystems. Bad touristic practises will put pressure on the species and drive them to more remote and isolated areas and eventually result in the reduction of visitor numbers.

Tourist guides and agencies have started to understand the ethics of conducting environmental and social responsible activities. The traffic of boats has increased in the last decade, speed boats are now perceived as a cause of disturbance to the local fauna. A complaint has been made by locals of Puerto Nariño that every day they see how boats full of tourists enter the Lakes of Tarapoto regardless of the agreements established by the TICOYA Reserve about permitted engines sizes and speed limits. Underwater noise causes disturbance and boat traffic increases the chances of a collapse with wildlife.

Tourism is not the only a potential threat to dolphin watching, the availability of dolphin's preys is also threatening the presence of dolphins in this part of the Amazon basin. This is coupled with intensification of fishing activities because of declining fish stocks causing conflicts with conservation of dolphins and other endangered species. Dolphins are now being killed by fishermen to keep them away from their nets and their catches. Every month this phenomenon is reported to the fishing authority (Produce) in Caballo Cocha, Peru. According to members of this institution, local people are now more frequently reporting dolphin carcases from Caballo Cocha Lake. There are an estimated 2000 individuals of the two species (*Inia geofrensis* and *Sotalia fluviatilis*) (Gomez *et al.* 2011) in the study area, including Peruvian waters. As migratory and highly mobile species, dolphins have been seen moving among the Tarapoto Lakes system, the Caballo Cocha Lake (Peru) and the Atacuari-Amazon confluence (Trujillo 1997, Gomez-Salazar 2004). Dolphin killing in Peruvian waters is likely to affect the population of dolphins in Colombian waters.

Another conflict currently taking place in the area and risking the survival of dolphin and caiman populations is the fishery of a catfish called Mota (*Calophysus macropterus)*. This species is a very popular fish traded from the Amazon to the main cities of Colombia and it has replaced the demand of the Capaz fish (*Pimelodus grosskopfii*) from the Magdalena River whose capture is actually void because of over fishing. Dolphins and caimans are currently killed to be used as bait to capture the scavenger fish Mota. Landing data show the species only represented 2% of

the catches at the port of Leticia between 1990 and 1996 but contributed 19% in 2003. Nowadays the species constitutes 10% of the landings with 815 t annually (CCI 2009). The demand for the species is from the Colombian markets but the killing of the dolphins and the fishery takes place in Brazilian waters; 85% of the fish landed in the port of Leticia comes from Brazil, 10% from Peru and 5% from Colombia (Beltran-Pedreros *et al.* 2009, Gomez *et al.* 2008). The main consumption of the species occurs in the Colombian main cities (Bogota, Cali, Ibague) making this demand a serious threat for these endangered species conservation.

Estupiñan *et al.* (2003) estimated that 100 dolphins and 90 caimans were killed in the Reserve of Sustainable Development Mamiraua, and used as bait to supply the ports of Leticia and other minor ports in Brazil with 15 and 18 tons of mota in 2002 and 2003 respectively. Serrano *et al*. (2007) estimated that 600 dolphins are being killed each year in this same area by dolphin and caiman hunters and mota fishers [Note: The data on the number of dolphins killed is still under revision, due to the illegality of the activity no official records exist, and the estimations of dolphins used as bait are based on an extrapolation of the mota fish landed in ports]. Each dolphin is traded for the equivalent of US$25 (Gomez *et al.* 2008). This contrasts with the US$6.6 million spent on dolphin watching in the south of the Colombian Trapezium (Hoyt & Iniguez 2008). This means that annually each live dolphin provides US$13,200 to the local economy compared with the US$25 that a dead dolphin represents.

Another problem now associated with the mota fisheries is the high level of mercury found in the species' tissues. According to Beltran-Pedreros (2009), levels of 527.82ng/g of mercury are found but levels should not exceed 500ng/g. Bioaccumulation of mercury is a major risk to human and ecosystem health.

Indigenous communities and handicrafts manufacture

The communities along the Amazon River in Colombia are famous for their handicrafts. Their products are influenced by their surroundings, especially by the river and its creatures. Carved figures made of "palosangre" (bloodwood) (*Brosimun rubescens*) represent the different and most outstanding aquatic species of the region, especially: dolphins, stingrays, turtles and fish. However, obtaining 'palosangre' is becoming more difficult. Artisans from Colombia need to go to Peru to get the wood due to the overexploitation in Colombian territory. Consequently, this symbolic and distinctive activity is at risk.

The activity plays an important role within the community. Wood carving work is mainly performed by men while women work the fibres, seeds, feathers and tree cortex to create all kinds of earrings, necklaces, ceremonial outfits and decorative items. The river and its biodiversity is the inspiration of around 200 families, especially women that depend on the selling of these products. Amazonian handicrafts are well known in markets all over the country. The main communities involved in this manufacturing are Mocagua, 20 de Julio, Siete de Agosto and Puerto Nariño.

Landscape viewing

The Amazon River, its lakes and tributaries, are surrounded by enormous forests that support a wide diversity of megafauna that attracts tourism as well as film and documentary makers from all over the world. The mysticism of its indigenous peoples also contributes to making this place special, giving it a spiritual mood. According to Daily *et al.* (2000) nature is an unparalleled source of wonderment and inspiration, peace and beauty, fulfilment and rejuvenation for many people.

The Departmental Government has identified Tourism as an alternative to improve local communities' livelihoods and the sustainable use of the biodiversity. The central government expects that by 2020 the city of Leticia (capital of the Colombian Amazon) will be the most important touristic centre in Colombia. The region is expected to become 'a biosphere reserve, a showcase of certified green-products and a sustainable provider of environmental, research, academic and transportation goods and services' (Chaparro 2007).

According to Ochoa (2008) from 2002 to 2006 the arrivals of visitors to the city of Leticia increased by 300%. The number of flights per week changed from three in 2000 to twice a day every day of the week in 2009 during peak season (June) (information provided by the Aeronautica Civil – Leticia).

Touristic initiatives near to Leticia are diverse. Activities conducted by private natural reserves (like the Tanimboca Reserve) constitute what is known as 'extreme tourism' offering different activities ranging from canopying, kayaking and hiking to dolphin watching and indigenous community visits. Initiatives within private reserves most of the time work in association with nearby indigenous communities. Local initiatives like *'Monilla Amena'* on the Leticia-Tarapoto road are examples of projects created and held by local people.

However, initiatives created by and for local indigenous groups have not been very successful. *Canoeros de Tarapoto* (Canoeist of Tarapoto) from the TICOYA Reserve in Puerto Nariño and CUyTA in the Community 7 de Agosto de Atacuari, have been local tourism initiatives that have received international and national support believing in the importance of empowering local people to strength their culture and to conduct a more sustainable tourism. Sadly, these local initiatives have failed due to conflicts among their people regarding organizational and financial management.

Tourism can become a conservation strategy only when projects are planned and accompanied by an integrated social program including educational and health aspects. Improving health facilities and education programs according to the essence of the indigenous communities and formulated from within the area will guarantee the welfare of the locals and with it the proper use of their surrounding freshwater resources.

Scientific research

The environmental, social and political importance of the area as well as the easy access to its freshwater ecosystems, have made it one of the most studied and researched areas of the Colombian Amazon. Although, there is a lot of research, only a few have been conducted on freshwater ecosystems (Ruiz *et al.* 2007).

However, despite the few researches conducted on these ecosystems, this study has investigated most of the freshwater bodies of the region and can be grouped into five categories: aquatic biota (44%); physical and chemical features of the water (42%); use and management of aquatic bodies (7%); fluvial limnology (4%) and aquatic environments alteration (2%), plus integrated studies (1%) (Ruiz *et al.* 2007). Most of the information known about river dolphins, manatees, caimans and other aquatic species that is available in Colombia and the region, as well as information about primary productivity and chemical features of black and white Amazonian waters have been collected in this area.

During the past 30 years at least 30 different organizations, mostly NGOs and Universities, from Colombia, The Netherlands, Spain and the United States have led the research.

The ecosystems services listed above are also affected by threats that sometimes are not even considered by local researchers at the moment of formulating and implementing conservation and poverty reduction initiatives.

Problems between local communities and other stakeholders

Lack of a permanent presence of researchers and organizations, especially during follow up processes with local communities, is one of the reasons why indigenous people in the area have lost interest in new proposals and many are no longer willing to cooperate in environmental projects in their territories. Currently local communities do not approve the presence of some organizations in their territories claiming lack of commitment and exploitation of their knowledge without giving anything in return, thus leaving a sense of disadvantage of the communities in the face of other stakeholders. This problem is overcome by initiatives such as the Natutama Foundation in Puerto Nariño, where cooperation between indigenous communities and researchers constitutes the foundation for solid and stable conservation programmes. From its creation, Natutama has shown the importance of working with members of the TICOYA Reserve as equals, giving them an important role within the conservation of their aquatic resources by considering them co-researchers and environmental educators in charge of communicating and spreading knowledge among their own people. As local researchers, they have been collecting and analysing biological data and participating actively in education campaigns in their surrounding communities, they also have become the best tool for the protection and knowledge of local endangered species (manatees, sloths, river dolphins and turtles of the genus *Podocnemis*).

One other problem is that local communities nowadays are more interested in money than in other benefits from conservation of their environment. Money is now a powerful incentive for local people and in some cases the only way to get them to cooperate.

Border conflicts

Due to its border location, the river and its resources must be shared with Peruvian communities on the southern bank of the Amazon and in the Atacuari river area. Differences in policies and regulations regarding the use of freshwater resources, and more exactly over fishing bans, closed periods, species and minimum catch sizes, cause conflicts between fishermen, loggers and inhabitants in general. These differences are already leading to overfishing, poaching and uncontrolled logging activities. Intrusions from Peruvians into the Colombian lakes and forests (and vice versa) have been denounced by the communities. Furthermore, logging activities on the Peruvian bank are escalating and are a cause of concern to the Colombian communities on the opposite bank. Any changes in the composition or presence of the ecosystems (flooded forests and floodplains) on one side of the river (Peruvian) will affect the other (Colombian), and therefore the freshwater dynamics and biodiversity.

Climate change

Changes in rainfall patterns in the highlands and increased frequency of phenomena like El Niño / La Niña (Southern Oscillation (ENSO)) are impacting the Amazon basin. Changes in the periodicity and timing of the hydrological seasons modifying flooding patterns are already noted in the study area. External conditions affect the regional climate and at the same time, internal activities like logging contribute enormously to climate misbalances. According to Laurance and Williamson (2001) fragmented forests are more prone than intact forests to periodic damage from El Niño droughts, and deforested areas with reduced evapotranspiration rates will impact the regional climate by constraining regional rainfall, increasing the vulnerability of forests to fire and increasing green-house gases to the atmosphere, reinforcing the already modified global climate. Changes taking place can also be produced by the natural evolution of the river system, however there are no data available to infer how much of these changes are induced either by human activities or natural processes.

Changes in normal hydrological cycles are now more often perceived by local communities. Long dry periods can result in propagation of wild fires, reduced water quality and shift in fish productivity. Alteration of the local climate may also alter the provision of food and supply of products to local and national markets. The diminution of fish during long rainy periods and the continuous demand for the resource coupled with changes in market prices will encourage increased fishing pressure. Uncertainty in forecasting rain and dry seasons will also affect the way elders and other members of the community predict when to sow and harvest crops or fish.

Other impacts to the area generated by changes in normal hydrological cycles are the increase of erosion and substrate deposit patterns. The appearance of wider sand banks or new islands as a result of an increment of sediments or the change of the river's trajectory may modify the

regular patterns of the nearby communities. Erosion of river banks affects the availability of land to cultivate or live.

An example of this is the case of *Isla de la Fantasia* (Fantasy Island). This island near the city of Leticia started its process of creation in 1976. *La Fantasia* has now been occupied for the last 30 years and currently has a population of 300 people (Aldana & Daza 2005). The creation of the island took approximately 4-5 years (Damaso *et al.* 2004) showing how fast a process like this can reshape the landscape as well as the lives of the inhabitants. The island supports the agricultural, livestock and commercial activities of the surrounding communities.

The creation of *La Fantasia* Island interrupted the exchange of waters between the Amazon River and the Yahuarcaca Lakes System. Before the existence of the island this wetland was separated by a narrower piece of land that during the high water period disappeared and allowed the connection of both systems. Today even when the island is flooded completely by the river, the connection between the two systems is not the same as before (Aldana & Daza 2005).

Currently signs of increasing sedimentation have been detected on the northern bank of the river (Colombian side) in the areas of Naranjales, Patrullero Island, Ronda and Rondinha islands, and La Fantasia Island. The opposite phenomenon is seen to be occurring on the Peruvian bank of the Amazon River, erosion is detected on the southern bank of the Amazon and on some of the river islands (e.g. Arara and Micos islands) (Aldana & Daza 2005).

Changes in river morphology can affect local communities' settlements either because they have to be relocated and find new areas that need to be cleared to be suitable to inhabit, or because they colonize new areas created by the movement of the river and its sediments. These settlement processes can come with new areas to develop fishing, sowing and livestock activities.

4.5. Conclusions

- Spatial, physical, biological or other characteristics, such as the needs of the local communities, required by the freshwater biodiversity and its ecosystems must be considered a priority. Biodiversity is also about eating, staying healthy and finding shelter for plants, animals or humans. As Kaimowitz & Sheil (2007) stated 'it is not a question of 'either/or,' but rather of finding a better balance'.
- The study area is an important source of wellness for the approximate 42,500 people who live there.
- The study area is currently exposed to a variety of pressures resulting from a series of uncontrolled driving forces within and outside the study area: need for food; need for space; need for clean water; need for recreation; and need for alternative sources of income.

- The existence of ecosystem services providing societal benefits is linked to a series of ecological and social processes that give life and health to the freshwater ecosystems.
- The local freshwater ecosystems are still able to adapt to change and to recover from disturbance, however, degradation and disappearance of this functioning will reduce their capacity to mitigate impacts provoked by natural or anthropological causes. This will result in a reduction of the services and benefits for human welfare, and in a complex and dynamic area like this the consequences can be devastating for the environmental, social and cultural capital of the Colombian Amazon.
- Acknowledging the freshwater capital and the services that it provides is vital to helping local policy makers in rural and urban managing and planning. Strengthening the bond among stakeholders plays a key role in implementing sustainable practises and conservation initiatives in fisheries, water management, waste management, agriculture and tourism.
- It is essential to integrate ecosystem services into socio-economic decision-making rather that consider them separately. It is important that all stakeholders formulate and implement their programmes and initiatives embedded in an integrated management strategy that accounts for biological, social, cultural, economic, political and historical factors.
- In the next few years political decisions in the area must aim to achieve a balance among agricultural production, extension of the urban centres and quality of the water, exploitation of fish and freshwater biodiversity, and the development of tourism strategies and maintenance of the cultural identity of the local peoples.
- The Amazon River is a continuous system, and any impact that the river and its components are exposed to even, when its source is located miles away (mining, dams in Brazil, and deforestation in the Peruvian and Colombian Andes), must be urgently included in every development and/or management plan for the Colombian Amazon and the countries causing the impact.
- Regional conservation initiatives like ACTO, the CBD, the Ramsar Convention on Wetlands, CITES and the IUCN have the power to make governments and institutions work together towards the conservation of the Amazonian ecosystems and its cultural heritage, however, national economic and development plans seem to be more powerful undermining the commitments of the international organizations.
- Fisheries, as one of the most representative economic and cultural activities, need to be given the attention they deserve by the central government. Improvements in the institutional structure and resourcing of the fishing authorities in the region is vital for the survival of the activity and to reduce the impacts it is having on freshwater ecosystems.
- The conflicts generated between the Mota Fishery and river dolphins constitute one of the most important threats to the freshwater biodiversity of the Study Area. The regional scale of the conflict and the number of people involved make it difficult to overcome. Events like this are an example of the complexity of the region, its biodiversity and peoples, as well as the difficulty of putting together efficient conservation initiatives and poverty reduction projects.

- Environmental education is the key element to any initiative to preserve the freshwater ecosystems and to strength cultural heritage. The national government needs to formulate and implement educational policies made especially for the local area. Experiences from other parts of the country with native communities might not be successful when the realities of those communities differ enormously from the ones in the south of the Colombian trapezium.
- Local indigenous communities are becoming more important in freshwater conservation initiatives, empowering these communities and considering them as allies in the construction of a better and more sustainable Amazonia is the key point to counteract the incoming pressure of a growing and changing society.
- Changes in the dynamics of the indigenous communities, their needs and what they want, including their inclusion in a capital market, the management of money and facing a rapid changing capital world are inevitable. Indigenous peoples, especially the youth, need a constant reminder of their culture and ancestral history. Forgetting their roots is the beginning of the disappearance of their culture and their environment.

This research has been divided in three main parts: a general diagnosis of the freshwater ecosystems and their users in the study area (Chapters 2 to 4), the identification of key conservation areas (Chapter 5) using a multi-criteria approach, and finally the formulation of a management framework (Chapter 6) that puts together the information gathered in the previous chapters.

So far the current status of the South of the Colombian Amazonian Trapezium has been diagnosed and described. The information provided until now should be the foundation to any conservation initiative intending to protect the local freshwater biodiversity and the livelihoods of the local indigenous communities. The elements identified in chapter 3 [fine filter targets (species) and coarse filter targets (habitats)] and the ecosystems services, and the human activities (drivers/threats) explained in chapter 4 will be used to assess 10 sites along the study area and will be definitive for the identification of important areas of conservation. The following chapters are aiming to give new tools to local stakeholders for the conservation and protection of the local and regional freshwater biodiversity.

CHAPTER 5

EVALUATION OF COMPONENTS OF THE FRESHWATER ECOSYSTEM IN THE SOUTH OF THE COLOMBIAN AMAZONIAN TRAPEZIUM

5.1 Introduction

Freshwater conservation and management decisions are characterized by complexity and uncertainty. This is a result of: the dynamism of freshwater ecosystems and the complexity of the human communities that live and depend on the resources provided by these ecosystems; and the difficulties in valuing natural resources and ecological services, accompanied by the involvement of numerous stakeholders in the process.

In Colombia, identification of key conservation areas either for the creation of protected areas or the implementation of conservation strategies is typically based on preferences, convenience and knowledge of the stakeholders. Selection of conservation surrogates, key ecosystems and cultural values, and the identification of threats to the environment are the main criteria used in the decision making processes for the choice of terrestrial key areas in the country (UAESPNN 2008). However, there are few initiatives in Colombia involving freshwater ecosystems or that are based on the assessment of ecological values following methodologies that give numerical quantities to qualitative categories.

Worldwide conservation initiatives, including the identification of key biodiversity areas, have started to be developed based on valuation of ecological characteristics (Cowx and Portocarrero 2011). Up to now the most common evaluation methods are grouped into economic and non-economic assessments. The former assigns a monetary value or price to ecological characteristics or ecosystem services. This gives a value to both the benefits and environmental costs of the assessed variables (Moreno-Jimenez *et al.* 2001, TEEB 2010). The latter is based on ecological and social knowledge and gives a better and more realistic approximation to the ecological characteristics valued and their importance to the ecosystem and human communities. Both the method performance and effectiveness are questionable because it is considered difficult to give monetary value to ecological or ecosystem performance (e.g. lakes or freshwater bodies as a spiritual enriching service or any other non-market good like environmental quality) and because decisions are made according to the preferences and priorities of decision makers, which sometimes may not be sufficiently representative (Ananda & Herath 2003, TEEB 2010).

Non-economic assessments include the Multi-Criteria Approach (MCA) which has been introduced in several fields for decision making purposes (ecosystemic conservation, infrastructure development, land planning), and has the potential to take into account a full range of social, environmental, technical, economic and financial criteria (TEEB 2010) and it manages the difficulty of their assessment. According to Munda (2004), the MCA also ‘supplies a powerful framework for policy analysis since this type of evaluation process is inter/multi-

disciplinary (with respect to the research team), participatory (with respect to the local community and stakeholders) and transparent (since all criteria are presented without any transformations in money, energy or common measurement rod)', therefore it seems appropriate for the assessment of complex, dynamic and unpredictable areas like the south of the Colombian Amazon.

This chapter aims to identify aquatic areas of high environmental value in a highly dynamic and complex (socially and environmentally) area of the south of the Colombian Amazon to serve as a basis for the formulation of management strategies for the conservation of the local freshwater biodiversity. The process for this identification is based on the ecosystem approach adopted by the Fifth Conference of the Parties of the CBD in 2000 and that nowadays addresses global conservation initiatives. The Ecosystem Approach has 12 principles[1] that if undertaken properly could ensure the protection of nature's goods and local human communities' livelihoods.

According to TEEB (2010), the Ecosystem Approach examines the functioning of the entire system and considers humans and their knowledge as part of that system. It also develops a wider and more inclusive plan of action by avoiding focus on individual services (e.g. fish) or relying on only one type of knowledge (e.g. fish stock assessment). A multi-criteria approach such as the Ecosystem Approach, enables identification of the key areas and promotes equitable decision making processes in any conservation, land planning and development programme. This chapter aims to identify important areas based on a non-economic evaluation of their components (biodiversity: species and habitats; ecosystem services and threats) using the multi-criteria evaluation methodology (Mendoza & Macoun 1999). The information obtained in Chapters 2, 3 and 4 is used as input for the identification of key conservation sites in the freshwater ecosystems of the Southern Trapezium.

5.2. Methods

The identification of key biodiversity conservation areas was undertaken by prioritizing the ecological values of various components of the ecosystem. This approach included a rapid

[1] The twelve principles of the Ecosystem Approach (CBD 2000): 1.The objectives of management of land, water and living resources are matters of societal choices. 2. Management should be decentralised to the lowest appropriate level. 3. Ecosystem managers should consider the effects (actual and potential) of their activities on adjacent and other ecosystems. 4. Recognising potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context. Any such ecosystem-management programme should: a. Reduce those market distortions that adversely affect biological diversity; b. Align incentives to promote biodiversity conservation and sustainable use; c. Internalise costs and benefits in the given ecosystem to the extent feasible. 5. Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach. 6. Ecosystem approach must be managed within the limits of their functioning. 7. The ecosystem approach should be undertaken at the appropriate spatial and temporal scales. 8. Recognising the varying temporal scales and lag-effects that characterize ecosystem processes, objectives for ecosystem management should be set for the long term. 9. Management must recognise that change is inevitable. 10. The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity. 11. The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practises. 12. The EA should involve all relevant sectors of society and scientific disciplines.

assessment methodology that identifies areas that are locally important for species, habitats and ecosystem services and at the same time are highly threatened by permanent or increasing anthropological pressures. This method addresses the strategically important issues of vulnerability and their irreplaceable character.

5.2.1. Multi Criteria Approach - MCA

Areas were assessed following a Multi-Criteria Approach, a decision making tool that allows the inclusion of a full range of social, environmental, technical, economic and political criteria in complex and dynamic areas (TEEB 2010). Following this assessment, a multi-criteria matrix (Appendix 3) was used to value a series of variables (species, habitats, ecosystem services and threats) and thus aid identification of key conservation areas. The variables are the product of the biological, environmental and social characterization of the Trapezium (Chapters 3 and 4). The matrix was completed by 15 different stakeholders; these being representatives of the most outstanding organizations (private and public) in the area (Appendix 2). Evaluation of the variables within the matrix was done adapting the methodology proposed in the *Guidelines for Applying Multi-Criteria Analysis to the Assessment of Criteria and Indicators* (Mendoza & Macoun 1999). A MCA relies heavily on input from different and diverse local experts and stakeholders that aims to come to a collective decision regarding the importance or not of a series of elements considered as conservation surrogates within freshwater conservation and management purposes. This kind of evaluation is known as a top-down approach, which according to Mendoza & Macoun (1999) can be used both before and after going into the field. It also can be used before going into the field to structure the variables to be assessed in the field and after as a way to make decisions based on data collected, as was conducted in this study.

i. Construction of a Multi-Criteria Matrix

Selection of variables

Three sets of variables were selected for this study.

FINE AND COARSE FILTER TARGETS (FFT AND CFT)

Based on the methodology for the identification of fine and coarse filter targets proposed by WWF, CI and TNC (Abell *et al.* 2002, CI 2008, TNC 2000), and after a review of the literature on regional and local freshwater species and ecosystems, their ecology, biology, the services and benefits they provide as well as threats, a group of species and habitats were identified and chosen as surrogates of conservation for the identification of key conservation areas (Chapter 3). Based on the literature four more groups were selected to complement the previous list (Species bringing nutritional benefits, species with pharmaceutical benefits, species acting as disease controllers, primary productivity). This new selection was done to assess the indigenous knowledge among stakeholders regarding these less studied targets.

ECOSYSTEM SERVICES AND SOCIETAL BENEFITS (ESSB)

ESSB were identified and analysed using an appraising and valuing approach considering the qualitative information of these services rather than their economic or developmental value (TEEB 2010) (Chapter 4).

ANTHROPOLOGICAL ACTIVITIES (THREATS -TH)

A literature review helped to identify anthropological activities, their dynamics and the way they are inflicting pressure on the area and affecting the local freshwater ecosystems and biodiversity (Chapter 4).

Pre-selection of sub areas (sites)

Previous knowledge gathered from the study area reinforced with information obtained from the literature led to a geographical division of the area into 10 sub-areas or sites. This division aimed to make the assessment of the area and its variables simpler, and possibly the future implementation of conservation and management strategies. This selection of sub-areas was based on the hypothesis that every freshwater environment in the study area is different from the other, therefore its biological composition, the threats to which it is exposed and the conservation and management initiatives needed also differ.

Selection of stakeholders (Institutions)

After listing the institutions working in the area in relation to freshwater ecosystems, biodiversity, scientific and social research and conservation initiatives, environmental management and/or environmental education, a group of researchers, decision makers and educators working on the same topics was selected to participate in the valuation of the variables selected. The stakeholders chosen met the following criteria: 1) belong to an institution with at least 3 years of constant presence in the study area; 2) work in the study area for at least 4-5 years in topics related to freshwater research, conservation or education; 3) wide knowledge of not only the biological but social, cultural and economy dynamics of the Trapezium.

ii. Assessment of the multi-criteria matrix

The process described below is a way to facilitate the decisions of each stakeholder regarding the importance of each variable within the different sites in the study area to establish the most significant (sites and variables) for freshwater conservation and management purposes.

1. Ranking

To assess each pre selected site, each stakeholder ‘ranked’ every proposed variable according to their knowledge and experience following a 9-point scale (1 – weakly important, 3 – less important, 5 – moderate important, 7- more important, 9 – extremely important). This technique gives stakeholders an opportunity to prioritize their preferences.

2. Relative weight calculation

This calculation attempts to minimize the variability that could exist between evaluators and to have a more robust and accurate evaluation. It also helps to characterize each site and establish which variables have more or less impact according to the ranks given by the stakeholders. The process was the following:

1. ranks given by the stakeholders were consolidated in a single matrix (Table 5.1);.
2. ranks were summed by stakeholder within each set of variables for each site (Table 5.1);
3. total sums were averaged for each set of variables in each site (Table 5.1);
4. averages of each set in each site were summed to obtain a final score that prioritizes key conservation areas (Table 5.1);
5. ranks were summed by variable within each set of variables per site (Table 5.2);
6. Relative weight of each variable was calculated by dividing its actual weight (Ranking in Table 5.2) by the total of all weights (Total sum) and multiplying by 100 (Table 5.3). This is done to highlight the importance given to each variable within each site and to allow comparison of each variable with respect to the others within the same set;
7. as a last step, a global average (all sites) was calculated for each variable by averaging the relative weights (Table 5.3).

Table 5.1. Consolidation of a single matrix and averaging ranks. Ev: Evaluator

Variables	Site 1				Site 2		
	Ev 1	Ev 2	Ev 3	**Average**	Ev 1	Ev 2	Average
Fine Filter targets - River dolphins - Caiman - Fish -	 8 5 5 ...	 7 4 5	 6 6 7			...	
Total sum FFT	**18**	**16**	**19**	**17.6**	**...**	**...**	**25.3**
Coarse Filter Targets - Beach -	 9	 6	 8			...	
Total sum CFT	**9**	**6**	**8**	**7.6**	**...**	...	**5.2**
Total Score				**25.2**			**30.5**

Table 5.2. Sum of ranking votes

Element to be assessed – Categories	**Sum of ranking votes**					
	Site 1				Site 2	
	Calculation			**Ranking**	Calculation	Ranking
Fine Filter targets - River dolphins - Caiman - Fish -	 8 5 5	 7 4 5	 6 6 7	 **18** **16** **19**	...	...
Total (sum)				**53**		
Coarse Filter Targets -Beach	 9	 6	 8	 **23**	...	...

Table 5.3. Calculation of relative weights

Element to be assessed - Categories	**Relative weights**				
	Site 1		Site 2		Global averages
	Calculation	**Ranking**	Calculation	Ranking	(Site1+Site2)/2
Fine Filter targets - River dolphins -Caimans - Fish -	 **18 / 53 * 100** **16 / 53 * 100** **19 / 53 * 100**	 **34** **30** **36**		 25.8 33.2 41.0	 30 31.5 38.5
Total		**100**		**100**	**100**
Coarse Filter Targets -Beaches	**23 / 42 * 100**	**54.8**	...	...	...

5.2.2. Numerical tests

Univariate Analysis of Variance was performed on all sets of variables (FFT, CFT, ESSB, TH) to test if there were significant differences in the means of the variables ranked either according to the geographical areas (factor = site) or to the point of view of the institutions represented by the evaluators (factor = institution). The Gaussian residual distribution (Descriptive Analysis-Kurtosis and Skeweness coefficients [-1.96> P <1.96]) was used to test for symmetry in the data for each data set. For those variables presenting homoscedasticity (homogeneity of variance) (Levene's test; P >0.05), the F-ratio (<0.05) was explored to confirm those variables that were statistical significant in terms of rejecting the null hypothesis (H_0) that 'all variables are ranked the same across the study area and by different stakeholders regardless of their affiliation'. The Student's t test (P <0.05) was used to find the source of the significant differences. Those with no homoscedasticity (Levene's test p<0.05) were treated using the non parametric Mann Whitney U test. The analyses were carried out using SPSS-PASW Statistics 18.

These analyses were done to confirm the robustness of the data and to prove if the multi-criteria approach chosen to identify key conservation areas in freshwater ecosystems is effective and replicable.

5.2.3 Conservation Initiatives and poverty reduction programmes mapping

All stakeholders were asked to mark on a map with a pin those sites where past and current conservation strategies have been conducted, as well as poverty reduction programmes implemented by the central government.

5.2.4 Variables mapping

The results of the assessment of the study area were mapped in 10-km grids (Figure 3.1). One or more grids represent the 10 sites selected (Figure 5.1). Maps were created using ArcGis 9.3.

5.3. Results

5.3.1. Multi Criteria Matrix

VARIABLES SELECTED AND THEIR ABBREVIATIONS:

FINE FILTER TARGETS

1. River Dolphins – *Inia geoffrensis* and *Sotalia fluviatilis*
2. Black Caiman – *Melanosuchus niger*
3. Manatee – *Trichechus inunguis*
4. River otters – *Pteronura brasiliensis* and *Lontra longicaudis*
5. River Turtle – *Podocnemis expansa*
6. Pirarucu – *Arapaima gigas*
7. Fish – Commercial and for local consumption (17 species)
8. BIRDS – Migrant and Aquatic
9. Species bringing nutritional benefits
10. Species with pharmaceutical benefits
11. Species acting as disease controllers
12. Productivity (Primary)

COARSE FILTER TARGETS

1. Varzeas – Flooded Forests
2. Floating vegetation – aquatic macrophytes
3. Beaches
4. Confluences
5. Main River
6. River pools – *Remansos*

ECOSYSTEM SERVICES AND SOCIETAL BENEFITS

1. Scientific and social research
2. Transport and navigation
3. Sport & game fishing
4. Local consumption fisheries
5. Commercial fisheries
6. Ornamental fisheries
7. Water for human consumption
8. Waste deposition
9. Climate balancing / carbon sequestration
10. Water for agricultural uses
11. Dolphin watching
12. Indigenous Communities
13. Landscape viewing

THREATS

1. Overfishing
2. Illegal use of fishing gears
3. Water pollution
4. Logging
5. Hunting
6. Conflicts between fisheries and aquatic fauna
7. Abstraction of water for agriculture – irrigation
8. Dams and flow regulation (including hydro-ways)
9. Lack of income alternatives – dependency on aquatic ecosystems
10. Lack of policies' enforcement

11. Failure in Rivers and Lakes' Planning
12. Conflicts among stakeholders
13. Border conflicts
14. Boat traffic
15. Uncontrolled tourism
16. Climate change
17. Human population growth
18. Mining
19. Changes in sedimentation and erosion patterns
20. Changes in land use (including agricultural development)

PRE-SELECTED AREAS (SITES)

Ten sub-areas were selected to make the evaluation processes easier. Each sub-area is described below and mapped in Figure 5.1.

River Amazon – R1 - San Jose Area (AMA_1)

This segment in the River Amazon comprises an extension of approximately 4 km and is a shared area with the community of Puerto Alegria (Yavari District, Peru). The area is located 20 km upstream the city of Leticia, between the 4°07'47.02'' S and 70°01'34.26''W and 4°04'52.35''S and 70°03'20.97''W. This segment of river is a white water lotic body (type I) influenced by seasonal river level changes. This area is located in one of the narrowest sectors of the Amazon River, aspect characteristic exploited by commercial fishermen (Bonilla 2006).

River Amazon – R2 - From Vamos Island to the Atacuari/Amazon rivers confluence. (AMA_2)

The area comprises 26 km of the River Amazon (3°51'17.82''S and 70°27'09.48''W - 3°50'30.56''S and 70°37'15.23''W), and is the western margin of Amazon River in Colombia. It is an area across which people travel between Iquitos, Caballo Cocha and Puerto Nariño.

Atacuari River (ATA_T)

A tributary located in the western part of the South of the trapezium in the border with Peru (3°50'30.56''S and 70°37'15.23''W). It is a black water river fed by the Atacuarillo Creek and other small tributaries of second and third order. Its length is about 13.18 km and its basin has an area of 1696.50 ha. The communities of San Juan de Atacuari and Siete de Agosto (Colombia) are located on its left bank (downstream) (Gutierrez & Riaño 2005).

Caballo Cocha Lake (Perú) (CAB_L)

Located in the district of Ramon Castilla (Mariscal Ramon Castilla Province, Loreto Region, Peru) (03º 55' 27'' S and 70º 32' 46'' W). It is bordered to the east by the City of Caballo Cocha, to the south by the community of Marichin, to the north by the Amazon River. The lake is an irregular shape with an area of 870.08 ha and an average depth of 49 m (Ortiz *et al.* 2010).

The lake is connected to the Amazon River through a 10-km channel. The lake is mainly black water during the low water season, but a mixture of black/white as result of inflow of water from the River Amazon during the flood season (Type I).

Loreto-Yacu River (LOR_T)

The Loreto-Yacu River is located at the south west part of the Amazonian Trapezium in the Municipal district of Puerto Nariño. It is a black water river with a length of 58.55 navigable km; its source is located at the dissected flatlands in the border with Peru and its mouth is located at 3°47'16.42''S and 70°21'40.80''W. Along its course this river receives the Agua Blanca and Pichuna Creeks. The basin comprises a series of important lake systems, Soco Lake situated 15 km upstream and the Tarapoto–El Correo lakes system near the confluence with the Amazon River (Riaño-Umbarila 2003).

PNN Amacayacu (Buffer zone): Amazon River, Amacayacu River, Mata Mata River, Mocagua Island (MOC_I)

This area occupies a segment of the Amazon River from the indigenous Community of Mocagua to the Amacayacu River, including the southern part of the NNP Amacayacu (3°48'34.32''S - 70°18'16.32''W). The area comprises Mocagua Island and its internal wetlands, as well as Zaragozilla Island located 60 km upstream the city of Leticia. These islands are part of the Indigenous Reserves Mocagua, Macedonia, El Vergel and Zaragoza covering an area of 2500 ha (Riaño-Umbarila 2003).

Loreto Yacu /Amazon rivers confluence. Patrullero and Vamos islands (PAT_I)

This area is located 85 km upstream the city of Leticia and comprises a segment of the Amazon River that goes from the confluence of the Loreto Yacu with the Amazon River (3°47'16.42''S - 70°21'40.80''W), to the far west point of Vamos Island (3°50'47.93''S and 70°25'32.89''W), including the northern part of Patrullero Island.

Tarapoto Lakes System (TAR_L)

The system is located at the NE of the municipality of Puerto Nariño near the border with Peru (03° 54' and 03° 12' South and 70° 17' and 70° 42' West), 86 km upstream the city of Leticia and 2 km upstream of the confluence of the Loreto Yacu and the Amazon River. Tarapoto Lake has a surface area of about 3227 m² and the satellite lakes that are part of the system have a surface between 11,424 and 97,305 m² (it changes according to the hydro-climatic seasons) (UNAL & Corpoamazonia 2007).

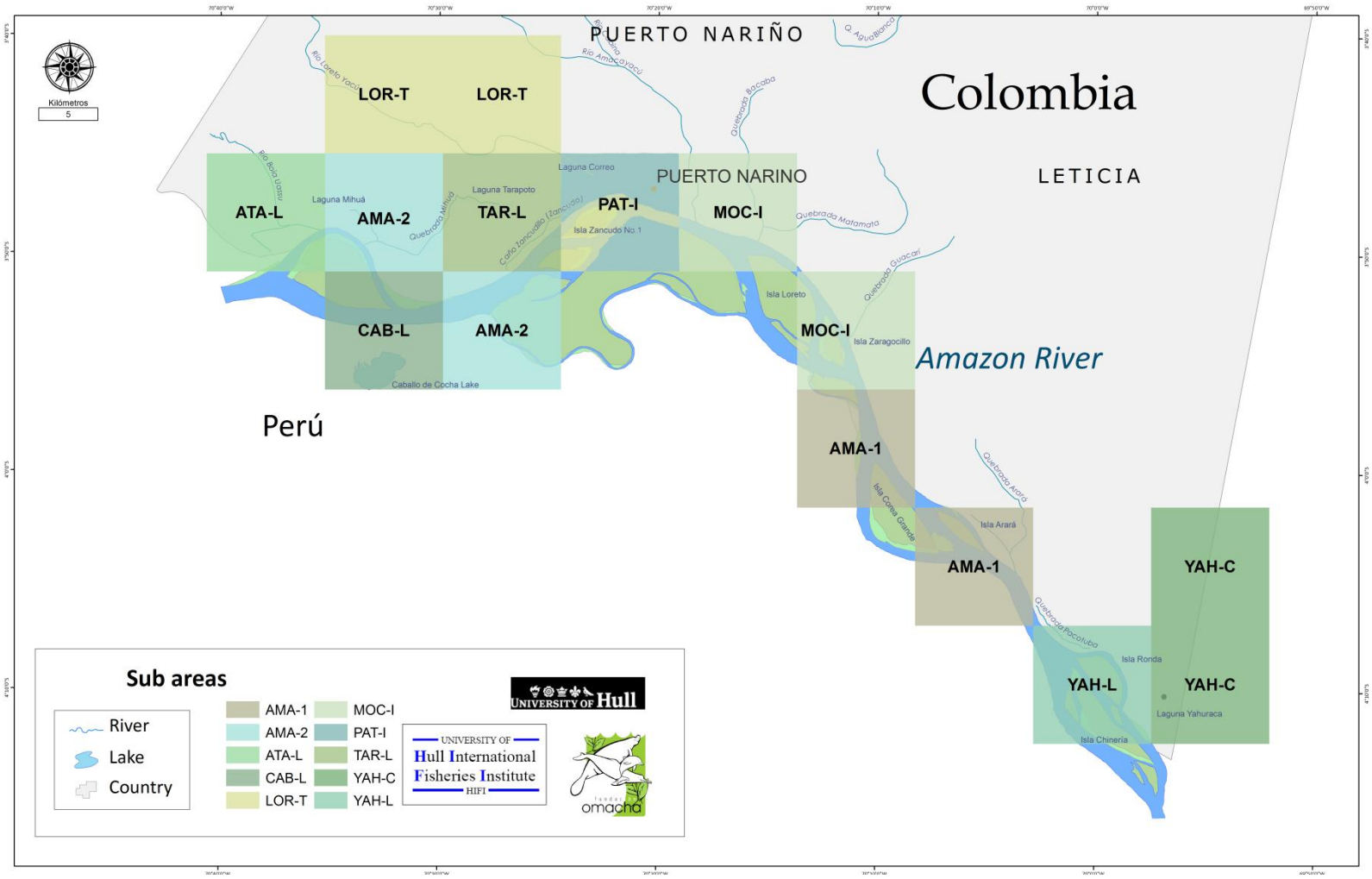

Figure 5.1. Map of the study area showing the 10 sites and the correspondent grids and abbreviations.

The Tarapoto Lake System has an indirect connection with the Loreto Yacu River through El Correo Lake. This connection is more visible during the rainy season when the waters of the Loreto Yacu influence Tarapoto's waters. Neither the Tarapoto or El Correo lakes have connection with the main channel of the Amazon River; this only happens during years of maximum flooding. The lakes have been classified as *varzea* lakes, which mean they are flooded forests. During low water season the lakes are considered black water type. The lake system is part of the Ticoya Indigenous reserve and its management is shared among local NGOs, the regional environmental authority (Corpoamazonia) and the national fishing authority (INCODER).

Yahuarcaca Creek (YAH_C)

This creek is located between 69°51' and 69°54' W and 4°10' and 4°15'S. Its source is located 5 km upstream in Lake III of the Yahuarcaca Wetland System. This is a black water creek not influenced by any white water system. Its hydrological regime is related directly to local rains causing high variation water level throughout the year (Baron 2006). The micro-basin has an area of 2683 ha (Corpoamazonia 1997).

Yahuarcaca Wetland System (YAH_L)

The Yahuarcaca Wetland System (4°08'LS 69° 59' LW) is located 2 km NW from the city of Leticia (Torres Bejarano 2006). The wetland system comprises a series of naturally interconnected ponds that have emerged from an old arm of the Amazon River. Four ponds form the main system: Lake I is the outermost and is connected to the Amazon River through a channel of approximately 100 m. The system is influenced by white waters coming from the river during the months of November to March (rainy season). One of the inner lakes (Lake III) receives the discharge of black water from Yahuarcaca Creek (Prieto-Piraquive, 2006). During the low water season the 4 main lakes are disconnected from each other and from the Amazon River. The lakes can be classified as continuously warm and polymictic (Rodriguez Munar 2008).

The final matrix is presented in the Appendix 3.

STAKEHOLDERS[2]

As stated in previous chapters, active participation of stakeholders in any research, conservation or decision making process is vital for the future of the local and regional freshwater biodiversity as well as for the improvement of the livelihoods of the local communities. From the 21 people representing 11 organizations meeting the criteria and contacted to collaborate in this study, only 14 from 9 organizations replied positively (Appendix 2). To evaluate the views and interests of each institution and how they might influence the

[2] Any group of people organised or unorganised, who share a common interest in a particular issue: policy makers, planners and administrators, researchers, scientists and local communities (Ananda & Herath 2003).

ranking, stakeholders were grouped into four categories according to the type of institution they were representing (NGO, Scientific Research Institution, Academia (University) and Government).

5.3.2 Multi-criteria matrix assessment and numerical tests

FINE FILTER (SPECIES) AND COARSE FILTER TARGETS (HABITATS)

Ranking: Relative weights and averages

According to the multi-criteria matrix assessment for all sites (global average), the most important or representative FFT variables were species bringing nutritional benefits (11.74), river dolphins (11.62) and fish (11.34) (Table 5.4), whilst species with pharmaceutical uses and species acting as disease controls had the lowest scores (4.81 and 4.44). The CFT with the highest values were flooded forests (21.21) and floating vegetation (18.46) (Table 5.5), whilst Main River (14.78) and River pools (13.27) had the lowest scores.

The areas with the highest ranking according to the assessment of their FFT were: Tarapoto Lake System (TAR_L) (80.60) followed by the area comprised by the southern part of the PNN Amacayacu and its buffer area (MOC_I) (71.72) (Table 5.4). These two areas were followed in order of importance by Caballo Cocha Lake (CAB_L), the rivers Loreto-Yacu (LOR_T) and Atacuari (ATA_T) and the confluence area of Loreto-Yacu/Amazon rivers including the islands Patrullero and Vamos (PAT_I). The segments of the River Amazon near San Jose (AMA_1) and Naranjales (AMA_2), the Yahuarcaca Wetland System (YAH_L) and Yahuarcaca creek (YAH_C) were ranked lowest for this category (Figure 5.2).

The final CFT scores for each site positioned TAR_L (43.97) and PAT_I (43.68) as the most important areas, followed by CAB_L, MOC_I, ATA_T, and AMA_2. The lowest scores were for LOR_T, AMA_1, YAH_L and YAH_C (Figure 5.3 – Table 5.5). FFT and CFT final scores were summed to group theses two categories to represent the local freshwater biodiversity (Table 5.6 and Figure 5.4).

The three maps (Figures 5.2, 5.3, 5.4) differentiate the area into two; the sites within the Municipal district of Puerto Nariño and Peru (west), (red and orange colours) indicating the importance of these areas to maintain local freshwater biodiversity, and sites on the east within the Municipal district of Leticia (yellow colours) indicating that these sites are not recognized as important areas for biodiversity maintenance. These sites are close to the city of Leticia where more people have settled, more boat traffic is recorded and disturbance to the natural environment in prominent. This can be considered a good indicator to follow the spatial changes of biodiversity across the area as a result of an increase of anthropological pressures.

Table 5.4. Relative weights (per variable) and total averages (sites scores) for FFT in the 10 selected sites. Numbers in parentheses represent the position obtained by each site. Colours represent conservation priorities: red: high, orange: medium, yellow: low. Variables in bold represent the highest ranks. (*) represents variables presenting significant differences according to the Mann-Whitney test and (♦) those according to pair wise comparisons (Students t-test). Variables were significant at 95% (*) or 99% (**).

Fine Filter Target \Subareas	AMA_1	AMA_2	ATA_R	CAB_L	LOR_T	MOC_I	PAT_I	TAR_L	YAH_C	YAH_L	Global averages.
River dolphins	**14.72**	**12.75**	**10.74**	**11.51**	**10.83**	**11.31**	**14.05**	**11.75***	8.47*	**10.02**	**11.62**
Black caiman	3.9♦	7.08	8.05	7.76	8.97	8.45	5.47	9.16♦	6.81♦	7.94	7.36
Amazonian manatee	5.14♦	9.13	**9.32**	8.73	**9.90**	9.70	**12.13♦**	**10.69♦**	6.26♦	6.25♦	**8.72**
River otters	5.32♦	6.30	8.68	6.51	**9.44♦**	6.34	5.17	6.93	7.73	6.90	6.93
River Turtle – Charapa	9.60♦	**10.07**	7.26	6.51	6.19	9.07♦	**9.61♦**	6.58♦	5.89♦	7.42	7.82
Pirarucu	8.15♦	9.60	**9.00**	**10.95♦**	**10.99♦**	**11.06♦**	8.87	**10.81♦**	9.02♦	**9.89**	**9.83**
Fish: Commercial and for local consumption	**17.73***	**12.44***	**10.58***	**10.40**	**9.44***	**11.56***	**11.24**	9.04	**10.68**	**10.28***	**11.34**
Birds: aquatic and migrant	7.10♦	8.18	8.53	**9.57**	8.66	**9.45♦**	**9.61**	**9.28♦**	**11.23**	**10.28**	**9.19**
Species with nutritional benefits	**12.94**	**11.49**	**11.84**	**11.10**	**12.38**	**10.57**	**11.98**	**10.81♦**	**13.07**	**11.45**	**11.74**
Species with pharmaceutical uses	4.25♦	4.41	**6.16♦**	5.41	4.48	3.85	3.25	4.93♦	**6.07**	5.33	4.81
Disease controls	4.50	3.77	4.42	4.71	3.56	3.23	3.55	3.29	**7.36**	**5.07**	4.44
Primary productivity	5.67	4.72	5.37	6.79♦	5.10	5.34	5.03	6.69♦	**7.36**	**9.11♦**	6.12
Sum relative weights	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Total average.	**48.2 (10)**	**66.1 (7)**	**67.62 (5)**	**68.47 (3)**	**68.27 (4)**	**71.77 (2)**	**66.5 (6)**	**80.6 (1)**	**50.32 (9)**	**64.73 (8)**	

Table 5.5. Relative weights (per variable) and total averages (sites scores) of the CFT in the 10 sites selected. Numbers in parentheses represent the position obtained by each site. Colours represent conservation priorities: red: high, orange: medium, yellow: low. Variables in bold represent the highest ranks. . (*) represents variables presenting significant differences according to the Mann-Whitney test and (♦) those according to pair wise comparisons (Students t-test). Variables were significant at 95% (*) or 99% (**).

CF Target\Sub-areas	AMA_1	AMA_2	ATA_R	CAB_L	LOR_T	MOC_I	PAT_I	TAR_L	YAH_C	YAH_L	Global averages
Flooded forest	15.65*	16.90	**20.97**	**22.53***	**23.87***	**18.96**	15.76	**22.62***	**29.67**	**25.16***	**21.21**
Floating vegetation	14.58♦	16.33♦	16.37	**19.69♦**	**19.94**	16.37	16.41	**20.08♦**	**23.87**	**20.97♦**	**18.46**
Beaches	16.44*	**21.40***	16.66	12.25	13.20	**20.04***	**19.87***	13.10	14.83	11.03	15.88
Confluences	**18.56**	16.62	**20.68**	18.16	16.57	15.08	**18.79***	17.97*	8.38	12.80	16.36
Main river	**18.03**	12.39	12.35	15.97	15.16	13.57	13.60	14.58	14.51♦	17.66	14.78
River pools - *Remansos*	**16.71**	**16.33**	12.93	11.37	11.23	**15.94**	**15.55***	11.62	8.71*	12.36	13.27
Sum relative weights	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Total averages	**31.4** (9)	**36.9** (6)	**37.4** (5)	**42.5** (3)	**36.0** (7)	**38.7** (4)	**43.6** (2)	**43.9** (1)	**26** (10)	**34.7** (8)	

Table 5.6. Total ranks for each site according to its biological composition (Fine Filter Targets and Coarse Filter Targets). Colours represent conservation priorities: red: high, orange: medium, yellow: low.

Surrogates of conservation \ Sub-areas	AMA_1	AMA_2	ATA_R	CAB_L	LOR_T	MOC_I	PAT_I	TAR_L	YAH_C	YAH_L
FFT – total average	48.2 (10)	66.10 (7)	67.62 (5)	68.47 (3)	68.27 (4)	71.77 (2)	66.50 (6)	80.60 (1)	50.32 (9)	64.73 (8)
CFT – total average	31.44 (9)	36.97 (6)	37.39 (5)	42.51 (3)	36.06 (7)	38.72 (4)	43.68 (2)	43.97 (1)	26.4 (10)	34.72 (8)
Total FFT + CFT	**79.64**	**103.07**	**105.01**	**110.98**	**104.33**	**110.49**	**110.18**	**124.57**	**76.72**	**99.45**
Positions	**9**	**7**	**5**	**2**	**6**	**3**	**4**	**1**	**10**	**8**

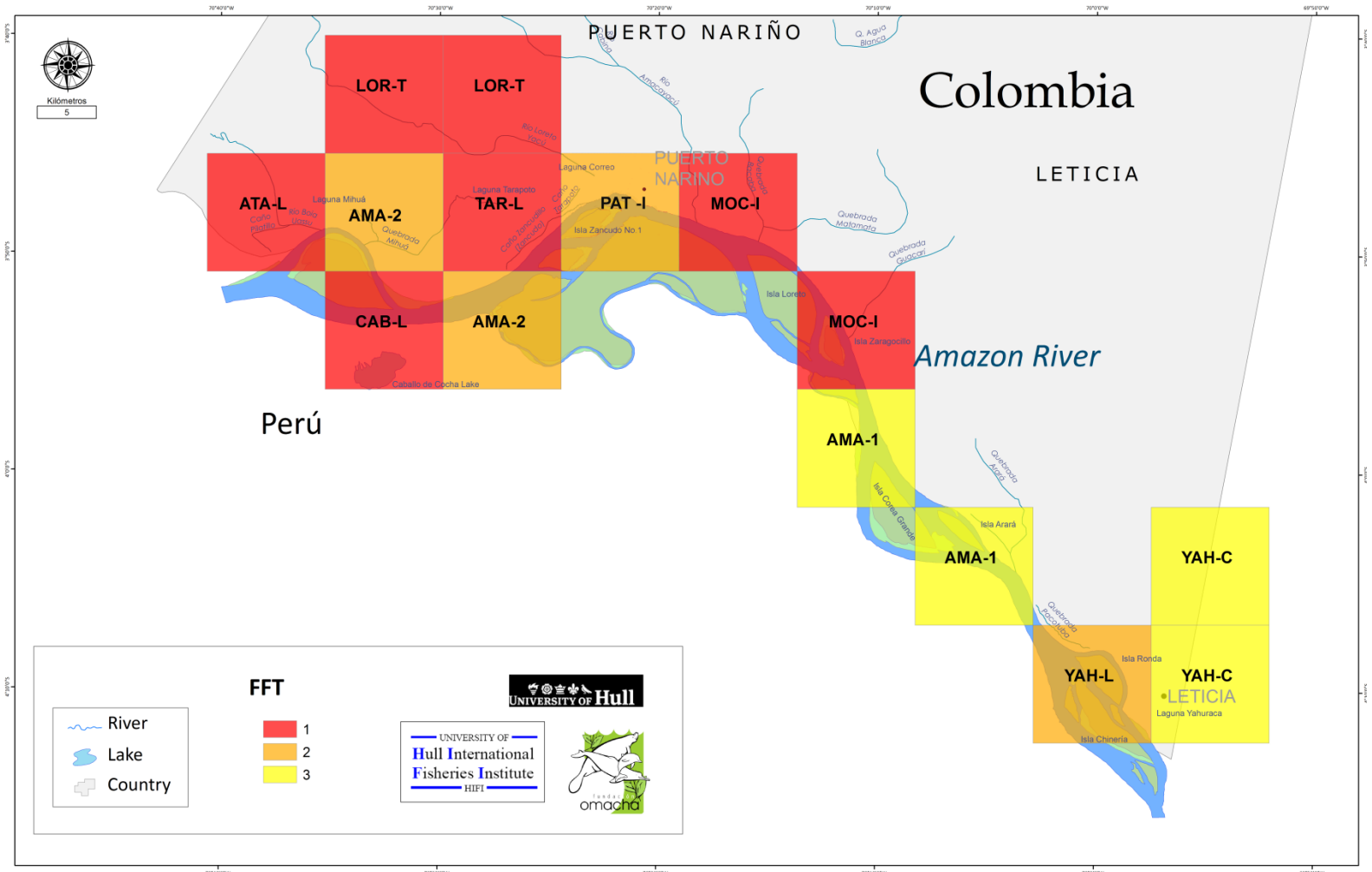

Figure 5.2. The 10 sites according to their Fine Filter Targets (Table 5.4). In red the sites of high conservation priority (highest ranks), in orange of medium conservation priority and in yellow of low conservation priority (lowest scores).

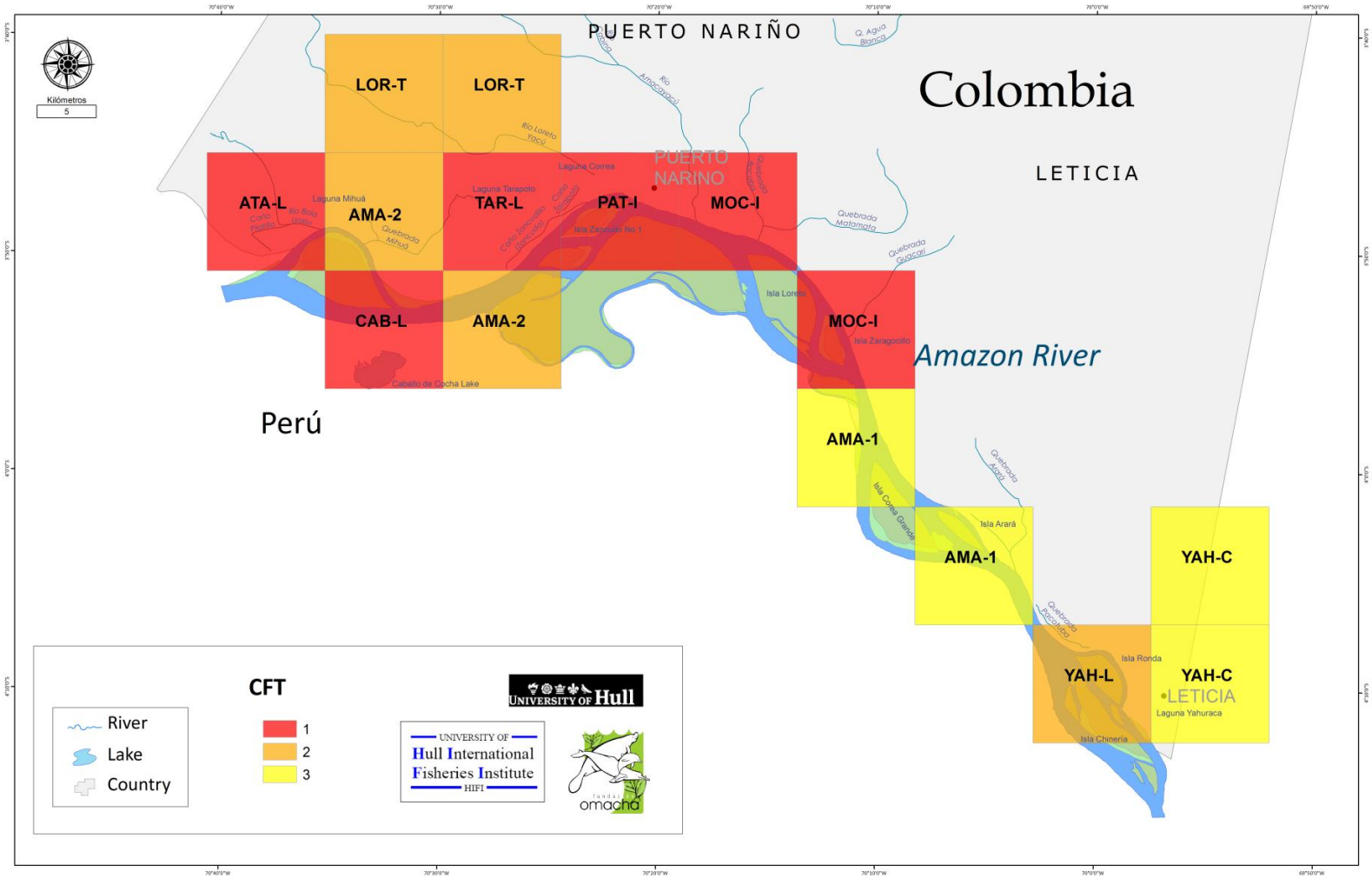

Figure 5.3. The 10 sites according to their Coarse Filter Targets (Table 5.5). In red the sites of high conservation priority (highest ranks), in orange of medium conservation priority and in yellow of low conservation priority (lowest scores).

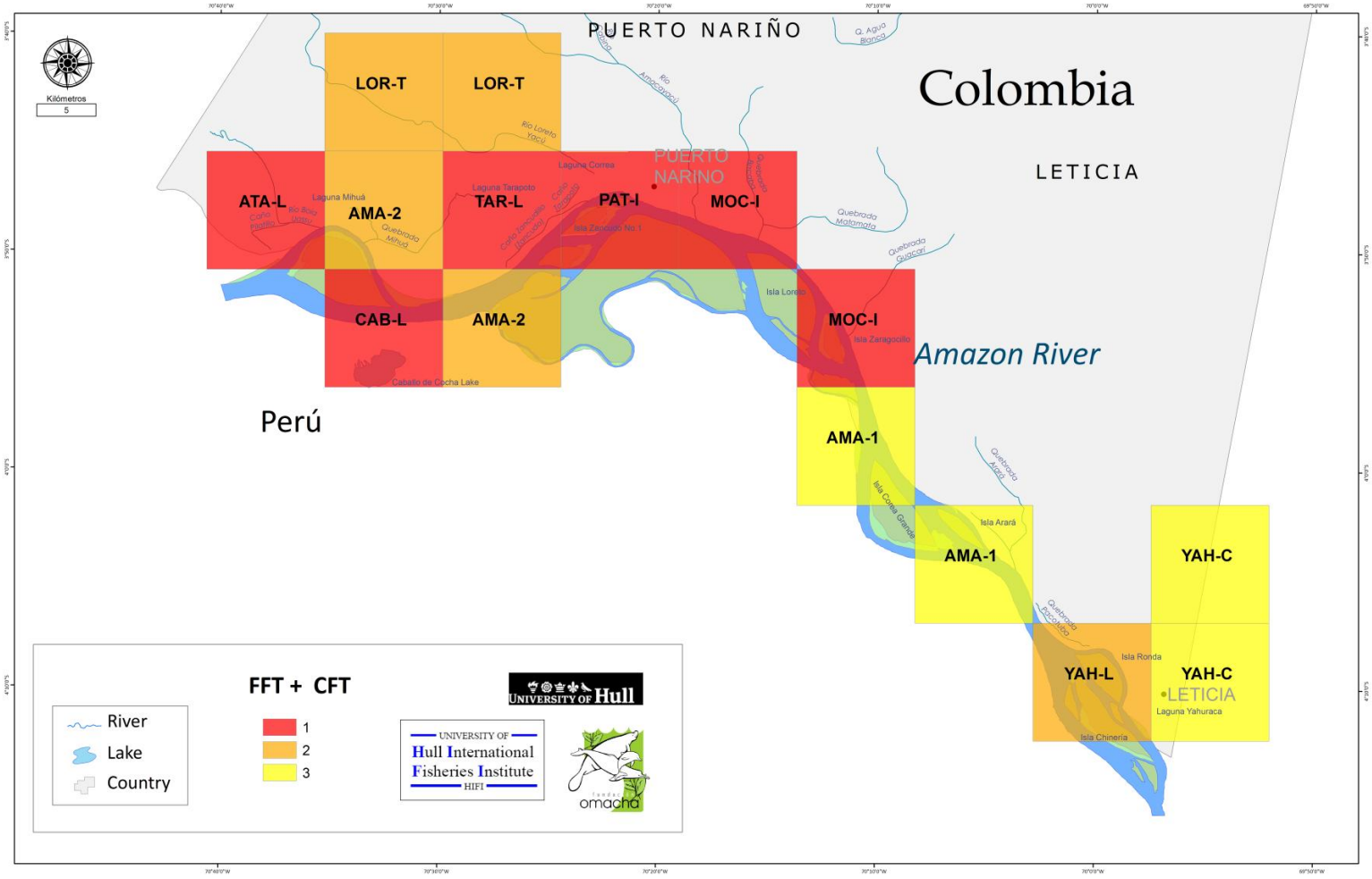

Figure 5.4. The 10 sub areas ranked according to their ecological attributes (FFT + CFT. Table 5.6). In red the sites of high conservation priority (highest ranks), in orange of medium conservation priority and in yellow of low conservation priority (lowest scores).

Gaussian residual distribution

Gaussian residual distribution was tested by a Descriptive Analysis and the Kurtosis and Skeweness coefficients [-1.96> P <1.96]). All variables fail to show Gaussian residual distribution

FINE FILTER TARGETS (FFT)

Sites as a Factor – Mann Whitney test and pair wise comparisons (Student's t-test) (Table 5.4).

River Dolphins: the Tarapoto Lake System seems to be the area more suitable for river dolphins compared with other sites. Yahuarcaca Creek is of little importance as a suitable habitat for the species and river dolphins have never been sighted in this black water tributary.

Black Caiman: AMA_1 and YAH_C are of little importance for black caiman, but TAR_L as the most important site for the species within the Trapezium.

Amazonian Manatee: TAR_L and PAT_I are key sites for the Amazonian manatee. AMA_1, YAH_C and YAH_L are significantly different from the rest of the sites reflecting that the species is not longer found at these sites.

River otters: AMA_1 is significantly (negative) different from other sites and not frequented by river otters, while LOR_T is considered more important for the species.

Charapa Turtle: AMA_1 and YAH_C are of lower importance for the species, but PAT_I and MOC_I, characteristic for their beaches, together with the TAR_L, to be the most important sites for the Charapa.

Pirarucu: TAR_L is an important site for the species while AMA_1 and YAH_C are not perceived important compared with the other sites like CAB_L, MOC_L, LOR_T, well known for their populations of pirarucu.

Fish: Three segments of the river are important or representative for fish in the Trapezium, AMA_1, AMA_2 and MOC_I. The tributaries ATA_T and LOR_T as well as YAH_L are of less importance. The importance of commercial fisheries and their association to the main stem of the Amazon is confirmed by these results.

Birds: The stretch of the river AMA_1 is poorly ranked compared with lakes and tributaries where better habitats for birds are provided. TAR_L and MOC_I on the contrary are more important for this group.

Species bringing nutritional benefits: Pairwise comparisons only showed significantly differences between the TAR_L and the YAH_C highlighting the importance of the lake over the creek.

Species with pharmaceutical benefits: Only differences were found between ATA_T and AMA_1 and between TAR_L and AMA_1. The tributary and lake are more important for the provision of these species than the main stem of the river.

Species acting as disease controls: No significant differences were found between the areas assessed.

Primary productivity: Lake systems (YAH_L, CAB_L and TAR_L) were significantly more important sites for their productivity than AMA_1, AMA_2, PAT_I, and YAH_C.

Institutions as a factor

Significant differences were found between the evaluations of the representatives of the NGOs, the university (Academia) and the institute researchers, and the stakeholders representing the Government. On all occasions, with the exception of the evaluation of the variable FFTbir (birds), government representatives gave the lowest ranks to the variables. Evaluations from the former three groups tended to be significantly higher in all variables.

COARSE FILTER TARGETS (HABITATS)

Sites as a factor – Mann Whitney Test and pair wise comparisons (Student's t-test) (Table 5.5).

Flooded Forest – *Varzeas*-: Significant differences were found between almost all possible combinations of pairs. TAR_L, CAB_L, YAH_L and LOR_T were significantly different from AMA_1 indicating the importance of lakes and tributaries. Human settlements, changes in land use, farming and cattle ranching taking place on the shores of the Amazon River have reduced the availability of this habitat type.

Floating meadows - aquatic macrophytes: Significant differences were found between sites highlighting the importance of lakes systems (TAR_L, YAH_L, CAB_L) for the maintenance of this habitat type. The segments AMA_1 and AMA_2 showed the opposite.

Beaches: The segments of the River Amazon representing this habitat type were PAT_I, AMA_1, AMA_2, and MOC_I.

Confluences: Significant differences were found showing the importance of PAT_I and TAR_L regarding this habitat type.

Main River: This habitat was found not to be important at YAH_C

River Pools – *Remansos*: Significant differences showed that this habitat is less important in YAH_C and more important in PAT_I.

Institutions as a factor

Significant differences were only found in the assessment of CFTmacr. Representatives of NGOs and the Government gave higher ranks to this variable than Academics.

ECOSYSTEM SERVICES AND SOCIETAL BENEFITS (ESSB)

Ranking: Relative weights and averages

The main ecosystem services in the study area with the highest ranks were: provision of fish supporting local subsistence fisheries (10.82), scientific and social research (10.69), landscape contemplation (9.91), role of freshwater ecosystems as communication and navigation routes and provision of fish to support commercial fisheries (8.91), and dolphin watching (8.34) (Table 5.7).

The total scores calculated for each sub-area showed the importance of the three lake systems within the study area. Caballo Cocha Lake (83.01), the Tarapoto lakes system (81.37) and the Yahuarcaca wetlands (76.43) scored first, second and fourth ranks accompanied by Loreto-Yacu River (79.54) in third rank. The two segments of river (AMA_1 and AMA_2) and Yahuarcaca Creek were ranked the lowest (Table 5.7 and Figure 5.5).

Gaussian residual distribution

Gaussian residual distribution was tested by a Descriptive Analysis and the Kurtosis and Skeweness coefficients [-1.96> P <1.96]). All variables failed to exhibit Gaussian residual distribution.

Sites as a factor – Mann Whitney Test and pair wise comparisons (Student's t-test) (Table 5.7).

Science and Social research: Lakes systems like TAR_L and YAH_L were considered more important for the provision of this service than other sites like AMA_2 and ATA_T.

Transport and Navigation: Significant differences were found between river segments, tributaries and lakes, highlighting the importance of the main river (AMA_1, AMA_2, MOC_I, and PAT_I) in the provision of the service.

Sport and game fishing: No statistical significance was found between sites.

Local Fisheries: No statistical significance was found between sites.

Commercial Fisheries: The importance of the main river (AMA_1 and AMA_2) and Caballo Cocha (CAB_L) in the provision of fish for commercial purposes was highlighted.

Ornamental Fisheries: LOR_T was identified as an important site for the provision of this service whilst AMA_1 was of little importance

Water for human consumption and Waste deposition: YAH_C, YAH_L and LOR_T were found to be important in providing water for human consumption and waste receptors.

Climate balance and carbon sequestration: Lake systems (CAB_L, TAR_L and YAH_L) were found to be important in balancing the climate and carbon sequestration.

Water for agricultural uses: No statistical significances were found between sites.

Dolphin watching: TAR_L and CAB_L were found to be important as dolphin watching sites while YAH_C is considered not important.

Indigenous Communities: MOC_I was found to be an important site for handicraft manufacture compared with other sites.

Landscape viewing: Significant differences were found between sites establishing AMA_1 and AMA_2 were of little importance for landscape viewing, whilst TAR_L appears to be key in the provision of this service.

Institutions as a Factor

There was no discrimination between the way the four different groups of evaluators assessed the variables of this category, although representatives of the government tended to under rank most of the ecosystem services assessed compared with other stakeholder.

THREATS

Ranking: Relative weights and averages

The threats scoring the highest values were overfishing (7.13), lack of policies' enforcement (7.09), illegal use of fishing gears (6.81), logging (deforestation) (6.25), human population growth (6.15) and uncontrolled tourism (6.08) (Table 5.8). Caballo Cocha Lake (103.6) and the Yahuarcaca wetland system (95.55) are the sites within the study area most highly impacted by the assessed threats. These areas are followed in order of risk by the Tarapoto lakes system and the segment of the Amazon River AMA_1, the buffer area of the NNP Amacayacu MOC_I and the area of confluence of the Loreto Yacu/Amazon Rivers (PAT_I). The Atacuari River (82.8), the segment of the Amazon River AMA_2 (79.5) and Yahuarcaca Creek (77.2) are the areas that according to stakeholders are threatened least (Figure 5.6).

Gaussian residual distribution

Gaussian residual distribution was tested by a Descriptive Analysis and the Kurtosis and Skeweness coefficients [-1.96> p<1.96]). All variables failed to exhibit Gaussian residual distribution.

Sites as a factor – Mann WhitneyTest and pair wise comparisons (Student's t-test) (Table 5.8).

No statistical differences were found between eight variables within this category: Water for agriculture, dams, lack of income alternatives, lack of law enforcement, failure in planning, climate change, mining and changes in water bodies

Table 5.7. Relative weights and total averages of the ESSB in the 10 sub- areas selected. Colours represent conservation priorities: red: high, orange: medium, yellow: low. **In bold** are those variables with the highest ranks. (*) represents variables presenting significant differences according to the Mann-Whitney test and (♦) those according to pair wise comparisons (Students t-test). Variables were significant at 95% (*) or 99% (**).

ESSB\Sub-area	AMA_1	AMA_2	ATA_R	CAB_L	LOR_T	MOC_I	PAT_I	TAR_L	YAH_C	YAH_L	Global averages
Scientific and Social Research	**10.61**	**10.92♦**	8.94♦	**9.71**	**9.24**	**11.38**	**12.05**	**11.08♦**	**11.54**	**11.43♦**	**10.69**
Transport and Navigation	**12.60♦**	**11.84♦**	**10.41**	7.99	7.46	**9.01♦**	**10.57♦**	6.36	6.69	6.16	**8.91**
Sport & Game Fishing	4.31	4.15	3.66	5.07	5.18	4.39	4.55	**6.58**	4.98	**6.36**	4.92
Local fisheries	**10.50**	**11.69**	**10.99**	**10.36**	**10.25**	**11.38**	**11.11**	**10.75**	**10.23**	**10.93**	**10.82**
Commercial Fisheries	**14.00***	**11.69***	7.33	**9.71***	7.84	7.89	**9.37**	8.34	5.51	7.45	**8.91**
Ornamental fisheries	4.20♦	4.30	6.59	5.83	6.45♦	4.39	3.74	5.81	**7.48**	5.86	5.47
Water for human consumption	6.53	4.46	7.33	7.88	**8.60♦**	5.18	5.48	7.02	**11.41♦**	**9.44♦**	7.33
Waste deposition	6.88	6.15	5.71	5.72	5.44♦	5.18	5.35	4.28	**9.71♦**	7.45♦	6.19
Climate balancing	3.26	4.61	4.98	**5.93♦**	5.18	4.50	4.41	**5.92♦**	**6.43**	**6.06♦**	5.13
Water for agriculture	5.60	**6.46**	6.15	6.04	5.31	**7.21**	5.48	5.05	**6.29**	5.66	5.93
Dolphin watching	**8.05**	8.76	7.33	**9.61***	**9.11**	8.45	**10.04**	**11.52***	3.80*	6.75	**8.34**
Indigenous communities	5.36	5.53	**9.09**	6.26	**8.60**	**11.04♦**	8.56	6.80	6.16	6.56	7.40
Landscape viewing	**8.05♦**	**9.38♦**	**11.43**	**9.82**	**11.26**	**9.92**	9.23	**10.42♦**	**9.71**	**9.84**	**9.91**
Sum relative weights	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Total averages	**65.2 (8)**	**64.0 (9)**	**68.3 (6)**	**83.0 (1)**	**79.5 (3)**	**72.1 (5)**	**67.1 (7)**	**81.3 (2)**	**63.6 (10)**	**76.4 (4)**	

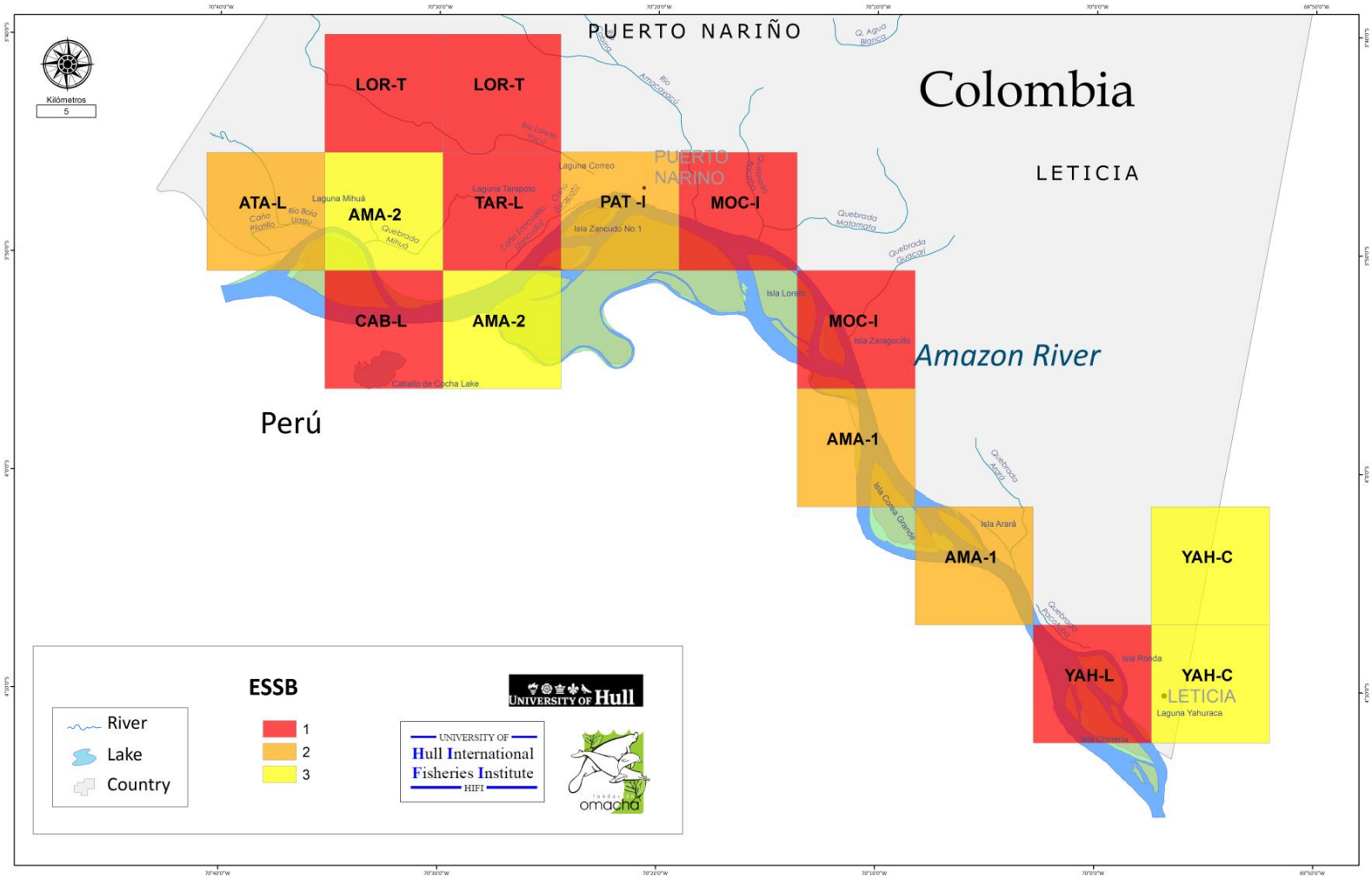

Figure 5.5. The 10 sub areas ranked according to their Ecosystem Services and Societal Benefits (ESSB) (Table 5.7). In red sites of high conservation priority (highest ranks), in orange of medium conservation priority and in yellow of low conservation priority (lowest scores).

Table 5.8. Relative weights and total averages of the TH in the 10 sub- areas selected. Colours represent conservation priorities: red: high, orange: medium, yellow: low. Those variables with the highest ranks are in bold. (*) represents variables presenting significant differences according to the Mann-Whitney test and (♦) those according to the pair wise comparisons (Students t-test). Variables were significant at 95% (*) or 99% (**).

Threat \ Sub-area	AMA_1	AMA_2	ATA_R	CAB_L	LOR_T	MOC_I	PAT_I	TAR_L	YAH_C	YAH_L	Global Averages
Overfishing	**8.02♦**	**7.26**	**6.28**	**7.98♦**	**6.62**	6.05	**6.35**	**7.28**	6.14	**7.35♦**	**7.13**
Illegal use of fishing gears	**6.25**	**6.71**	**7.35**	**6.85♦**	**7.00**	**7.59**	**6.82**	**7.50**	6.61♦	**7.18♦**	**6.81**
Water pollution	4.10	3.69	4.01	6.10♦	4.84	4.20	5.76	4.39	**8.00♦**	**6.67♦**	5.37
Logging	4.57♦	5.47♦	**6.55**	6.47♦	**7.00**	5.33	5.76	5.89	**7.30**	5.98	**6.25**
Hunting	4.38	5.61	5.88	**6.57♦**	**6.62**	5.64	5.76	**6.96♦**	4.98	4.79	5.69
Conflicts fisheries and fauna	**8.40♦**	**6.84**	5.48	**6.94♦**	6.11	4.72	**6.94**	5.68	2.43♦	2.99♦	5.71
Water for agriculture	2.70	2.19	2.13	2.44	2.03	2.66	2.00	1.60	2.78	2.13	2.13
Dams	1.49	1.91	1.60	1.22	1.52	1.54	1.64	1.28	1.50	1.19	1.39
Lack of income alternatives –	5.04	**6.02**	**6.01**	5.25	**5.98**	5.54	5.29	5.25	4.52	5.64	5.57
Lack of policies' enforcement	**7.37**	**7.12**	**6.95**	6.29	**6.62**	**7.18**	**6.70**	**7.50**	**7.30**	**7.10**	**7.09**
Failure in river and lake planning	6.25	**6.71**	6.41	5.91	4.96	**6.77**	5.41	5.57	5.80	5.90	5.60
Conflicts among stakeholders	4.48	4.24	4.67	4.22	5.47	**5.74**	3.64♦	**5.57♦**	**6.26**	5.04	5.20
Border conflicts	6.25*	4.79	**6.68***	2.06	3.31	3.59	4.94	2.57	1.85	1.79	3.78
Boat traffic	**5.78♦**	4.79	4.41	5.07♦	5.47	5.13	5.52♦	**5.78♦**	3.48	4.02	5.15
Uncontrolled tourism	4.38	4.38	4.94	5.82♦	**6.87**	**7.18♦**	**6.47**	**8.36♦**	6.14	6.50♦	**6.08**
Climate change	4.85	**6.02**	5.48	4.69	4.20	5.33	4.35	4.93	**5.91**	**5.81**	5.18
Human population growth	5.50	5.47	**6.14**	**7.69***	5.73	4.92	5.88	5.14	**6.72**	**7.27***	**6.15**
Mining	1.30	1.78	1.73	1.22	1.65	1.23	1.52	1.28	1.04	1.11	1.29
Sedimentation and erosion patterns	3.92	**4.79**	3.34	2.91	3.82	**5.03**	**4.82**	3.42	4.17	4.70	3.84
Changes in land use	4.85	4.10	3.87	4.22	4.07	4.51	4.35	3.96	**6.96**	**6.75♦**	4.50
Sum relative weights	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Total averages	**87.9 (4)**	**79.5 (9)**	**82.8 (8)**	**103.6 (1)**	**86.5 (6)**	**87.6 (5)**	**85.2 (7)**	**92.7 (3)**	**77.2 (10)**	**95.5 (2)**	

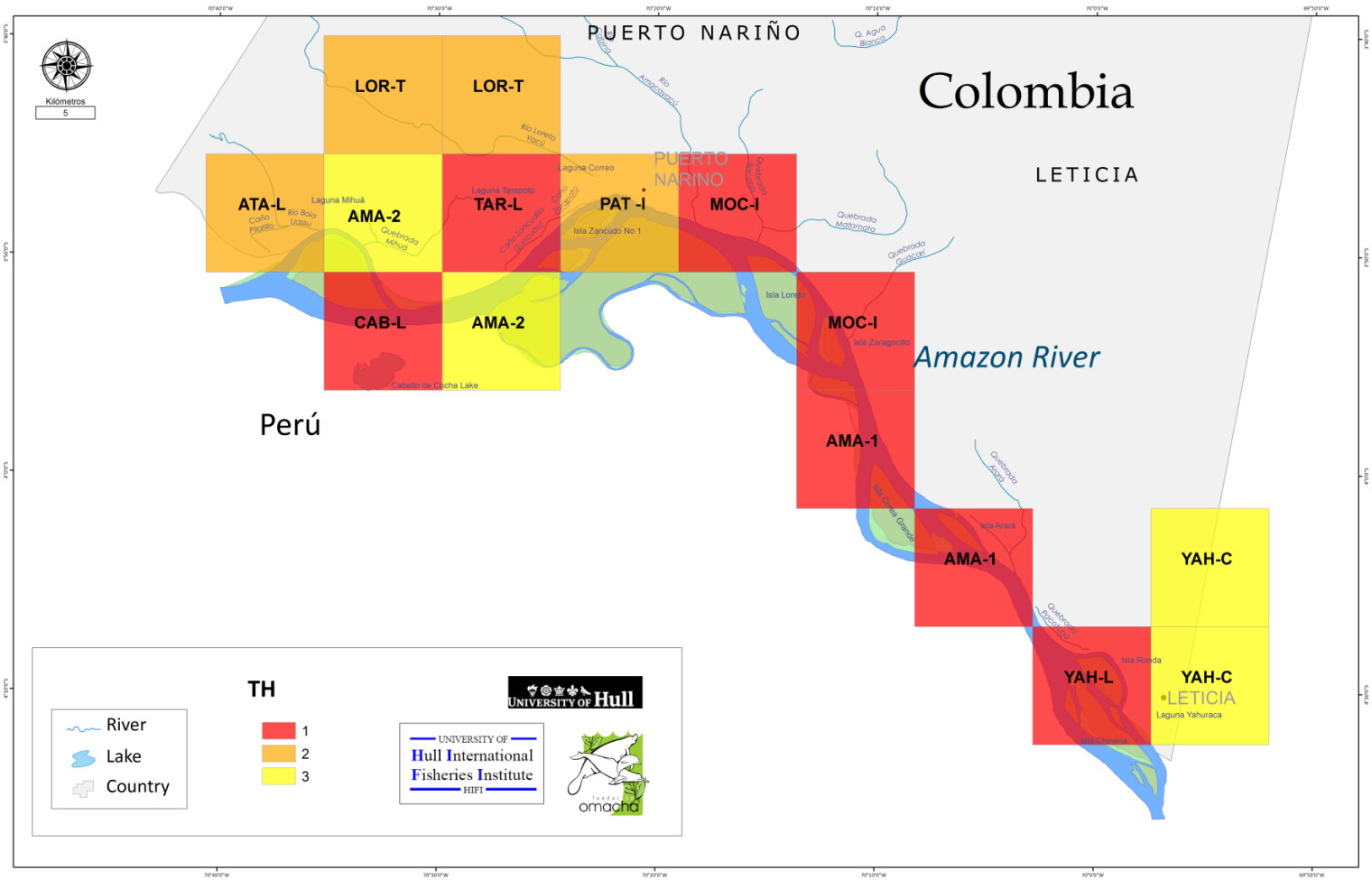

Figure 5.6. The 10 sub areas ranked according to the Threats to which they are exposed (Table 5.8). In red sites of high conservation priority (highest ranks), in orange of medium conservation priority and in yellow of low conservation priority (lowest scores).

Overfishing: This threat is important in AMA_1, YAH_L and CAB_L.

Illegal use of fishing gears: The lakes CAB_L and YAH_L were the areas where illegal gears are most used whilst least use of illegal gears was at YAH_C.

Water pollution: Importance threat in YAH_C, YAH_L and CAB_L.

Logging: Important threat in CAB_L when compared to AMA_1 and AMA_2.

Hunting: CAB_L and TAR_L are the sites most affected by this threat.

Conflicts between fisheries and aquatic fauna: Key threat at AMA_1 and CAB_ L but less impacting at YAH_L and YAH_C.

Conflicts among stakeholders: Significant differences were only found between TAR_L and PAT_I. The Tarapoto lakes system as one of the most exploited areas in the Municipal District of Puerto Nariño and as a site with a high number of users have always constituted a point of tension between users and stakeholders.

Border conflicts: AMA_1 and ATA_T are the sites most affected by this threat due to the proximity to Peruvian settlements and the fact of having to share the rivers and their resources.

Boat traffic: This threat affects mostly the areas of AMA_1, CAB_L, PAT_I and TAR_L, which are characterised by heavy boat traffic of all type of boats (cargo, touristic, public transport, private).

Uncontrolled Tourism: Significant differences showed the importance of this threat to TAR_L, YAH_L, CAB_L and MOC_I. These sites constitute the most important touristic sites in the area.

Human population growth: CAB_L and YAH_L are the sites affected the most by this threat. This is because of the proximity of these water bodies to expanding human settlements.

Changes in land use: Significant differences highlighted the importance of this threat at Yahuarcaca Lake (YAH_L) where the pressure from the expanding city of Leticia has started to be felt.

Institutions as a Factor

No significant differences were found when assessing the variables Conflict between river dolphins and fisheries and Use of illegal fishing gears. These were the only two variables where the 4 groups of stakeholders agreed. For the other threats, there is no common pattern of ranking, but significant differences were found in the way NGOs and Governmental representatives assessed these variables compared with Academia and the Research Institute.

Key conservation areas in the South of the Amazonian Trapezium

The four institutional categories combined assessed the Tarapoto Lakes System (TAR_L) (298.7), Caballo Cocha Lake (297.6) (CAB_L), the Yahuarcaca Wetland System (271.4) (YAH_L), Loreto-Yacu River (270.4) (LOR_T) and the buffer area of the NNP Amacayacu (270.3) (MOC_I) as key areas for the conservation of the freshwater biodiversity of the Trapezium. The conservation and protection of these five areas is considered of high priority. The area of the confluence of the Loreto Yacu/Amazon rivers (PAT_I), the Atacuari River (ATA_T) and the segment AMA_2 were classified as medium priority. The segment of the River Amazon AMA_1 is considered as vulnerable due to its fourth place in the assessment of threats and Yahuarcaca Creek is classified as low priority (Table 5.9 and Figure 5.7).

5.3.3 Conservation Initiatives and poverty reduction programmes

Stakeholders identified ten conservation initiatives that have been conducted or are currently in motion in the South of the Trapezium. Fishing agreements, aquaculture/aviculture projects, management plans for aquatic resources, protected areas, legislation enforcement workshops, poverty reduction programmes, local tourism, co-management initiatives for lakes or hydro-biological resources, and environmental education. All these initiatives were mapped (Figure 5.8) and the results highlight those areas that have been receiving more attention from local and national stakeholders.

The purpose of this was to visualize in a simple and rapid way how money and human resources have been distributed through the study area during the past decades, and to understand why some areas have more or less attention and how this might have an impact on the conservation of their biodiversity and the livelihoods of their users.

Fishing Agreements – This strategy has become the strongest initiative to overcome problems of overfishing, illegal use of fishing gears and conflicts between fisheries and wildlife. Fishing agreements have shown to be effective in Brazil, where managed lakes fishing productivity is 60% higher than in lakes with no management (McGrath *et al.* 2007). For the Tarapoto lakes system and as part of an agreement signed among the Foundation Omacha, the Fishing Authority (INCODER) and the Cabildo Mayor of the Ticoya Reserve (Puerto Nariño), a series of guidelines were formulated by members of the community and stakeholders regarding proper fishing techniques, times, gears and species. The results are published and available (Trujillo & Trujillo 2009); however these fishing agreements are struggling to be implemented due to lack of funding. The only agreement enforced in the area is the ban imposed on the pirarucu fisheries since 1987 (Article 6, Resolution 89 of the 27th of May 1987 available from http://www.fao.org/fi/oldsite/FCP/es/COL/body.htm).

A management plan for the fish resources of Caballo Cocha Lake was formulated and approved in 2010 by the office of PRODUCE (Ministry of Production) in Iquitos (Ortiz *et al.* 2010). This management plan is one of the first co-management strategies regarding fisheries implemented in the area.

Table 5.9. Total ranks for each of the 10 sub-areas. Colours represent conservation priorities: red: high, orange: medium, yellow: low.

Surrogates of conservation \ Sub-areas	AMA_1	AMA_2	ATA_R	CAB_L	LOR_T	MOC_I	PAT_I	TAR_L	YAH_C	YAH_L
Total FFT + CFT	79.64 (9)	103.07 (7)	105.01 (5)	110.98(2)	104.33 (6)	110.49 (3)	110.18 (4)	124.57 (1)	76.72 (10)	99.45 (8)
Total ESSB	65.26 (8)	64.06 (9)	68.32 (6)	83.01 (1)	79.54 (3)	72.16 (5)	67.10 (7)	81.37 (2)	63.6 (10)	76.43 (4)
Total average TH	87.90 (4)	79.58 (9)	82.83 (8)	103.6 (1)	86.51 (6)	87.67 (5)	85.29 (7)	92.75 (3)	77.2 (10)	95.55 (2)
TOTAL SCORES	**232.8 (9)**	**246.7 (8)**	**256.2 (7)**	**297.6 (2)**	**270.4 (4)**	**270.3 (5)**	**262.6 (6)**	**298.7 (1)**	**217.5 (10)**	**271.4 (3)**
Conservation priority	**3**	**2**	**2**	**1**	**1**	**1**	**2**	**1**	**3**	**1**

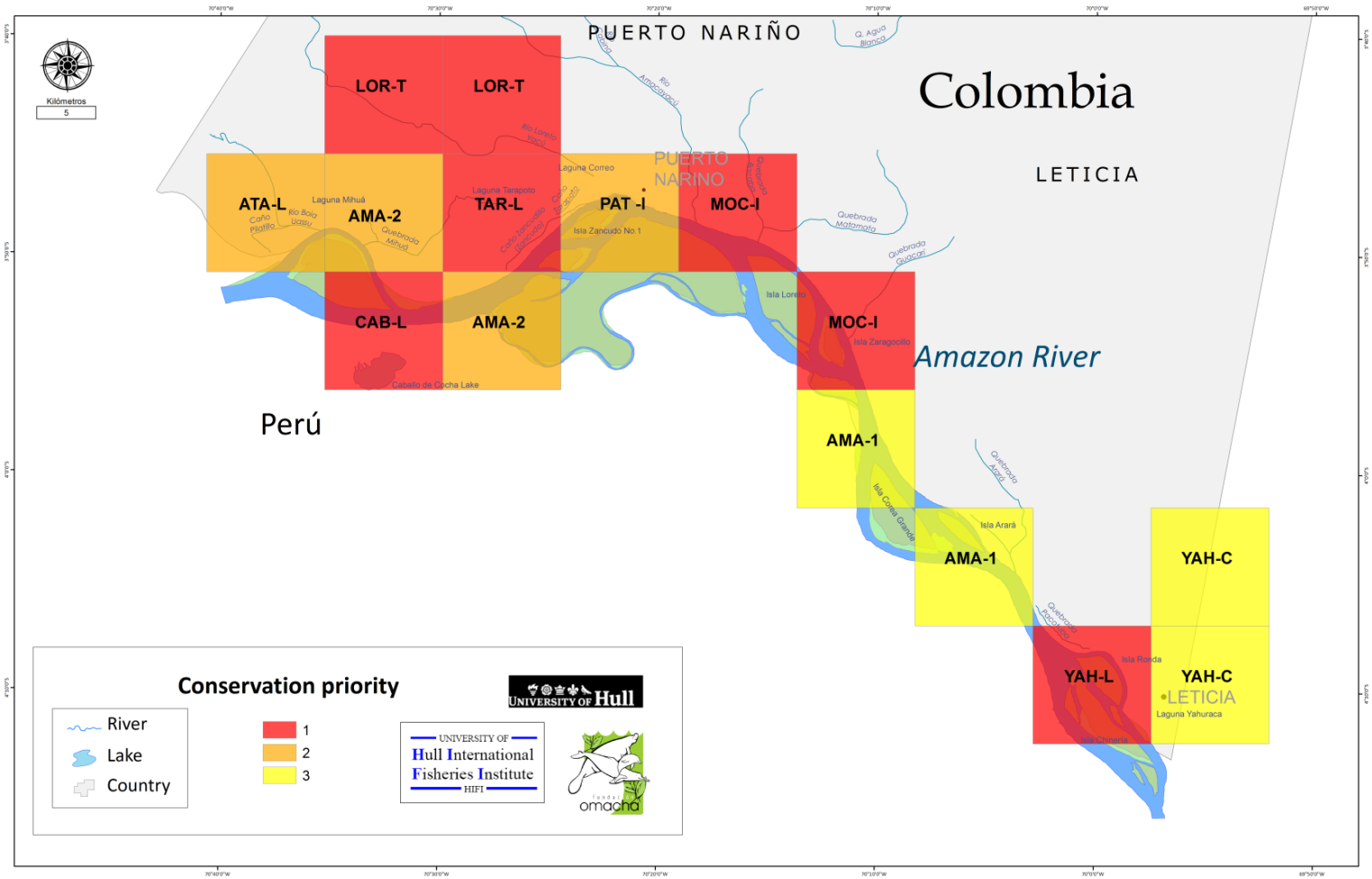

Figure 5.7. Key conservation areas in the South of the Colombian Amazonian Trapezium. In red sites of high conservation priority (highest ranks), in orange of medium conservation priority and in yellow of low conservation priority (lowest scores).

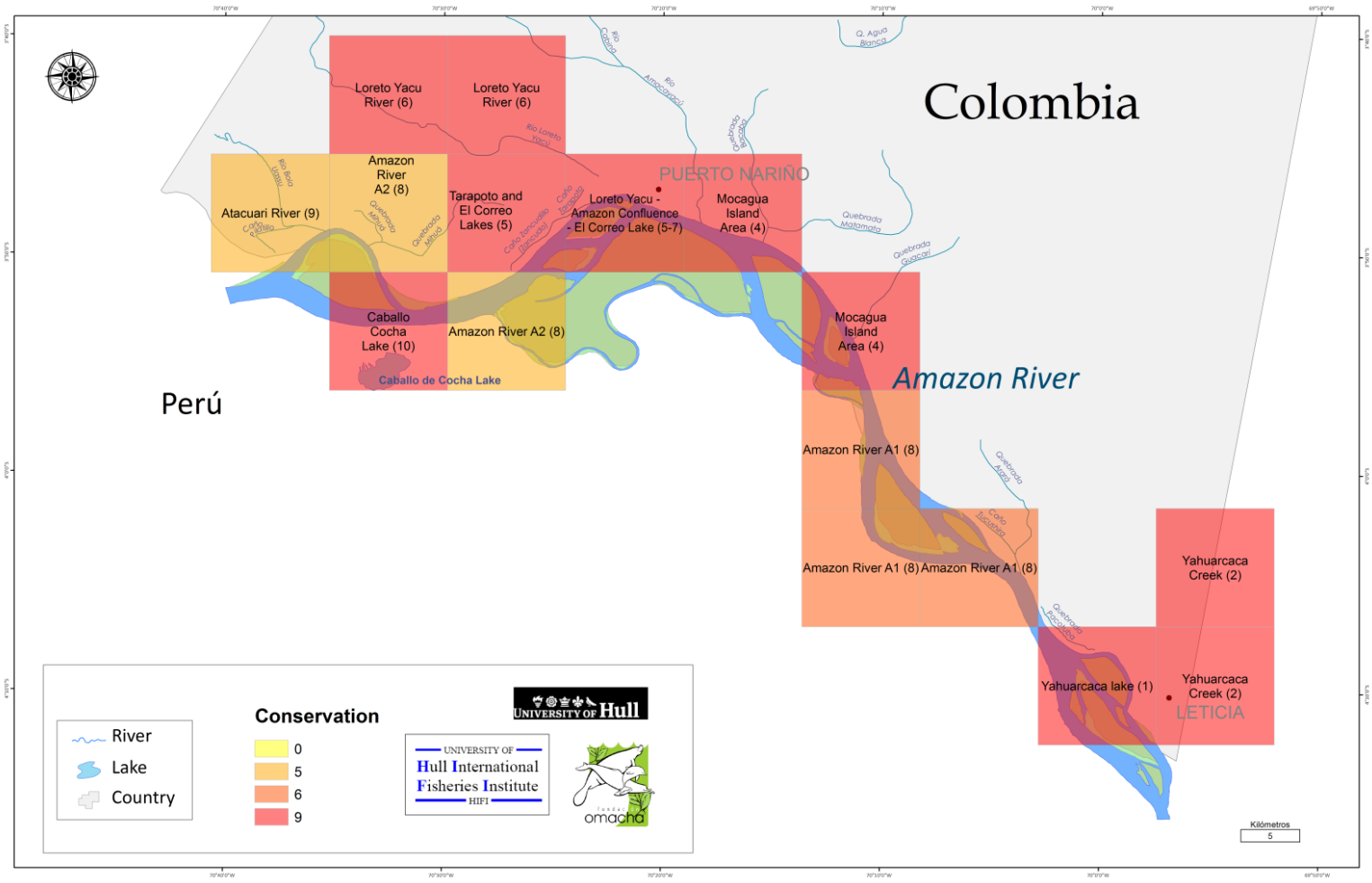

Figure 5.8. Distribution of effort dedicated to the study area according to the implementation of a variety of conservation initiatives and social programmes. The numbers 0-9 represent the number of initiatives implemented in each segment of the Trapezium (Section 5.3.3).

The National University of Colombia is currently formulating a series of fishing agreements and co-management plans for the fish resource for the Yahuarcaca Wetland system as a result of years of working with the nearby indigenous communities. These fishing agreements are being formulated by the communities according to their needs and expectations.

Aquaculture / Aviculture programmes - Several attempts have been made to give local people better alternatives to generate income to reduce the impact of their activities on the freshwater resources. Different to other parts of the country and the world where overfishing is partly overcome through aquaculture initiatives, this alternative has failed in this area (Vieco Albarracin & Oyuela Caycedo 1999). On multiple occasions, private and governmental organizations have tried to make it work regardless of the needs or cultural and social background of the communities. Currently 13 ha of infrastructure are available to perform aquaculture activities, but almost 50% are under used. This is mainly because animal husbandry has never occupied a place within the communities' life calendars (they have their own ecological and cultural calendars). As hunter and gatherers these communities are not 'programmed' to look after their food, take care of fish or chickens, feed them, and keep them clean and healthy. Another reason why these initiatives have failed is the lack of competitiveness of this activity compared with the renewable resources provided by the river. Regardless of these failed initiatives, some communities are keen to propose them as an income alternative and stakeholders have failed in saying no.

Management plans for aquatic species or habitats – Different documents have been formulated as frameworks for the conservation and proper use of aquatic fauna in the area. These plans are the National Action Plan for Colombian Manatees (Caicedo-Herrera *et al.* 2004), the Book of Endangered fauna of the Colombian Amazon: analysis and conservation proposals (Trujillo *et al.* 2008a), the National Plan for Marine and Continental Turtles of Colombia (MMA 2002), Actions for the use and conservation of the endangered aquatic fauna in the Colombian Amazon (Castellanos *et al.* 2009), the Action Plan for South American River Dolphins 2010 – 2020 (Trujillo *et al*. 2010), the National Action Plan for Aquatic Mammals (MAVDT in press) and the Management Plan for the Floodplains of the Tarapoto Lakes System and the adjacent area of the Loreto-Yacu and Amazon rivers, representing one of the first co-management initiatives implemented in the Trapezium (UNAL & Corpoamazonia 2007). Information provided by research conducted in Tarapoto Lake and surrounding areas has been key in the formulation of frameworks and guidelines for the whole Trapezium and further parts of the basin.

The Foundation Omacha, Corpoamazonia, the Sinchi Institute and Foundation Natura have conducted extensive work with local communities in the Municipality of Puerto Nariño. The project entitled: Actions for the use and conservation of the aquatic threatened fauna in the Colombian Amazon (phase I) (Castellanos *et al.* 2009), included, in addition to the formulation of co-management and fishing agreements and strategies, environmental education activities and legislation enforcement workshops.

An example of a management plan formulated from within the communities comes from the Reserves of Mocagua, Macedonia, El Vergel and the NNP Amacayacu. A decade ago the Cracidae *Crax globulosa* [Spix, 1825] was almost extirpated from Mocagua Island and the nearby forests by poachers, and the same situation was happening to pirarucu in the inner lake of Mocagua Island. A co-management scheme initiated by members of the local communities with the support of the researcher Sarah Bennet[3] (*pers. comm.*) resulted in the formulation of a management plan for the local fisheries, lakes and the two species most threatened. Local communities took control of their aquatic resources and banned the uncontrolled and illegal hunting of both species and regulated the fishing of other species (these regulations are still in force). After a few years the populations of both *Crax* and pirarucu have recovered (John J. Leon *pers. comm*[4]). This is one of the few examples of success of a co-management strategy formulated by local communities and with the support of an external stakeholder. Other successful co-management experiences come from Brazil where the use of local knowledge on Pirarucu has involved local fishermen in research and conservation activities, empowering local people and making them responsible for the proper use of the species and its habitats (Benatti *et al.* 2003).

Yahuarcaca Creek has a management and zoning plan adopted by the Municipality of Leticia in 1997, but little has been done with it (Municipality of Leticia 2007).

Most of the initiatives mentioned above have been interrupted when no money is available for their continuity and the implementation of valuable outputs. Local communities tend to rely on these organizations and work very well together but from the moment the organization is no longer actively working with them, local communities struggle and fail to work independently.

Protected Areas or areas of special management – The Tarapoto lake system has been proposed by the MAVDT to the Ramsar Convention on Wetlands as a strategic site of conservation. This request is in progress. This area as well as Caballo Cocha Lake has also been proposed within the regional initiative SARDPAN – (South American River Dolphin Protected Area Network) (Hoyt 2011) as key areas for the conservation of river dolphins in the Amazon River basin.

The areas of Yahuarcaca Lake, Mocagua Island and the NNP Amacayacu were declared Important Bird Areas (IBAS) (IAvH 2008) in 2008, but their management plans have not been formulated or published making it hard to manage or control illegal and damaging activities taking place in these sites. For the area of Yahuarcaca, the Municipality of Leticia promulgated this IBA as an Area of Special Management (IAvH 2008); however, this promulgation has not changed this wetland system in terms of preferential management or money investment.

Legislation and its enforcement workshops – A series of workshops are held each time a conservation initiative or scientific research is presented to the Indigenous Reserve leaders. In

[3] Independent researcher of the NNP Amacayacu, creator and manager of a Primate Rehabilitation and reception centre inside the Park.
[4] Indigenous leader. Macedonia Reserve.

these workshops, the initiatives and activities to be implemented are presented and mechanisms are formulated and set up with the local community. Local communities are aware of what the national legislations say about fishing regulations and poaching, knowledge that has contributed to the formulation of fishing agreements, management plans and other social and conservation initiatives. Once a year the Fisheries Authority calls a local meeting to hear the complaints and needs of fishermen, but these meetings have had little impact on the activity and their operators.

Poverty reduction programmes – The Colombian Government, through the Presidential Agency for the Social Action and International Cooperation- Accion Social, has implemented a series of programs aiming to improve the livelihoods of indigenous communities through the development of micro projects to enhance food security. These initiatives have been implemented all over the Trapezium. Between 2006 - 2007 the Resa Project (Red de Seguridad Alimentaria – Food Security Network), was implemented in collaboration with the TICOYA Association, the SINCHI Institute and the UMATA (Municipal Unit of Technical and Agricultural Assistance). This project included among its components the husbandry of poultry and pigs. The second initiative Familias Guardabosques – 'Forest Rangers Families', is an economic subsidy given to every family within the indigenous territories, half of the money is given in cash and the other half goes to a savings account. This programme aims to reduce the dependency that these families have on the forest resources (Vieco 2010). The third programme called Familias en Accion – 'Families in Action' gave monetary subsides to families with children under 18 years old. This aims to improve the nutrition and education of children of indigenous families with parents that are not employed or receiving retirement money. All indigenous families in the study area benefitted from these subsides (Accion Social 2008). These poverty reduction programmes have been heavily criticised. The inclusion of indigenous people in a capitalist society has changed the way of living of these peoples. These programmes have failed trying to overcome problems that have deeper causes related to historical events and issues related to weak education and health policies.

Local tourism initiatives – A few local initiatives have been implemented by different communities throughout the Trapezium. In the Municipal district of Puerto Nariño, the initiative *Canoeros de Tarapoto* (Canoeists of Tarapoto) formulated by the Ticoya Reserve in collaboration with the Foundation Omacha, Foundation Natutama, EDC Natura (Spain), and the Vila Real City Council (Spain), was proposed to provide a more eco-friendly experience to visitors by taking them to the Tarapoto Lakes by canoe instead of motor boat, and with the companion of a local guide. However, this initiative failed to become an important and leading touristic project in the region when clashes among members ended up in its dissolution. Local tourism initiatives are important to counteract escalating and uncontrolled tourism projects that are taking place in the Trapezium. In the urban centre of Puerto Nariño, many people are starting to think of tourism as a better income alternative than fishing. If this topic is not managed properly not only the ecosystems will be in risk but also the cultural heritage of the area.

In the area of Yahuarcaca Wetland system the people from the community La Playa are being trained in tourism practices, business management and wildlife watching. This initiative is seen as a way to improve and strength their capacity for supplying this service, lead by the National University, with the support of SENA (National Learning Service) [5]. However, most of the tourism currently taking place in these lakes is managed by bigger companies located in the City of Leticia and attract most of the visitors before their arrival to the Trapezium.

In the area of Loreto Yacu, ethno-tourism was seen as a perfect income alternative for the community of San Juan del Soco. Within the Life Plan of the Ticoya Reserve, this type of tourism was identified as profitable, and for this reason local people received training from SENA and the infrastructure was established to receive tourists. However, this initiative failed when in 2008-2009 only one tourist arrived in the community (Vieco 2010). Lack of joint activities and communication among institutions, organizations and enterprises forces people to work on their own instead of working together for their mutual benefit. Initiatives generated from the Life Plans of these indigenous reserves theoretically must match the initiatives and projects proposed in the Municipal, Departmental and National Development Plans, but this does not happen.

Finally, the area of Mocagua Island, due to its proximity to the NNP Amacayacu, benefits from visitors arriving in the protected area. This has been used by the communities which now are considered one of the most important in handicraft manufacture and trade. Agreements between the tourist operators in the park and the community of Macedonia have contributed to improve the livelihoods of this community and positioned their art work as one of the most recognized and attractive in the region and the country.

Environmental education – Education programmes and campaigns have been formulated and implemented in the Trapezium area for the last 2 decades. The Foundation Natutama works with local indigenous educators/guides responsible for carrying out educational activities with children and communities in the different schools of the Municipality of Puerto Nariño. The Foundation Omacha carries out regular visits to the local communities where educational material is delivered. Most of this material has been produced and published by different organizations with the participation of the local communities. Environmental education has been identified as the major tool for the success of any conservation programme formulated and/or implemented in the area and it should be seen as a transversal tool used in all social or conservation programmes. The participation of children, fishermen, elders and women in every stage of any initiative has been mandatory.

5.4. Discussion

5.4.1. Key conservation areas for the conservation of the local freshwater biodiversity.

Tarapoto Lakes System (TAR_L)

[5] Project: Training the communities of La Playa, Castañal and San Sebastian in the co-management of fishing resources of The Lakes in the Colombian Amazon'. UNAL- USAID

According to the outputs of the multi-criteria assessment, this lakes system constitutes the most important site for the conservation of the local freshwater biodiversity as well as for the maintenance of important ecosystem services. Ranked first in the assessment of FFT and CFT and second in the ESSBs, confirms the results obtained in previous chapters where Tarapoto Lake is recognized for its ecological and social attributes (Figures 3.2, 3.3, 4.1). However, those ecological, social and cultural features are at risk. Ranked third in the threats valuation not too far from the other lake systems [Caballo Cocha (1) and Yahuarcaca Lake (2)], highlights the vulnerability of these systems in the study area.

The multi-criteria assessment and the statistical tests (Table 5.4 and 5.5) highlighted the importance of key elements that have been supporting the local and regional economy, and the livelihoods and cultural beliefs to these Amazonian people. River dolphins have been recognized, together with other top predators (caiman and pirarucu), as one of the most important species in the lakes not only for their ecological features (Chapter 3), but for their importance within the indigenous cosmogony and in the emerging dolphin watching industry (Chapter 4).

This lakes system is a closed area that brings protection and isolation to an important number of species. The maintenance of its habitats, especially the flooded forest during the high water season and the floating meadows during the transitional periods, gives the system and its biodiversity extra protection. For this reason birds, fish, turtles, manatees and dolphins use it as refuge, feeding and nursery areas. These attributes are also used by the surrounding indigenous communities which depend almost exclusively on this system, the quality of its waters and the health of its habitats.

These results confirm what others have stated regarding the importance of Tarapoto Lake for dolphins and fish for subsistence fisheries (Ruiz *et al*. 2007, UNAL & Corpoamazonia, 2007, Trujillo *et al.* 2010).

So far the fine and coarse filter targets selected and assessed in this research are well studied and acknowledged by all stakeholders, however, regarding ecosystem services this site has been poorly studied. The area is recognized by its importance to local fisheries, scientific and social research, dolphin watching and landscape viewing, services that are well known by stakeholders, but services with wider regional impact and key in current global conservation strategies like the role of lakes in climate balance and carbon sequestration are unknown.

Nowadays it is important to consider that local biodiversity conservation initiatives must change and adapt according to global tendencies. The valuation (economic) of ecosystem services has become a conservation strategy that puts together strategies with an ecological and social perspective, and economic criteria used by national and local governments in land planning and development, and poverty reduction schemes.

Poor knowledge of all elements of the system might contribute to those direct and indirect drivers putting pressure on this area. So far the attention given to this important lake system,

represented in money invested and conservation projects implemented, has hidden the need to research and explore key services and ecological processes. To ensure support conservation initiatives at this site and its surrounding areas requires the system to be fully understood. This new knowledge will open new doors that might bring improved conservation strategies, more money and better opportunities to local inhabitants. The site being proposed as a Ramsar site confirms this argument. If this site is proclaimed as a wetland of international importance more attention will be given and there will be more opportunities to protect the site.

Caballo Cocha Lake (CAB_L)

The evaluation of this lake was similar to the Tarapoto Lakes system. Those attributes recognized as important and key to this systems do not differ much from the ones recognized for Tarapoto (Table 5.4). Many similarities can be found between the two lake systems, the type of their waters, their species, habitats and annual dynamics. As in Tarapoto, Caballo Cocha supports an important human population and constitutes the main food provider to a population of some 10,650 people (Ríos-Zumaeta *et al.* 2002), however, the pressure on the system and its components is higher and this is reflected in the evaluation of threats where this lake ranked first, and is considered the most threatened water body in the South of the Trapezium.

The importance of Caballo Cocha as a supplier of fish, clean water and a key habitat for river dolphins and birds, gives it not only environmental importance but social, cultural and economic significance. However, the increasing population on the Peruvian bank and the uncontrolled use and inadequate management given to their aquatic resources seem to be rapidly affecting the livelihoods of those who depend exclusively on the lake (fishers, tourist operators, researchers).

All the major threats to the lake cannot only be tackled through local conservation initiatives, which so far had no real impact on people's behaviour towards the freshwater resources. The formulation and publication of the first management plan for the fisheries of the lake (Ortiz *et al.* 2010) is expected to have a wider impact and to tackle the problems arising from overfishing and the illegal use of fishing gears including the direct killing of river dolphins; however, the success of this plan relies on the availability of funds to continue the implementation of the strategies proposed and the political will of those enforcing the law and acting as environmental and fishing authorities.

The area suffers from its distance to the regional capital Iquitos making it difficult to implement and enforce conservation measures. This isolation can sometimes be more harmful than any direct pressure put on the system, and harder to tackle. Political and institutional distancing is also felt when no common policies regarding the use of the freshwater and terrestrial resources exist between Colombian and Peru. This needs to be addressed urgently, due to the rate in which these resources are disappearing in Caballo Cocha and the southern bank of the Amazon River.

Colombian conservation initiatives need to include the freshwater ecosystems of Peru. As a connected system and considering the migratory characteristics of aquatic conservation targets,

any harm to this lake will affect the freshwater biodiversity and habitats present on the Colombian side. This is the reason why this site was included as a conservation target for protecting Colombian freshwater biodiversity.

Yahuarcaca Wetland System (YAH_L)

As with the other lake systems, Yahuarcaca constitutes an important source of food and clean water to not only the nearby indigenous communities but to a growing city of 24,500 people. This lake has been recognized as important for the conservation of the local freshwater biodiversity and to act as nursery, feeding area and refuge to fish including the threatened pirarucu, dolphins and birds, as well as to support key Amazonian ecosystems (flooded forests and floating meadows), and key social and key economic activities like fisheries and tourism. However, these same activities are those threatening this key site where overfishing, the illegal use of fishing gears and uncontrolled tourism are among the main pressures.

The proximity of this wetland system to the urban centre (Leticia) has made it highly vulnerable to the effects of population growth, water pollution and current changes in land use. The area was ranked second in the threats assessment (Table 5.8), positioning it as highly vulnerable and a priority for conservation. However, the main threats affecting the area come from different levels of impact from activities developed by indigenous communities, *colonos'* settlements and the urban centre. In contrast to Tarapoto Lake, the use and management of Yahuarcaca is not the responsibility of any indigenous reserve and a series of stakeholders share its resources and management. This contributes to weak enforcement of policies and regulations.

Attention needs to be paid to the growing population and the impacts that this is bringing to the three lakes systems. These systems have proved to be vital to maintain important elements of the Amazonian biodiversity and to regulate processes that result in the provision of key ecosystem services that have a local and regional impact. The role of these black water lake systems in the regulation of climate and as carbon sequestrators is something that is still unknown and needs to be investigated and promulgated. Lakes are the main sources of food for local communities and tourist attractions, thus actions focussing on a better understanding and protection of their biological and social elements are necessary. However, as mentioned previously, the success of these initiatives depends on how well are these implemented, the participation of all stakeholders including indigenous communities (so far all communities are included in all conservation strategies) and policy makers and environmental authorities (something that is problematic).

Loreto Yacu River (LOR_T)

In comparison with the lake systems little information is available from this tributary. For this reason the assessment of the variables presented in this research has provided key information to characterize this important site that ranked fourth in the overall multi-criteria assessment.

The FFT and CFT prioritized by stakeholders seem to be the same for most of the sites, including the Loreto Yacu River, reinforcing the migratory features of the freshwater wildlife. So far this migratory pattern of the species has been protected in rivers and well conserved flooded forests in lakes and tributaries. However, this site differs from the rest by maintaining the few remaining populations of otters in the study area and to serve as a corridor for a small and recovering population of manatee. Considering the past and current pressures to otters and manatee, the good conservation state of this tributary has contributed to the protection of threatened and charismatic regional species.

The communities along this river depend exclusively on the river to perform all their daily activities and so far the area is not considered highly threatened. It occupied sixth place in the threat assessment. However, the source of this river is in Peruvian territory, so any harming activities, especially logging (highly uncontrolled, unregulated and escalating), taking place in that area will have an impact on the biodiversity and livelihoods of the people using this tributary.

As part of the growing tourism industry in the area, the communities along Loreto Yacu are getting more and more interested in incursion into this business. Uncontrolled tourism has been recognized as an important threat at this site, and for this reason there is an urgent need to address emerging local tourism initiatives in a way that can match sustainability criteria and achieve social equity.

NNP Amacayacu (Buffer Zone), Amazon River between the Amacayacu and the Mata Mata River, Mocagua Island (MOC_I)

This site stood out because of the importance of its beaches as key habitats for caimans, highly threatened turtles and bird species. Beaches, only available during the low water period, are highly threatened in the Trapezium because of land use changes, a growing population, pollution and uncontrolled tourism. For this reason the conservation of this important habitat in this segment constitutes a conservation priority. Mocagua Island, part of this site, provides, apart from beaches, a series of habitats key for the subsistence of nearby communities. The island's inner lake is also a source of fish and a biodiversity refugee.

An important population of pirarucu relies on this lake and the management given by the nearby communities. So far the lake and its resources have been successfully protected by the Mocagua, Macedonia and El Vergel communities, which through fishing agreements and co-management strategies have saved these resources from extinction (e.g. pirarucu and *Crax globulosa* or piuri). This previous success in wildlife conservation must be used to address new management plans. These indigenous communities have proven to work together towards the same interest and succeeded.

It is important to highlight that the presence of the NNP Amacayacu and the multiple social work conducted by its members, bring sometimes conflicts and discomfort, however, social work with surrounding communities is mandatory and permanent. This is an advantage at this site and its

inhabitants. The proximity of the communities to the Park's Visitors Centre has also benefited these communities through the selling of their handicrafts, which are appreciated by locals and nationals and constitute an important income stream for these people.

Despite these positive experiences, the problems in the area are the same as other sites. Attention must be given to empower locals to control access to their resources, enforce policies and management strategies, and to improve their manufacturing and trading techniques and opportunities.

The Loreto Yacu/Amazon confluence - Patrullero and Vamos islands (PAT_I), Atacuari River (ATA_T), Amazon River - Naranjales segment (AMA_2), Amazon River – San José – segment (AMA_1) and Yahuarcaca Creek (YAH_C)

Results from the assessments placed these sites in the bottom five. Although these areas did not have the highest scores, each one presents particular features that need to be highlighted and acknowledged for present and future freshwater conservation initiatives and to complement the initiatives conducted at the other five sites (Tables 5.4, 5.5, 5.7, 5.8).

The area of the Patrullero and Vamos Islands (PAT_I) is recognized as an important site for manatees that migrate from the Tarapoto System during the low water period. The pools or *remansos* created around these islands provide a shelter for this endangered species, as well as dolphins and fish. Another important element is the beaches created during the dry season that provide an important habitat for reptiles and birds that use them to nest. These beaches are the last ones used to reproduce by the few charapas in the area. The proximity of these islands to Mocagua Island creates an important area and refugee for all these species, therefore protection and conservation actions must be undertaken together.

The Atacuari River (ATA_T) is an important area for river dolphins, fish, birds and manatees. The confluence with the Amazon is a vital fishing area for the nearby communities of Colombia and Peru, as well as being an important dolphin watching location. Atacuari is locally recognized by its handcrafts; the manufactured pieces are different from those of the Mocagua area and constitute an important part of the Cocama culture and economy. However, due to the distance of these communities from the urban centres their trade and promotion is complicated and there is little tourism that manages to get to this western part of the Trapezium.

The segments of the river Amazon AMA_1 and AMA_2 rank low, possibly because little research has been done at these sites. The valuation of each set of variables showed that the best studied sites got the highest scores; the same happened to the best known variables. There is a big gap in scientific information within these areas. In the South of the Trapezium most of the research has been done in lakes, followed by tributaries and only a little on the main stem of the river. Results from the multi-criteria matrix can be biased by scale of research effort. Despite gaps in knowledge, the segment AMA_1 was ranked fourth in the evaluation of threats indicating the vulnerability of the area. Evaluated independently, the presence of river dolphins and big catfish as well as commercial fisheries was considered vital ecosystem services. These

important assets are at the same time responsible for the vulnerability of the area. Overfishing and illegal use of fishing gears are highly related to the conflict between fisheries and dolphins, and any border problem that might exist between Colombian and Peruvian fishers. So it is clear that even when the multi-criteria matrix assessment did not consider this area within the top five, this segment of river constitutes a vital area for local and regional economies.

The importance of rivers as targets of conservation has been undermined because of their role for transportation and communication pathways and as massive buffers for human impacts. Also rivers are not as well studied and protected as lakes and small tributaries in the area. The Amazon River in that area is more than a navigation route or border between two countries. As an interconnected system it is not enough to deal with problems and to give solutions to one side of the river; any environmental, social, economic and political situation taking place in Peru and harming the river must be taken into account.

Finally the areas AMA_2 and Yahuarcaca Creek were not recognized to have outstanding features that identified them as key conservation areas. However, as a connected system their protection and proper management, and the use of their aquatic resources are vital for the protection and stability of the rest of the selected areas. The AMA_2 segment exhibits the same threats as most other areas and it is considered important for the presence of beaches, dolphins, fish and river turtles. The northern bank of this segment is also considered a very rich and important site for agricultural activities due to the deposits of silt brought by the river with every flooding season. For many years the communities on this bank have grown rice, corn and cassava and have acquired a series of machines to process these products. In the year 2000 the Association of Women of Naranjales was created and started a small business with a corn grinder. Later, the community acquired a rice peeler and a plantain flour processor. Currently the machines are not in use and the people stopped growing plantain and corn (Vieco 2010). This area might not have ranked as high as the former ones, but the capacity shown by communities to work together is a positive point that must be used for future initiatives implemented in the area. Learning from previous situations and addressing new strategies better is vital to the conservation of not only this segment of the River Amazon but to nearby freshwater ecosystems (Atacuari River, Caballo Cocha Lake, Loreto Yacu River, Tarapoto Lakes). The role of this segment as a freshwater corridor is vital and its inclusion in a wider conservation strategy must be mandatory.

Yahuarcaca Creek is acknowledged for its role in the provision of ornamental fish, an economically important activity in the area, the region and the country. The creek is threatened by water pollution resulting from the discharge of solid wastes from the municipal dump located 300 m from its mouth. The creek also supplies water to the Yahuarcaca Wetland System. According to the stakeholder ranks, the creek does not support any particular feature that makes it stand out from the rest, but any change to the creek's stability and health will impact on the Yahuarcaca Lakes that have been already ranked as the second most threatened site in the South of the Trapezium.

These latter five sites have received less attention and interest from the local and national stakeholders; attention and efforts have focused on lake systems. Conservation initiatives have struggled to succeed and social projects have not constituted a reliable income alternative to the communities. As with the rest of the cases, all this is the result of a lack of policy enforcement and weak governmental presence, as well as weak programme continuity.

The sustainability of the study area will depend ultimately on proper policy enforcement, efficient governmental presence, positive changes in social and environmental policies, and a shift of priorities in the central government where economic development stops being the number one interest of the nation, and its biological and social diversity conservation constitutes the foundation to build up a more equitable, fair, productive and sustainable country.

5.4.2 Multi-criteria assessment

The selection of a multi-criteria approach and a matrix for the assessment of the study area, and the selection of key conservation areas has proven to be an effective tool in participatory decision making in dynamic and multi-disciplinary spaces such as freshwater planning. However, the usefulness of this approach depends on the ability of respondents providing accurate answers. In this research the relevance and strength of Multi-Criteria Analysis depended ultimately on the knowledge and experience of the people assessing the variables and on the analysis of the results.

Multi-Criteria Analysis helps the decision making process through a better knowledge and understanding of the problem, the variables to evaluate and the stakeholders directly involved. This approach has the ability to separate the decision elements and track down the decision making process. This is useful in areas like the South of the Amazonian Trapezium where a multidimensional problem is addressed, saving time and making it easier to communicate the basis of all decisions. The use of this methodology also helped to reach a general consensus in a multidisciplinary team, regardless of whether they agreed on the relative importance of the criteria or the ranking given to the variables.

Ideally the more stakeholders included in the assessment the better and more reliable the results. However, gathering together all stakeholders can be difficult and in some cases some might not be keen to give their opinion to avoid compromising themselves or their organizations. For this particular research, the most important environmental governmental organizations in the area, the Environmental Authority Corpoamazonia and the Administrative Department for the Environment, Biodiversity, Sustainable Agriculture and Business Development (DABADE), were not included despite several attempts to contact them. As environmental authorities and decision makers their points of view play an important role for aquatic ecosystem planning and management.

The flexibility presented by this methodology and its capacity to be adapted to different areas, evaluators and objectives, makes possible the use of a multi-criteria matrix approach in different areas of the Colombian Amazon and to replicate this technique in areas where the identification

of key conservation areas and freshwater resources' management schemes have not been formulated.

- Variables with the lowest ranks

From the 51 variables assessed, there were a few that received the lowest ranks. The main reason is related to a lack of knowledge and information available or to the low impact or importance of the variable.

Regarding the Fine Filter Targets, the species with pharmaceutical uses (FFTphar) and those acting as disease controllers (FFTD_con), where ranked lowly within each of the 10 sites (Table 5.4), mainly because there is little information available or collected regarding these species. The little information available comes mostly from the forest and terrestrial ecosystems, and the information collected from freshwater ecosystems is limited. The role of freshwater ecosystems in the provision and/or maintenance of these species needs to be explored to improve their use and conservation, as well as to contribute to the search for cures for several diseases.

Regarding the Coarse Filter Targets, the river pools or *remansos*, and the main river, were the two habitats with the lowest ranks (Table 5.5). River pools play an important role as shelter areas for fish, dolphins and manatees during the low water season, but little is known about their dynamics and composition. These habitats are not seen as important in the study area and this lack of knowledge will risk the conservation of multiple species. The *remansos* act as complementary habitats to most of the species moving from the lakes to the main river. As with every freshwater habitat in the area, the presence of one ensures the maintenance of certain species when other habitats disappear due to changes in the hydrological patterns. There is no point in protecting lakes, flooding forests, and other habitats when no attention is paid to other less visible but vital habitats that ensure the survival of the local biodiversity.

The role of the Main River as a target for conservation has not been clearly understood by either the local people or stakeholders. For multiple reasons the conservation of a large river like the Amazon is not an easy task. For decades conservation of lakes and small tributaries has been the focus but large rivers are communication and transportation arteries as well as national borders. However, this study shows that those sites located on the main river (AMA_1, AMA_2, MOC_I and PAT_I) present important features regarding their freshwater composition. Apart from MOC_I, the rest of these areas have not been the target of many conservation initiatives (Figure 5.8). The river needs to be seen as a surrogate of conservation, the habitats that it creates, the ecosystem services that it provides and the silent threats that affect it must be considered. However, sustainability of the entire river depends on the eight countries along its length. The Amazon Cooperation Treaty Organization (ACTO) constitutes that multijurisdictional commission in charge of promoting the harmonious development of the Amazon River basin and to ensure the conduction of joint actions among countries to ensure the conservation of the environment and the rational use of the natural resources. ACTO presence in the area is weak and not acknowledged by the local people. For this reason it is

crucial to try to make the role of ACTO more visible and to make sure it is included in all small and medium local initiatives to achieve little by little wider results.

Regarding ecosystem services, the ad hoc practise of sport and game fishing in the area ranked this variable in the bottom of the ecosystem services group.

Finally, the lowest ranked threats were dams and mining mainly because; neither of these threats is directly affecting the area. Gold mines and dams are a major problem in the Brazilian Amazon but despite the distance between the study area and the source of these problems, their impacts on the local freshwater ecosystems can be recognized. External pressures need to have a contingency plan. However, the economic benefits obtained from these activities might hinder any mitigation plan or conservation strategy.

- Stakeholder assessment

Representatives of the NGOs ranked categories higher than the representatives of the Government in all four groups of variables. This suggests government representatives who are in charge of making decisions and enforcing laws and regulations do not seem to have a full knowledge and understanding of the freshwater biodiversity in the area. The wide knowledge NGO representatives, academia and researchers have about the freshwater ecosystems and their biodiversity apparently enables them rank the variables with higher values. In decision making processes, lower ranking will position these variables at the bottom of priority elements to protect. However, for the last couple of decades the NGOs, academia and institute researchers have decided what to study and conserve not local or central government, but these conservation and research initiatives have been truncated by a lack of central and especially local government cooperation translated into laws and regulations formulated completely out of context, and weak presence of the state institutions in the area. Although it is important to mention that things are changing, and more support, translated in terms funds and acceptability of projects and initiatives, is being made available, there is still a need for further support from national and local environmental and fishing authorities. It is also necessary to strengthen stakeholder networking and to spread the information among everyone working in the area. The lack of knowledge that the government representatives have on the environment is related to the weak effort from other stakeholders to make their information visible.

5.4 Conclusions

- The Tarapoto Lakes System, Caballo Cocha Lake, the Yahuarcaca Wetland System, Loreto-Yacu River and the area of the Mocagua Island are key areas for the conservation of freshwater biodiversity in the South of the Colombian Amazonian Trapezium.
- The Tarapoto Lakes System is the area with the highest value regarding the presence of key freshwater species and habitats. The system acts as a refuge to important surrogates of conservation.
- Caballo Cocha Lake ranked first in the provision of ecosystem services and societal benefits, being a vital support system to the Peruvian village and nearby Amazonian

communities. It also ranked first in the assessment of threats, positioning it as a vulnerable and threatened freshwater system.

- The area (AMA_2) amidst Caballo Cocha Lake, the Atacuari confluence and Loreto Yacu River, Patrullero Island area constitutes an important corridor for freshwater species, such as fish, river dolphins and manatees.
- Key areas for freshwater conservation were selected on the basis of their capacity to: a). preserve viable examples of the biodiversity within the ecological, social, economic and cultural dynamics (representatively - Fine and Coarse Filter Targets); b). protect areas with special biological significance, key to the maintenance of important ecological processes within the limits of knowledge and available information (ecological condition - ecosystem services and benefits); c). permit the existence of biodiversity in the long term under conservation measures (efficiency); and d) provide continuity among rivers and other aquatic habitats considering their longitudinal connection (connectivity).
- Interpretation of the statistical results, as well as with the multi-criteria matrix, must be accompanied by prior knowledge on the area, and preferably on the variables assessed.
- The use of Multi-Criteria Analysis suggests it is a useful technique to identify key conservation areas and to also enable stakeholders to disaggregate elements of the freshwater ecosystems to identify their importance within the freshwater ecosystem.
- The variables with the highest rankings are those better studied and understood (river dolphins, manatees, fish, pirarucu, birds, flooded forests, floating vegetation, fisheries: local and commercial, transport and navigation, dolphin watching, landscape viewing, overfishing, illegal use of fishing gears, logging). Those with the lowest values either are poorly studied (e.g. species with pharmaceutical uses, species acting as disease controllers, river pools, climate balance) or their impact on the area is perceived as low (sport and game fishing, dams, mining).
- The methodology used in this research could be replicable, adapted and implemented in other areas of the Amazon River basin as an alternative freshwater conservation approach.
- Even when an important part of the information used to assess the variables comes from casual conversations with local people, research conducted in the area and from the literature, it is important to adapt this methodology (ranking process and matrix) so it can be applied to local communities and the results can be contrasted with research by decision makers.
- The South of the Colombian Amazonian Trapezium is a very dynamic and complex area in which any conservation decision must be taken according to this dynamism and complexity.
- Fishing agreements, co-management plans, legislation enforcement workshops are the main alternative initiatives proposed to local communities to improve their livelihoods. However, these processes are slow and need time and money to keep them going until the communities themselves can adopt them and the projects become self-sustainable.

- Conservation initiatives need to be formulated and implemented for each site taking into account the characteristics that define each, as well as the role and connectivity existing between them.

CHAPTER 6

MANAGEMENT PLAN FOR THE CONSERVATION OF THE AQUATIC BIODIVERSITY AND ECOLOGICAL PROCESSES OF THE SOUTH OF THE COLOMBIAN AMAZON TRAPEZIUM

6.1. Introduction and background

The Amazon River Basin in Colombia is one of the most important eco-regions of the country due to the richness of its waters and the role that it plays in the provision of vital ecosystem services to local communities and the entire Amazon region. Rapid changes in local community patterns, conflicts with the territory ownership and lack of law enforcement by the local authorities are now of concern for those trying to conserve the biodiversity and cultural identity of the region.

In Colombia over the past decade efforts to conserve the national biodiversity have focused on formulation and implementation of action plans for single species endorsed by the Ministry of Environment Housing and Territorial Development (MAVDT)[1], Regional Autonomous Corporations (CARs), and National and International NGOs (WWF, WCS, CI, TNC). Efforts have focussed on marine and terrestrial ecosystem conservation and only a fraction on freshwater ecosystems. For instance, it was not until 2010 that the National Policy for the Integral Management of the Water Resources was launched. Regarding the identification of wetlands of international importance, only five have been recognized by Ramsar in Colombia and none are located in the Amazon River basin. Only one of the seven National Natural Parks in the Region (NNP La Paya in the Putumayo Region) has been created for the purpose of conserving freshwater ecosystems.

There have been some actions to conserve individual elements of the aquatic biodiversity, especially in the South of the Colombian Trapezium which, because of its strategic geographic position, diversity of its freshwater ecosystems and species, bond of its peoples to the freshwater resources and diversity of stakeholders, is an important focus of research and implementation of conservation initiatives. Currently a few management plans for aquatic species (especially for aquatic mammals) have been formulated, as well as fishing agreements and environmental education initiatives in specific locations proclaiming a set of rules for the controlled and rational use of the freshwater biodiversity. However, historically, there has been a lack of success in conservation strategies and weak enforcement of the legislation makes implementation of more effective and new conservation measures a priority.

[1] In September 2011 the MAVDT was transformed into the Ministry of Environment and Sustainable Development. However within this document the MAVDT will be considered the National environmental authority

Freshwater biodiversity conservation needs to be understood as an inclusive strategy, where environmental, economic, social and cultural aspects are integrated and where a variety of single initiatives need to fit into a puzzle that only when completed makes sense (Cowx & Portocarrero Aya 2011). Throughout this research a series of conservation strategies [Surrogates of conservation (Chapter 3), Ecosystem Services and threats assessment (Chapter 4), identification of key conservation areas (Chapter 5)] were explored as individual strategies for the characterization and conservation of the freshwater biodiversity of the South of the Colombian Trapezium. These strategies considered together constitute the foundation of an inclusive ecosystem management and conservation strategy for the area presented here as a Management Plan (Chapter 6).

The Management Plan for the Conservation of the aquatic biodiversity and ecological processes of the South of the Colombian Amazon Trapezium intends to explain the current situation that the local freshwater biodiversity and its users are facing, the social, economic, political and environmental issues and constraints that are exacerbating this situation, and the stakeholders interaction and how this plays an important role in any conservation strategy success. Towards the end of this Chapter a series of management actions are proposed, that if are successfully conducted, will enable the South of the Colombian Amazon Trapezium to become a national example of how economic development can happen without compromising the integrity of the local freshwater biodiversity or of the local communities.

6.2. Management framework

Organisation of the freshwater biodiversity and resources sector in Colombia is a hierarchical and multiple-disciplinary structure. At the National level, the regulation and conservation of freshwater resources falls under the management of two Ministries: the Ministry of Environment, Housing and Territorial Development (MAVDT) in charge of the conservation and sustainable use of all freshwater elements of the biodiversity and the Ministry of Agriculture and Rural Development (MARD) in charge of inland fisheries (Figure 6.1a and b).

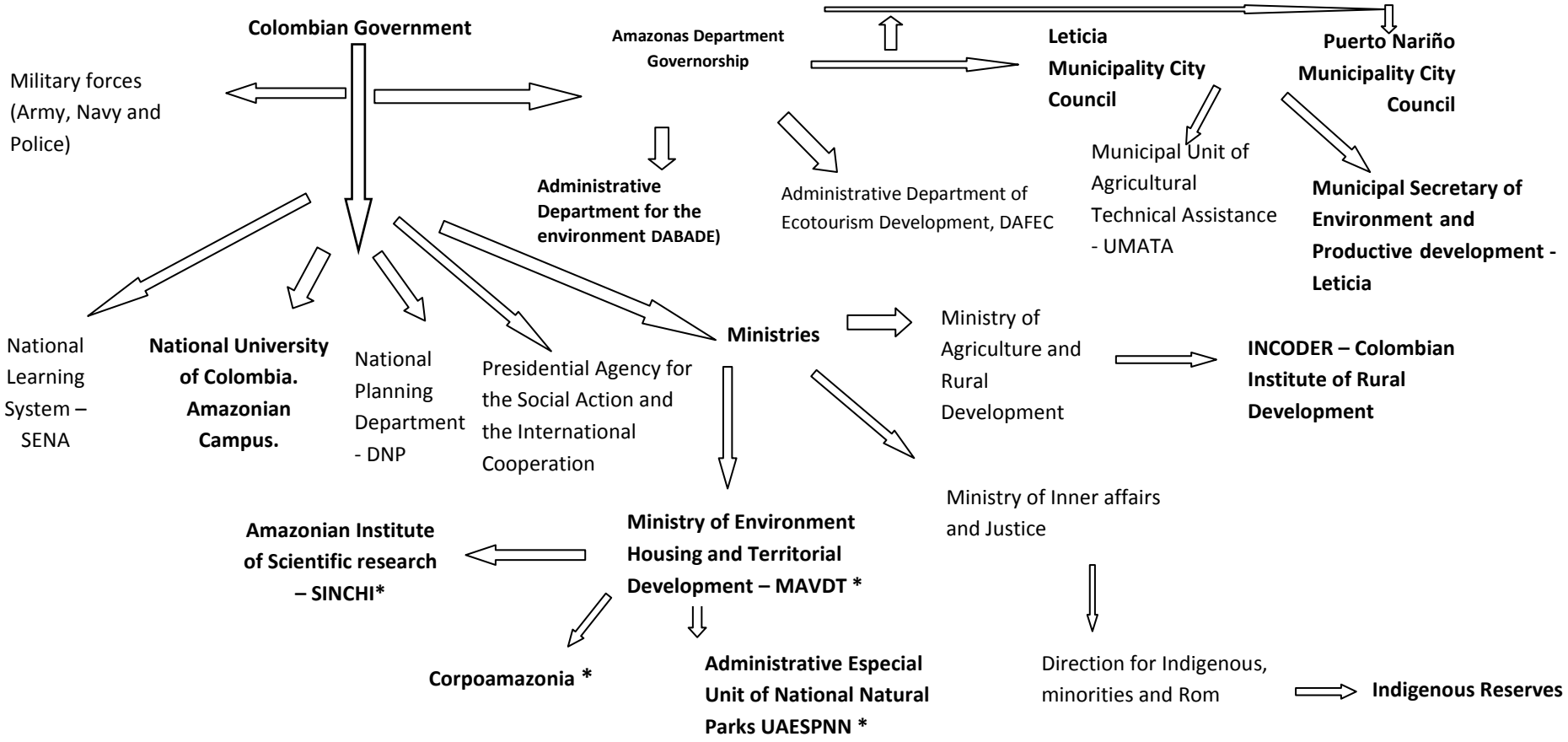

Figure 6.1a. Freshwater biodiversity management organisational framework. **Public Sector**. Organizations with an asterisk **(*)** are part of the National Environmental System – SINA. **In bold** Organizations directly involved in Freshwater biodiversity research and conservation. Interactions among stakeholders are not expressed in the figure but take place.

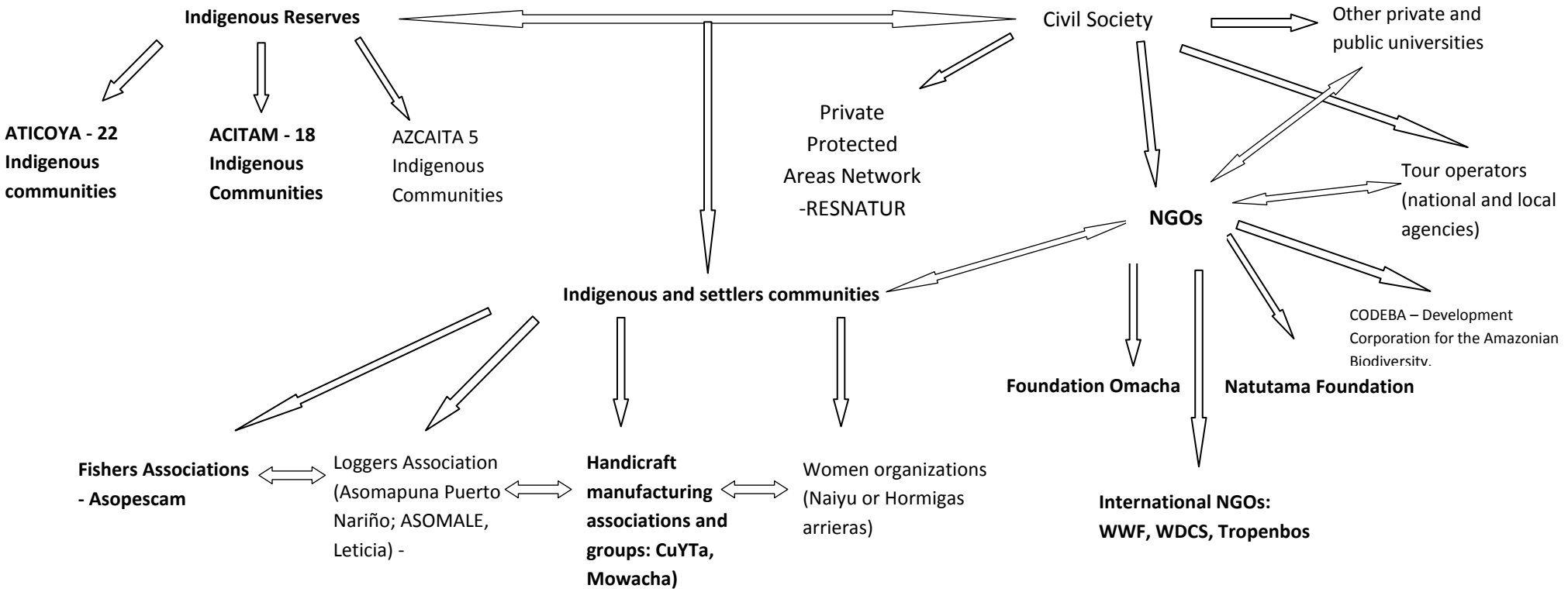

Figure 6.1b. Freshwater biodiversity management organisational framework. **Private and Social Sector**. **In bold** Organizations directly involved in Freshwater biodiversity research and conservation. Interactions among the private and public sector are not expressed in the figure but take place.

The Autonomous Regional Corporation, Corpoamazonia, is the regional environmental authority. It has full autonomy in all decision making processes and financial management. Together with the MAVDT, the Especial Administrative Unit of National Natural Parks (UAESPNN), the Sinchi Institute and the Institute of Hydrology, Meteorology and Environmental Studies (IDEAM), forms the National Environmental System (SINA) created by Law 99 in 1993. Corpoamazonia is in charge of implementing the national policies, plans and programmes defined by law or parts of the National Development and Investment Plans.

Fisheries are under the control of the Fisheries and Aquaculture Infirmary, A branch of the Colombian Institute for Rural Development (INCODER) which is part of the Ministry of Agriculture and Rural Development (MARD). The control of fisheries and everything related to the activity in the area relies on only one member of the staff, making this branch ineffective and not trusted. .

At a Departmental level, the Administrative Department for the Environment, Biodiversity, Sustainable Agriculture and Business Development (DABADE) is in charge of conservation and sustainable use of any of the freshwater and terrestrial resources of the Department of Amazonas. At a Municipal Level, the Municipal Unit of Agricultural Technical Assistance (UMATA) and the Environmental and Productive Development Office of Leticia contribute to the task of protecting the environmental resources of the South of the Colombian Amazon. The only National Protected Area in this locality, the Amacayacu National Natural Park, is under the management of the Especial Administrative Unit of National Natural Parks (UAESPNN).

Supporting the role of these environmental institutions, and acting as links between the local communities and these institutional organizations, local and national NGOs and the Academia have carried out scientific and social research and implemented conservation initiatives for at least 25 – 30 years. In a local level, indigenous reserves are governed by a *Cabildo*, comprising indigenous leaders (*curacas*) from each of the indigenous communities that are part of each reserve. Freshwater resources at the local level are controlled and used by local communities, which together with NGOs and researchers have developed management and action plans for fisheries and endangered species such as river dolphins, manatees, caimans and cracids, in recent years.

In the south of the Trapezium, three Indigenous Associations are in power: The Ticuna, Cocama and Yagua Association (ATICOYA) in Puerto Nariño, the Indigenous *Cabildos* of the Amazonian Trapezium Association (ACITAM) in Leticia and the Traditional and Ancestral Indigenous Authorities of the Amazonian Trapezium Zonal Association (ACITAM) on the Leticia-Tarapaca road in Leticia. Surveillance and control of the river is also a responsibility of the Colombian Army and Navy and development initiatives conducted in this fluvial system are the responsibility of the Ministry of Transport.

The Fishers Association ASOPESCAM from the municipality of Leticia is the only organized group controlling the commercial fishery in the segment of the Amazon River between the Colombian community of San José and the Peruvian community Puerto Alegria. Not all commercial fishers of the area are associated with the group. Verbal agreements between this association and Peruvian fishers have been established to perform commercial fishing activities. In other segments of the river and in the nearby lakes, the use of the resources (subsistence fisheries) is done according the proximity of the communities to the water body. It is understood that those communities closer to the water body are those allowed and entitled to it.

The current top-down structure imposes a command-control structure, but local communities, NGOs, Academia and even local and national environmental authorities are moving towards the establishment of community management or co-management, which in this case is a co-operative or advisory management framework, where the collective of people proposes the management of a defined area or a particular resource (Trujillo *et al*. 2009, Sandström & Rova 2010). These initiatives are currently taking place in the three main lake systems of the study area - the Yahuarcaca Wetland System, the Tarapoto Lakes System and the Caballo Cocha Lake in Peru. In these locations fishing agreement have been or are being formulated (Trujillo & Trujillo 2009, Ortiz 2010). The design of co-management strategies are now formulated under frameworks of cooperation by the users and other stakeholders. In these agreements, criteria for social, economic and environmental sustainability, according to the needs, characteristics and dynamics of the region and the population are included (Trujillo *et al*. 2009).

Freshwater resources conservation and management practices are prevalent in the study area. These have improved in recent years and in most cases they involve participation and approval of the local communities, local governments and the State. Despite of this, their implementation and enforcement are weak and lack well defined strategies and funds. Financial resources come from the government through Corpoamazonia and the Fisheries and Aquaculture Infirmary, as well as from the Academia (Public or private Universities) and from international NGOs such as WWF, WDCS, WCS that work in association with the local NGOs (Foundation Omacha and Foundation Natutama). There are also management problems associated with effectiveness and clarity of roles among stakeholders, including overlapping roles of institutions and territories, as is the case between the National Natural Park Amacayacu and the TICOYA Indigenous Reserve (139,871 ha overlap) (EOT 2007).

A number of other non environmental organisations are working in the South of the Amazonian Trapezium; Accion Social (Social Action) on poverty reduction programmes: Families in Action and Forest Rangers Families subsidise indigenous families to improve the livelihoods through the development of micro projects to enhance food security and reduce dependency of these peoples on the forest and fresh waters. The National

Learning Service (SENA) carries constant training and capacity building activities. SENA provides technical training to all inhabitants of the region to improve their livelihoods, and the social, economic and technological growth and development of the South of the Amazonian Trapezium. There are also a few women's organizations (Association of Women of Naranjales, Naiyu), loggers Association of Puerto Nariño (Asomapuna), and the loggers association of Leticia (Asomale), as well as handicraft manufacturing associations and cultural groups (CuYTa, Mowacha).

6.2.1. Freshwater biodiversity regulations

Amongst the current management tools to restrict access and use of the local freshwater biodiversity are:

- The Book of the Endangered Fauna of the Colombian Amazon: Analysis and Proposals for its conservation (Trujillo *et al.* 2008a),
- The National Action Plan for Migratory species (MAVDT & WWF 2009),
- The Colombian National Action Plan of Aquatic Mammals (MAVDT in press)
- The Action Plan for River Dolphins in South America (Trujillo *et al.* 2010).
- The National Programme for the Conservation and Management of the Colombian Manatees (Caicedo-Herrera *et al.* 2004)
- National Action Plan for Marine and Freshwater Turtles (MMA 1995)
- The National Bird Conservation Strategy (Rengifo *et al*. 2000)
- The National Conservation Plan for Water birds (Arzuza *et al.* 2008).

Amongst the policies and regulations in place are:

- Law 99 of 1993. This regulation was the result of the *Earth Summit* held in 1992 and constitutes the foundation to the environmental management and system in Colombia
- National Biodiversity Policy 1994
- Law 388 of 1997 - principles and regulations of the territorial, urban and rural organization
- Vision 2019: This document proposes a series of ambitious goals on peace, social justice, infrastructure, life quality, productivity and competiveness
- National Policy for the Integral Management of the water resource – 2010
- National Policy for inland wetlands – 2001
- PGAR or Regional Environmental Management Plan for the South of the Colombian Amazon – 2002 - 2011

- PAT or Triennial Action Plan – Corpoamazonia - 2007 -2009
- POTs of Leticia. Territorial Zoning Plans.
- EOTs of Puerto Nariño. Territorial Zoning Schemes
- Ten-year Environmental Plan. Corpoamazonia. 2010-2019: It sets a series of goals and objectives regarding the conservation and use of the Nation's natural resources.
- The resolution 0219 of 1964 which forbids the collection of eggs and individuals of the river turtles Charapa (*Podocnemis expansa*) and Tericaya (*Podocnemis unifilis*).
- The Resolution 574/1969 and the Resolution 848/1973 banning the hunting of river otters.
- The Resolution 574 of 1969 that forbids the hunting of endangered mammals (terrestrial and aquatic) in Colombia. This regulation also aims to forbid the illegal transportation, trade and use of products derived from the species, however subsistence hunting is allowed.

A series of Fishing Agreements have also been set up in the last few years with the participation of local fishers' communities, Indigenous leaders, NGOs, the National University of Colombia, the Sinchi Institute and the Fisheries and Aquaculture Infirmary. A Management Plan for the wetlands located in the *varzea* system of the rivers Loreto-Yacu and Amazon was formulated in 2007, in accordance with the Ticuna, Cocama and Yagua Reserve Life Plan and the Municipal Land Zoning Plan frameworks of Puerto Nariño (UNAL & Corpoamazonia 2007).

Other use and management strategies are:

- The Agreements of responsible fishing for the proper use of the Tarapoto Lakes System (Trujillo & Trujillo 2009).
- The Fishing Management Programme in the Caballo Cocha Lake (Peru) (Ortiz *et al.* 2010).
- The current project 'Building capacities for the community management of fishing resources by the Communities of La Playa, Castañal and San Sebastian de los Lagos in the Yahuarcaca Wetland System in the Colombian Amazon'. (UNAL & USAID in press).

These strategies are supported by national regulations and policies aiming to protect fish as aquatic resources through the implementation of regulations regarding fishing gears, times, places and minimum capture sizes.

- The Decree-Law 2811 of 1974 (National Natural Renewable Resources and Environmental Protection Code).
- The Decree 1681 of 1978 (Regulation of hydro biological resources and modification of the Decree-Law 2811 of 1974)
- The Agreement 15 of 1987 (minimum capture sizes for commercial species)
- General Fishing Statute, formulated under Law 13 of 1990 and regulated by the Decree 2256 of1991, aiming to regulate the integrated management and rational exploitation of the fishing resources to their sustainable use constituting the national framework to conduct fisheries within the Colombian territory.

Other regulations have been formulated related to permits and patents (Agreement 009 of 2003), extraction quotas for commercial and ornamental species (Agreement 008 of 2003 and 039 de 2005, Resolution 389 of 2005), and fees and taxes (Agreement 005 of 2003). A fishing and commercial ban (from the 31st of October to the 15th of March) has been in place for pirarucu, *Arapaima gigas*, since 1987 (Article 6, Resolution 89 of the 27th of May 1987) and it is applicable in Peru, Brazil and Colombia (Ruiz et al. 2007).

These regulations are important for the management and proper use of the freshwater resources. Most of them have been formulated from and by the local communities and with the full support of local and national stakeholders, but their implementation, monitoring and enforcement have failed for multiple reasons including: lack of funds and weak stakeholder participation, lack of commitment of the local communities, which in most of the cases demand financial compensation for monitoring and surveillance activities, lack of clarity and the vagueness of the regulations generating confusion when applying and enforcing the law (Trujillo *et al.* 2009).

6.2.2. Social structure and ethnic organization in the South of the Trapezium

The people who live in the South of the Colombian Amazon Trapezium belong mainly to six different ethnic groups: Tikuna, Yagua, Cocama, Uitoto, Ocaina and Bora. The Tikunas are one of the strongest and largest indigenous groups in the area who have been settled over the last four centuries (Riaño-Umbarila 2003). The Tikunas are not only restricted to the Colombian territory, but they have also managed to maintain and consolidate their territory within the Peruvian and Brazilian borders. In the Municipality of Leticia, 25% of the population is indigenous whilst in the Municipality of Puerto Nariño 87.6% of the 7574 inhabitants are indigenous people (DANE 2010). The rest of the territory is shared with settlers (c*olonos*) coming from other areas of Colombia, Brazil and Peru, and with people born in the area but not considering themselves as indigenous (Riaño-Umbarila 2003, Ochoa 2008). According to the latest census conducted in 2005, the total (indigenous and non-indigenous) population expected by 2010 for the Municipal district of Leticia and the Municipal district of Puerto Nariño is 47,000 people; of those

22,000 in the rural territory (14,539 in Leticia and 5,549 in Puerto Nariño) and 25,000 for the urban centres (25,128 in Leticia and 2,025 in PN) (DANE 2010).

The population is distributed amongst 2 urban centres (Leticia and Puerto Nariño) and 16 indigenous reserves holding 45 communities: 20 on the northern bank of the River Amazon in the rural area of Leticia, 5 located on the Leticia-Tarapaca road (Km 9 to 11) and 20 in the Municipality of Puerto Nariño (UNAL & Corpoamazonia, 2007; Leticia Municipality 2002).

These ethnic groups have a hierarchical society and are divided in clans. According to Oyuela-Caycedo and Vieco-Albarracin (1999), the hierarchical society can be interpreted under the model of house society, which means that the hierarchy is given with respect to lineages and is expressed through the house or Maloka (indigenous word for house). The Clans have a prescriptive marriage that favours the endogamous control of territories and settlements.

According to Riaño-Umbarila (2003), the Tikuna and Cocama are mainly fishers whilst the Yaguas are not. These three ethnic groups are associated with water resources and live on the banks of the River Amazon and its tributaries, and represent the most common ethnicities in the area. Local indigenous people are traditionally subsistence fishers and farmers. Their economic activities are based on the exploitation of the natural resources (wood and fruits gathering, hunting), however, nowadays an important 18% of household income comes from regular jobs involving construction, transportation and the public sector (Trujillo & Trujillo 2009). Fishing and farming activities are linked to flooding which supports the creation of a variety of habitats for fish and deposits sediment on the flood bank enriching the land for farming purposes. Some crop farming is done in the periphery of the floodplain where the soils are nutrient poorer and flooding is minimal, and thus depends on rainfall. Cattle (cows and buffalos) rearing is not an important activity for the indigenous people in the area, but is increasing through diversification by non-indigenous people. As a result, more areas along the river bank have been cleared.

Fishers, loggers and in general all indigenous inhabitants are still struggling to find the right balance amongst the appropriate levels of extraction of products from the forest and the river, their ancestral believes and the pressures of a global market. Most of the social and conservation work is done with indigenous communities without realizing that settlers or non-indigenous (*colonos*) people are also responsible for the use of the freshwater and forest biodiversity and resources. Control over the local indigenous fishers, loggers and handcrafters' associations is easier to enforce by indigenous leaders, but the *colonos* activities are risking the sustainability of the local ecosystems and is an important challenge to local, regional and national authorities.

6.2.3. Stakeholders analysis

The Headquarters of all national and local governmental institutions are based in Leticia, where regionally recognized non-governmental organizations and local organizations and associations are also found. Fishers constitute the most important social group in the region. As the main economic and subsistence activity in the area, fishers constitute one of the most important key pieces in the management and conservation of the freshwater resources, biodiversity and ecosystems in the South of the Colombian Amazon Trapezium.

Every year a number of stakeholder discussion workshops are undertaken prior to any conservation initiative being implemented in the area. Since most of the conservation and social work is done within indigenous territories, permission and acceptance by the indigenous communities must be given prior to the work starting. The workshops include not only the direct groups involved (indigenous communities and funding institutions) but environmental and fishing authorities that might play an important role within the implementation and regulation enforcement phases.

Fishing communities are the key group on which all conservation and social efforts are focused nowadays. During the past decade during the formulation of different Management Plans and fishing agreements, fishers have consistently raised a number of issues affecting the freshwater ecosystems, their biodiversity and the welfare of indigenous families. Complaints over the safety of fishers are of concern, especially amongst commercial fishers. As an economic activity, its contribution to the national GDP is very low, although this activity is crucial for local communities; fishing and other fishing products from the Department of Amazonas only represent 3.8% of GDP. However, this estimate does not include the millions of Colombian Pesos resulting from packaging, public services, refrigeration, taxes and transportation, items included in other GDP categories (Ochoa *et al.* 2006). For this reason, fishing is not considered a proper job and no health or labour benefits can be claimed. Amazonian fishers do not account for proper health coverage or insurance and the risks to which they are exposed during the performance of the activity are high and in some cases can be life threatening. Better working conditions and benefits are demanded by commercial fishers. These requests have been heard by members of the fishing authority (INCODER) on several occasions but little has been done.

Fishers are also not able to access credit facilities because of the nature of their job, the lack of permanency, the instability of the activity and lack of assets to back up a loan. The cost of fishing gear, its replacement, improvement and so on limit the performance of the activity and keep fishers in this cycle of dependency and neediness exacerbating the misuse of fishing gears and overfishing.

Fishers are struggling and not happy with the yields obtained from the river, something that has caused conflict between them and protection of endangered aquatic species, such as the river dolphins, which are seen as direct competitors for the resource. There is a widespread perception that fish catches are declining, and nowadays local communities are buying fish from Peruvian fishers instead of fishing themselves. Fishers are aware that the misuse of fishing gears such as nylon nets during the low water season and in forbidden areas like confluences and lakes are partly responsible for this scenario. However, dolphins are blamed on a daily base for this decline. Direct killing of dolphins happens especially in the Peruvian lake of Caballo Cocha. The Ministry of Production of Peru is aware of the situation and together with the Colombian NGO Foundation Omacha set up a Fishing Management Programme (Ortiz et al. 2010) for the resources of this lake. When dolphins are not killed, they are harmed. From a cultural point of view this transgression shows an important change in the people's vision of sacred elements in their ancestral believes (Trujillo *et al.* 2011).

Fishers are aware of the seriousness of the situation and the complexity of a fishery involving species protected by law. They have participated in workshops and conservation campaigns that aim to discourage hunters and fishers in the use of dolphins and in some cases black caiman as bait for the mota fishery. Regardless of alternative baits, there a series of alternatives have been proposed (e.g. remains from slaughterhouses), but the multiplicity of stakeholders and importance of the fishery within the local economy have made it difficult to move forward and to make significant changes. For this reason, the situation is now taken to a higher level: the Foreign Ministries of both countries (Colombia and Brazil) are now trying to find out a solution.

Other complaints from local communities involve tourist operators. Important tourism agencies are bringing thousands of visitors into the area every year. However, two main complaints have been expressed. Firstly, fast engine boats enter the Tarapoto and El Correo lakes everyday with no concern about the speed, noise or disturbance that this might cause. Communities from Puerto Nariño have regulated the boats entrance to these lakes by controlling the size of the engines allowed to transit in that area (UNAL & Corpoamazonia 2007). However, enforcement of this regulation has not happened. The implementation of regulations developed through different freshwater resources management plans have not been enforced because of lack in continuity of funds and conflicts amongst members of the TICOYA reserve. Secondly, big national and local tourism agencies that have established in Bogota and Leticia offer 'all inclusive' packages leaving no chance for local communities to benefit from tourism. Visitors are taken to nearby communities to buy a few handicrafts and maybe to buy a couple of drinks. This causes discontentment among villagers. Currently more local initiatives formulated by local people are trying to find sponsorships from other stakeholders and international donors, to promote more eco and cultural friendly touristic activities, but before these

local initiatives can develop, local people must be trained in business management, and education and capacity building programmes must be implemented.

Although there are fairly good relationships between communities and other stakeholders (NGOs, Corpoamazonia, Sinchi Institute, National University and UAESPNN), there are conflicts related to land ownership. Overlapping parts of the TICOYA Reserve and the NNP Amacayacu have always caused issues between the two parts. Settlements within National Parks are not allowed and no use of the biodiversity, apart from tourism and research, is allowed within their boundaries. Conflicts are always present regardless of the efforts of NNP Amacayacu personnel (EOT 2007). Trans-boundary issues are of concern for the authorities of the National Park that daily deal with trespassers conducting illegal poaching and logging activities. Other conflicts related to landownership take place in the surroundings of the urban centre of Puerto Nariño where areas claimed to be part of the TICOYA reserve (*parcialidades* – partialities) have not been legally entitled and this is restricting growth of the urban centre. Puerto Nariño is surrounded by indigenous land and development and urban planning is limited, upsetting non-indigenous people that find it hard to buy land or settle in the area (EOT 2007). A similar situation takes place in the Municipality of Leticia where the areas that do not correspond to indigenous territories are part of the Amazonian Forest Reserve leaving only a few hectares for urban growth and development.

The roles of the variety of stakeholders and institutions involved in freshwater biodiversity management in the area are not always fully understood by local people. They perceive that the enforcement of fisheries, logging and illegal hunting by the fishing and environmental authorities is weak, and for this reason local communities are now more involved and aware of the importance of their participation in the enforcement of agreements and regulations to protect their own resources. Empowering and strengthening local people is the key to ensure the successful implementation of conservation initiatives. Recuperating cultural patterns and giving more freedom and participation to communities in all decision-making processes constitute a tool and strategy for indigenous communities to retake control over their territories and resources.

6.2.4. National Government Policies

The status of Colombia as a recognized mega-diverse country forces it to have a strong National Biodiversity Policy and to follow up the commitments acquired with the CBD, CITES and Ramsar Convention concerning the conservation of its biodiversity (ecosystems, species and genes) and important ecological processes, especially in freshwater ecosystems.

The following are the international conventions and agreements signed by the Colombian government and the National Policies regarding the national renewable natural resources, biodiversity and freshwaters:

- Convention on Wetlands (Ramsar, Iran, 1971)
- Convention on the Conservation of Migratory Species of Wild Animals – CMS
- Agenda 21
- Convention on Biological Diversity (CBD)
- Convention to Combat Desertification
- United Nations Framework Convention on Climate Change
- Convention on International Trade in Endangered Species of Wild Fauna and Flora CITES
- Millennium Development Goals (MDG)
- ACTO – Amazonian Cooperation Treaty Organization
- Andean Community (CAN):

The main laws and regulations in Peru and Brazil regarding freshwater resources and biodiversity are:

Peru	Brazil
• National Constitution of Peru • Organic Law for the Sustainable Use of the Natural Resources – Law 26821 • Environment and Natural Resources Code • Law on the Conservation and Sustainable Use of the biological diversity – Law 26839 • General Law of fishing - Decree-Law 25977 • Regulation of the General Law of fishing – Modifications D.S No. 012-2001-PE • Fisheries Management Regulation of the Peruvian Amazon - Supreme Decree 015-2009-PRODUCE	• Forestry Code – Law 4771 of 1965 • Law for the Protection of Wildlife – Law 5197 of 1967 • Law of Environmental crimes (Law of Nature) – Law 9605 of 1998 • Law 2713 of 2001 of the protection of aquatic fauna and the development of fishing and sustainable aquaculture in the State of Amazonas

6.3. Issues and constraints within the management framework

The main weaknesses in the legislation and management framework include, but are not limited to:

- Limited provision in terms of human resource and financial capacity to monitor or regulate the law. Low budget designated to environmental conservation in the region.
- Weak enforcement and control of policies and regulations on the management of natural resources and aquatic ecosystems.

- Negative perception of the environmental authorities (National Police, Army, Navy, Corpoamazonia and INCODER) by local communities.
- Decision makers with poor understanding of the biological and ecological dynamics of the aquatic ecosystems and their interaction with resource users.
- Lack of articulation of initiatives and projects among public and private institutions. Weak communication network among stakeholders.
- Inadequate social and environmental work conducted with non-indigenous peoples.
- Lack of recognition of the strength and importance of local communities regarding the management of their natural resources and benefit sharing from these resources.
- Local communities now only work for money. Within any project or initiative, financial compensation must be offered to local communities to get their full cooperation.
- Within the National Protected Areas System there are no strategies for the protection of aquatic ecosystems or freshwater biodiversity. Most of the strategies are focused on terrestrial ecosystems.
- Lack of education and work opportunities for local people, especially in rural areas.
- An important part of the research is focussed through NGOs that depend on external, and not always constant, funding.
- Implementation and monitoring phases of most conservation strategies formulated and developed among the communities and stakeholders are imperilled by funding.
- Limited recognition of the value of the freshwater ecosystem services and societal benefits. An economic approach to improve their understanding is urgently needed. In most cases these resources have been undervalued constraining the formulation and scope of conservation programmes.
- Indigenous people are still seen as fixed communities and most of the social and environmental strategies implemented have not taken into consideration the changing economic and social circumstances with regard to resource use patterns.

6.4. Issues impacting on the freshwater biodiversity and ecosystem services of the South of the Colombian Amazon Trapezium

Shortcomings in present freshwater biodiversity management practices have been identified based on information collated in the characterization chapters (2, 3 and 4), identification of key conservation areas in the freshwater ecosystems of the study area (chapter 5), information collected from informal conversations with local people in the field, and information presented in the previous sections of this chapter. To meet national

conservation objectives and satisfy the needs and requirements of local communities the various issues identified need resolution (Table 6.1). The key issues for management of the freshwater biodiversity of South of the Amazonian Trapezium are described below.

Table 6.1 Summary of the key issue and options, consequences, conservation priority and actors for management of the freshwater biodiversity in the South of the Colombian Trapezium.

Issues /Constraint	**Options/interventions**	**Consequence**	**Priority**	**Actors**
Fisheries Issues				
Fisheries are showing signs of over exploitation, commercial and subsistence species have shifted through time.	For any fisheries management plan to be effective it needs an integrated approach where social, political and economic aspects are considered. The multi-species, multi-gear character of these fisheries, make standard assessment models and concepts of overfishing inappropriate. For this reason it is important to conduct accurate stock assessments looking at fish assemblages, stock structure, mortality rates, growth rates, and production (Welcomme *et al.* 2010).	Reduction of fishing pressure and effective and controlled use of fishing gears. No more river dolphins are killed due to negative interactions with fishers. Improved local peoples' livelihoods. A Household income coming from alternative productive projects.	High	INCODER Sinchi Fishers Associations TICOYA ACITAM NGOs
The mota fishery is risking the survival of river dolphins and caimans in the region (Brazil/Peru/Colombia)	Urgent management intervention is needed to mitigate its impact on endangered populations as well as prevent future conflicts among the countries involved. The collection of reliable data is complicated because of the illegality of part of the activity (use of dolphins as bait), necessitating formulation of an alternative research strategy. Implementation of alternative fishing baits. National and Regional campaign warning mota consumers regarding the origin of the species.	The use of dolphins and caimans as bait will be zero. The fishery becomes totally legal making it sustainable. The fishery is fully understood and data regarding catching and landings are collectable and accurate. New alternative baits are used and the species yields are maintained. Fish consumers all over the involved countries within and beyond the Amazon region start to create a buyers conscience that will regulate their demand on Amazonian products.	High High High Low	Governments from Colombia, Peru and Brazil. Fishing Authorities of Peru and Brazil. INCODER Sinchi Universidad Nacional de Colombia Fishers Associations TICOYA ACITAM NGOs Fish traders.

Provision for monitoring, control and surveillance is inadequate or nonexistent, leading to illegal fishing in the closed season and use of illegal gears	Reformulation of conservation and education strategies is needed to improve the knowledge on fisheries in all environmental authorities to make more efficient regulations enforcement. Constant education programmes and training with local communities aiming to empower these communities for the management and control of their own resources.	Local Environmental Authorities will have a full knowledge about permitted species, gears, catching sizes and seasons therefore a better enforcement of legislation will take place regulating catches and landings. Ideally local communities will auto regulate regarding the harvesting of fish. Little intervention of the environmental authorities should me needed.	High High	INCODER Sinchi Fishers Associations TICOYA ACITAM NGOs SENA Universidad Nacional de Colombia. National Army, Navy and Police force.
There are weaknesses in the implementation of all fishing agreements or management plans formulated by and with local communities.	Funding provided by the Fishing Authority and other funding organizations need to cover not only the formulation part of a Fishing agreement, but at least part of its implementation. Local communities need to start being self-sufficient and from their inclusion in alternative income projects generate resources that enable the implementation of these agreements.	Constant funding will come into the area reducing the gaps exciting between the formulation and implementation phases keeping people motivated and committed.	High High	INCODER Sinchi Fishers Associations TICOYA ACITAM NGOs
There is little interest by the Central Government regarding the importance and role of fisheries in the provision of food security and rural livelihoods.	There is a need for a comprehensive review of the role of fisheries in provision of food security and rural livelihoods. Mechanisms to encourage central government to provide adequate financial and human resources for the management of fishery resources are urgently required. An ecosystem services approach is key to value this activity from not only an ecological or social point of view, but also from an economic perspective.	The livelihoods of local communities will improve when fishing is acknowledged as a job and benefits (health and pension) are provided to its performers. More money will be provided by the central government through the Fisheries Authority to develop alternative projects involving the transformation of the raw product therefore more income can be generated to local families. New jobs are created benefiting fishers' families. Increase in number of people as members of the fishing authority	High High	INCODER Sinchi Fishers Associations TICOYA ACITAM NGOs SENA Universidad Nacional de Colombia

		to improve the management of the activity.		
Fish farming so far has failed in indigenous communities limiting its potential as a conservation strategy.	Train young people in schools and present this alternative as a potential job for when they finish their studies. Use the existing infrastructure in Leticia to train new people in the area. If the activity has failed with indigenous communities, strengthen non-indigenous people already involved in the business.	Fish farming will play a more important role within the local fish production. Fishing pressure will be reduced from rivers and lakes. Young people will have an alternative of living after finishing school, especially for those that cannot afford to go to the University.	Medium Medium High	INCODER Sinchi Fishers Associations NGOs SENA Universidad Nacional de Colombia Local Schools
Ecosystem Issues				
Little knowledge on ecosystem services provision and their importance to local communities.	An ecosystems services evaluation study needs to be undertaken urgently to provide the economic framework for supporting the protection, conservation and development of fisheries, wildlife, water consumption and other services delivered from the freshwater ecosystems of the area.	Fundraising will improve towards those ecosystem services that play an important role in the local, regional and national economy. Better knowledge and understanding of the local freshwater biodiversity will be obtained. The valuation of ecosystem services will represent another conservation tool for the area.	High	MAVDT, Corpoamazonia Universidad Nacional de Colombia, NGOs
Development projects in neighbour countries are indirectly affecting the freshwater biodiversity of the study area	Stronger regional policies must be formulated to overcome the widespread impacts of these projects and to ensure the protection of vulnerable areas beyond the immediate locality of the source of source.	Pressures will be reduced in their source point and their impact on further areas will therefore be reduced. Transnational cooperation schemes will be developed strengthening regional cooperation. Ideally new development projects will be done in consultation with the other countries of the region, as well as the formulation and implementation of Conservation strategies.	High	OTCA CBD Ramsar Local and central governments from Colombia, Peru and Brazil NGOs Sinchi Corpoamazonia Ministries of Foreign business, International Relationships, Economy, Transport from the involved countries.
Agricultural activities are decreasing crop biodiversity and	Reinforce familiar agricultural units (chagras) as the foundation for food	New income alternatives for local communities.	High	UMATA, Sinchi, Corpoamazonia Universidad Nacional,

therefore risking local food security	production in the area. Train women in techniques that enable the transformation of raw food into processed items adding value. Open new markets beyond the area to promote the maintenance of diversified crops.	Better use of their harvested products. Increase of biodiversity Strengthening of an ancestral activity.	Medium Medium	SENA, NGOs, Ministry of Commerce.
Uncontrolled deforestation has been a constant pressure to terrestrial, aquatic and amphibian ecosystems.	Involve loggers within the conservation initiatives conducted in the area. Make process to acquire logging permits more efficient and fast. Binational initiatives need to be conducted with Peru to avoid trespassing of Peruvians into Colombian Territory (and vice versa).	Reduction in illegal deforestation. Increase of legal and sustainable logging practices. Decrease in clashes between Colombian and Peruvian communities.	Medium Medium Medium	UMATA, Sinchi, Corpoamazonia Universidad Nacional, NGOs, Ministy of Production (Peru).
Urban growth is responsible for an increment in water pollution.	Environmental education in the urban centres needs improvement. Improve solid wastes and sewage treatment and disposal in urban centres. Start a recycling strategy all along the study area.	Reduction of litter disposed in public spaces and aquatic ecosystems. Leticia will be more attractive to visitors. Reduction of pollution of water bodies urban and rural areas. Recycling campaign formulated and in motion favouring the protection of freshwater ecosystems. Local communities involved in the separation and recycling of certain material which can provide economic benefits.	Medium Medium Medium	Leticia City Council, Puerto Nariño City Council, NGOs, Local Schools
Livelihoods issues				
The introduction of tourism as the new economic boom is risking the local culture and identity.	It is necessary to formulate an Action Plan for the activity in the area together with indigenous communities and governmental and private organizations.	The performance of tourism in the area will be inclusive and all benefits provided will be shared equally by the communities involved.	High	Central Government, Ministry of inner affairs and Justice, Ministry of Development, Leticia City Council, Puerto Nariño City Council,

				TICOYA, ACITAM, Universidad Nacional, NGOs,
Exclusive dependency on freshwater biodiversity, little income alternatives	Train people in different skills to diversify their income options and relieve pressure off the ecosystem.	Local communities with improved livelihoods due to the diversification of income alternatives.	High	UMATA, Sinchi, Corpoamazonia Universidad Nacional, SENA, NGOs
Gender-specific conservation initiatives is minimal	More involvement of women is needed and gender-related initiatives can become an ally to improve local families' livelihoods.	Increased participation of women in conservation planning. Active participation of women in the local economy.	HIgh	UMATA, Sinchi, Corpoamazonia Universidad Nacional, SENA, NGOs, TICOYA, ACITAM.
Shortcomings in health and educational national and regional strategies have repercussions on the lives of Amazonian peoples.	The Ministry of Social Protection and Education need to work hand by hand with the Ministry of Environment to formulate inclusive programmes understanding the link between human communities' livelihoods and ecosystem conservation.	Indigenous communities with strong education programmes training children, youth, and adults and creating conscience regarding the use of their resources. Improved health system that will benefit the quality of life of the local communities.	Medium - High	MAVDT, Ministry of Social Protection, Ministry of Education, Regional Health Agency, NGOs, Universidad Nacional, SENA.

Fisheries issues

- Fisheries are showing signs of over exploitation in terms of shifts in species fished: big commercial catfishes (*Brachiplatystoma filamentosum* (Lechero - Pirahiba) and piramutaba (*Brachyplatystoma vaillantii*) are less common and new and more abundant species like mota (*Calophysus macropterus*) are being caught. For commercial fisheries, the biggest potential influence is external to the study area, i.e. market demand, weak regulation and policies formulated outside the study area, lack of policy enforcement and Government presence. Internal influences are related to the welfare of fishers, working and living conditions, as well as economic opportunities to improve their livelihoods.
- The mota fishery has gained importance in the area supporting many families. However, the use of endangered species as bait to enhance fish yield is considered one of the main direct threats to local freshwater biodiversity.
- Changes in consumption patterns are also causing overexploitation. Indigenous people have preferences for certain fish species that are subject to certain restrictions, but new people arriving into the area, with no cultural understanding has contributed to the reduction in abundance of traditional species like tambaqui

(*Colossoma macropomum*), jaraqui (*Semaprochilodus* spp. and pirarucu (*Arapaima gigas*).

- Provision for monitoring, control and surveillance is inadequate or nonexistent, leading to illegal fishing in the closed season and use of illegal gears. This is exacerbated by lack of knowledge about permitted species, catching sizes, gears, and so on, by the environmental police and members of the National Army (in charge of patrolling the rivers).
- There are weaknesses in the implementation of all fishing agreements or management plans formulated by and with local communities. Lack of funding, external guidance and support from the people limit the continuity of processes adopted by the communities. Time gaps between formulation and implementation phases threaten the process and compromise their outcome.
- There are weaknesses in data acquisition, management and dissemination for commercial and even more for subsistence and ornamental fisheries. This information is fundamental for successful regulation and management of the fisheries.
- There is a need for a comprehensive review of the role of fisheries in provision of food security and rural livelihoods. Mechanisms to encourage central government to provide adequate financial and human resources for the management of fishery resources are urgently required. An ecosystem services approach is key to value this activity from not only an ecological or social point of view, but also from an economic perspective.
- Fish farming has failed in indigenous communities, although this strategy may be successful if young people are trained in schools. The lack of interest of young people in learning fishing techniques performed by their fathers and grandfathers will have an impact in the future and getting them involved in fish farming might counter many of the threats to the activity. Non indigenous people are able to engage in the fishing activity, but need more support from the Fisheries authority.

Ecosystem issues

- Rivers need to start being considered important targets for conservation and not as transportation waterways or simple lifeless geographical boundaries. Changing the perspective that decision makers and development strategist have about lotic bodies might have a significant impact on the formulation of policies and development strategies for Amazonian rivers.
- Mining and hydropower projects taking place in Brazil are indirectly affecting the freshwater biodiversity of the study area (migrating fish with mercury traces in their tissues).

- Agricultural development is a permanent threat to the ecosystem, the intensification of mono-cultures and reduction in variety is starting to risk not only local biodiversity but cultural and health–related aspects of the local communities.
- Uncontrolled deforestation has been a constant pressure to terrestrial, aquatic and amphibian ecosystems. Global markets keep driving the performance of the activity and weak regulation and policies' enforcement constitute the main reason why the activity instead of decrease have increased in extension and magnitude.
- Urban growth is responsible for an increment in water pollution. Solid waste and sewage treatment and disposal in the city of Leticia are inadequate and poorly planned. This is threatening water quality of nearby water bodies as well as the health of the communities settled in the surroundings of the city's dump. Leticia is perceived as a very untidy city, and a potential threat to tourism. Environmental education in the urban centres needs improvement. Conservation and social initiatives are focused mainly on the rural communities and little has been done with urban communities that are contributing enormously to the degradation and deterioration of water bodies and water quality.

Livelihood issues

- Many different socio-economic issues are driving changes in the freshwater biodiversity of the South of the Amazon Trapezium. An increase in tourism and the inclusion of this economic activity within the National and regional development plans, are slowly driving local people into a new economic boom, leading them to change traditional survival activities, such as fishing and farming, and to employ themselves in tourism-related activities.
- Tourism agencies are overtaking business in the area and outcompeting local communities. Unfair distribution of the benefits provided by the activity is affecting the local communities, which are one of the main 'attractions' that tourists look for when they visit the area.
- Inclusion of indigenous peoples into the capitalist market has changed the traditional trading patterns in the area. Changes in fishing and farming patterns to fulfil the market requirements and conflicts amongst people have resulted from a poor understanding of finances, money and capitalist trading.
- Lack of income opportunities for indigenous communities has caused them to depend almost exclusively on the freshwater resources and to get involved in illegal activities that represent easy money towards household income.
- Shortcomings in health and educational national and regional strategies have repercussions on the lives of Amazonian peoples on a short and long term bases. Weak sex education and health care affect women's daily lives and contribute to an uncontrolled population expansion.

- Women's involvement in conservation initiatives is minimal. Little gender-related initiatives are implemented in the area. Child prostitution in indigenous communities is common and a consequence of a lack of income alternatives to these families.
- Although indigenous people in the Amazon River basin are not considered to be 'poor' according to the World Bank[2] poverty index, poverty could easily become in a common concept for indigenous communities as overexploitation of their natural resources continues, dependency on a capitalist market increases and there is a loss of cultural traditions and believes. This will compromise food security in the area, sustainability of ecosystems and welfare of traditional peoples.

6.5. Management and Conservation Plan for the Aquatic Biodiversity and Ecological Processes in the South of the Colombian Amazon Trapezium

The recommendations given in this section are a series of proposed actions projected within nine identified working lines (key issues) and presented as interventions set in the context of (discrete) projects. These recommendations are mainly directed at local and national stakeholders in charge of policy making, fundraising, and development of conservation. Each working line constitutes an important element within the overall management strategy and each needs to be considered in an integrated manner. Some of the recommendations have already been put in motion in some parts of the study area, but this section provides an overall review to the situation faced by the freshwater ecosystems as well as by their users, and aims not only to propose new strategies but to reinforce those already in existence. At the same time stakeholders are identified as well as their respective roles, rights and responsibilities.

The possible success of these recommendations will rely enormously on stakeholder participation and collaboration at all levels and will be indispensable to establish a common perspective on sustaining the freshwater ecosystems and the productive activities that depend on them. Local community participation is equally or even more important than stakeholder's commitment.

Conservation initiatives formulated and implemented in the area need to adopt a global approach to address the local problems associated to freshwater biodiversity use and management as laid down in the CBD, CITES, Ramsar Convention, and FAO Code of Conduct for Responsible Fisheries (Cowx *et al.* 2011).

The following section establishes a series of working lines proposing projects, objectives and activities. This section should act as guidance for the prioritization and implementation of conservation strategies in the area. However, it is important to clarify

[2] 'Poverty is pronounced deprivation in well-being, and comprises many dimensions. It includes low incomes and the inability to acquire the basic goods and services necessary for survival with dignity. Poverty also encompasses low levels of health and education, poor access to clean water and sanitation, inadequate physical security, lack of voice, and insufficient capacity and opportunity to better one's life'

that this document needs first to be endorsed by the local governmental and indigenous authorities before any implementation initiative takes place. A logical framework approach (LFA) (Appendix 4) was used as a planning technique. According to Cowx *et al.* (2011), the LFA is widely used to bring not only stakeholders together to focus on common problems but serves as a tool that can take forward the solutions generated to implementation.

6.5.1 Overall objective

To enable the South of the Colombian Amazon Trapezium to contribute to the local and national economy, and provide goods and services that enhance the social wellbeing for current and future generations without compromising environmental integrity by 2020.

Goals of the Plan

The key issues identified above and related directly to the freshwater biodiversity, institutional framework, livelihoods of the local communities, ecosystem functioning and services delivery, were used to identify nine working lines that will drive the implementation of the Plan:

1. Fisheries Management
2. Agricultural practices improvement
3. Habitat restoration
4. Environmental Education
5. Local Communities Empowerment
6. Spatial Planning
7. Stakeholders Network Enforcement
8. Scientific Research
9. Central and local Governments organization and primordial actions

These working lines will be addressed according to their priority of implementation: high, medium and low. The development of these issues aims to reach a series of different goals.
(1) to conserve and protect the freshwater biodiversity of the South of the Amazonian Trapezium, this includes species, habitats and environments, (2) to ensure the continuity of the freshwater ecosystem processes and services vital for the biodiversity maintenance and the local communities' livelihoods, the Amazon region and the country, (3) to enhance the livelihoods of local rural communities, ensuring food security and income opportunities through the proper use and management of the freshwater resources, (4) to promote sustainable exploitation of the fisheries resources of the area, (5) to provide stakeholders information to improve decision making processes regarding the conservation and sustainable use of freshwater biodiversity as well as the development,

investment and improvement of indigenous communities, areas of special management and urban centres, (6) to contribute to the agreements signed by the Colombian Government regarding biodiversity conservation (CBD, CITES), freshwater and wetland conservation (Ramsar Convention), and indigenous communities (OIT) as well as to what it has been stated in the different national biodiversity policies and national, regional and local development Plans.

6.5.2 Management Actions

Working line 1: Fisheries Management

High priority must be given to this working line.

Project Title: Enhance research, information gathering and dissemination on fisheries (commercial and subsistence) of the study area.

Objectives

Keep generating knowledge on the status of the fish stocks used for subsistence and commercial fisheries in the South of the Colombian Amazon Trapezium.

Develop ecosystem indicators, inventory and monitoring systems for subsistence fisheries, as well as assessment of ecosystem functioning and health.

Activities

- Increase the number of freshwater environments where scientific research on fisheries is conducted.
- Carry out multi-species stock assessments, considering the composition of the stock, the changes in fish assemblages, as well as the changes in fishing gears and effort.
- Collect and evaluate data on the value of subsistence fisheries and biodiversity to the national, regional and local economies.
- Deeper research on ornamental species as well as on fishing techniques and market dynamics.
- Train local fishers to collect biological information on fish and ecosystems.
- Improve national, regional and international information networking.
- Improve communication among stakeholders.

Project Title: Enforcement of fisheries laws and regulations

Objective

Implement management actions to guarantee the sustainability and integrity of the fish stocks and other freshwater species in conflict with the activity (river dolphins, black caimans)

Activities

- Carry out research on the social, economic and cultural dynamics of fisheries in a local, regional and national level.
- Use education as a tool to transform harming fishing practices into sustainable activities with benefits to local livelihoods.
- Boost the creation of local fishers associations and strength existing (Acopescam) by building capacity and cultural empowerment.
- Formulation of Management and Conservation Plans for endangered fish species.
- Stop the use of endangered fauna in the mota (*Calophysus macropterus*) fishery by using alternative baits (slaughterhouse remains and/or artificial baits).
- Promote the formulation and implementation of fishing agreements not only in lake systems but in rivers and tributaries.
- Enforce the establishment of the Leticia 'Core'. Strategy already in motion in other parts of the Colombian territory aiming to facilitate discussion and decision making regarding fisheries. This initiative is under the supervision of the fisheries and aquaculture infirmary.
- Enforce bi-national and international agreements (border agreements) and treaties on fisheries (commercial and ornamental). Harmonize regulations on the use of hydro-biological resources among Peru, Brazil and Colombia.
- Support aquaculture projects already functioning in Leticia and in indigenous communities and increase the studies related to this topic, their feasibility, impediments, and projections. Develop and implement new technologies to improve infrastructure. Use schools' infrastructure and student labour to develop aquaculture projects.

Project Title: Generation of alternative income opportunities through the use of fisheries discards and post harvesting fish transformation

Objective

Generate new alternatives of income through the use of discarded fish and fish products: skin, scales, and bones.

Activities

- Enhance training of fishers, especially on managerial issues, entrepreneurial dynamics, finances and fish processing and transformation. This is intended to support the proposed alternative income initiatives by giving fishers and their families tools to create and manage their own enterprises.
- Creation of small businesses to use the skin of catfishes to manufacture wallets, belts or other accessories. Use of scales and fish bones for handicraft manufacture.
- Continue supporting post-harvesting activities and industries (e.g. AMAPROPEZ in Leticia) and enhance the establishment of new associations or co-operatives involved in fish filleting and product transformation.

Working Line 2: Agricultural practices improvement

High to Medium priority must be given to this working line.

Project Title: Improvement of chagra production and profits

Objectives

Improve agricultural practices for the indigenous communities.

Identify agricultural products to process and commercialize under sustainability standards.

Activities

- Reinforcement of the cultural and social meaning of *Chagras* as the core agriculture family unit.
- Creation and enforcement of local associations, prioritising women's organizations, to generate employment and income opportunities.
- Improve agricultural practices focused on obtaining more and better products for self-consumption and commercialization.
- Establish training programmes supported by SENA for the use of machinery needed in food processing, as well as in the maintenance of the equipment.
- Training programmes on manipulation, processing, packaging and food trading. These programmes need to include finance management, investment and fundraising.
- Together with the Ministry of Commerce and the Humboldt Institute, create new markets for Amazonian processed products as part of the National Programme of Green Markets

Working Line 3: Habitat Restoration

High to Medium priority must be given to this working line.

Project Title: Reforestation of riparian forests and of species use in handicraft manufacture

Objective

Reforest riparian forests in lakes systems and rivers to maintain a diversity of environments for aquatic and terrestrial species supporting local biodiversity and the provision of important ecosystem services.

Activities

- Collection of seeds and seedlings of native species to establish a series of nurseries in the study area to reforest areas in need.
- Concerted effort to reforest species used in handicraft manufacture (e.g. *Brosimum rubescens* - Palo de Sangre)

Project Title: Effective protection of key aquatic habitats

Objectives

Protect key aquatic habitats and environments.

Implement new alternatives to reduce water and air pollution.

Activities

- Protection of beaches during the low water periods. Banning of unsuitable agricultural practices, tourism and human settlement.
- Work closely with all members of society (indigenous and non-indigenous - peasants, loggers, fishermen, land owners, ranchers, citizens) to improve their practices and ways to approach the environment.
- Control the increasing ranching practices. Control the trade of buffalos and cattle within the study area.
- Improve solid wastes management and solid waste dumping sites. Create effective recycling campaigns to implement in all rural and urban areas.
- Improvement in the sewage systems in urban centres and indigenous communities.
- Use of alternative sources of energy to reduce the dependency on fossil fuels to provide electricity.
- Reparation of existing solar panels.

Working Line 4: Environmental education

Medium to low priority must be given to this working line.

Project Title: Positioning environmental education as a mandatory conservation and social strategy within any conservation, poverty reduction, livelihood improvement programme.

Objectives

Enforce cultural patterns and ancestral believes in all levels of the indigenous society.

Train local teachers in environmental management issues.

Train school children in natural resources management, project formulation, fundraising strategies, and agriculture and aquaculture sustainable practices.

Improve local participation of indigenous and non indigenous communities in all conservation and alternative income projects formulation and implantation steps.

Activities

- Together with the Ministry of Education and Departmental of Education Agency reinforce the implementation of bilingualism in all academic institutions (Spanish-Tikuna, Spanish-Yagua, Spanish-Cocama) to reinforce cultural traits in younger generations.
- Reinforcement of ancestral rituals and practices by bringing elders and youngsters together to strengthen awareness of ancestral heritage in the younger generations.
- Education components built into conservation, poverty reduction or social initiative programmes formulated for the area to ensure full participation of local communities and stakeholders.
- Working closely with school teachers, training them in subjects related to freshwater conservation, threats and management strategies at the local, regional and national levels.
- Producing educational material for schools according to the needs of the children of the region.
- Include in all secondary school curricula, programmes related to natural resources management and sustainable agriculture and aquaculture practices.
- Include within the programmes offer by SENA modules and programmes to build capacities regarding project planning, fundraising, data collection (scientific and social), technical and scientific reports production, and other tools that might benefit the management of fisheries, and local freshwater resources.

- Training local people as tourist guides, co-investigators and informal educators to interact directly with local communities and empower young people and indigenous leaders, reaffirming their culture and improving their income opportunities.

Working Line 5: Local communities empowerment

High priority must be given to this working line.

Project Title: Empowering local communities towards biodiversity management and conservation

Objectives

Strength the participation and involvement of local communities in decision making processes.

Improve local people's capacities to formulate and manage their own alternative income projects and initiatives.

Consolidate a local strategy among indigenous reserves to harmonize actions, rules and fair benefit distribution resulting from tourism activities.

Activities

- Boost the creation and establishment of local associations of fishermen, farmers, tourism operators, educators and women.
- Train local organizations in financial and business management focused on tourism and green markets (agriculture and fish products, handicrafts).
- Train local organization in fundraising techniques.
- Create and implement new gender-related programmes to empower women organizations and individuals, as they have been identified as playing an important role in freshwater biodiversity conservation.
- Formulate and implement 'Pride Campaigns', where flagship species are selected by members of the community and used in marketing campaigns to support and promote conservation actions and to build support for the interests of all parties.
- Building capacities in local communities towards high quality tourism services provision.
- Create a local tourism strategy for rural communities involving small tourism providers and local and national agencies, and a tourism action plan, all aiming for fair distribution of benefits arising from the activity.
- Consolidation of partnerships among governmental entities, the private sector and the local communities.

- Implement the concept of 'pro-poor tourism'[3] (PPT) (UN), to develop tourism strategies planned for the study area. Although indigenous people in the Amazon are not catalogued as poor, this approach will benefit them.
- Involve national and international agencies bringing tourist to the area in local conservation initiatives by requesting they donate a portion of the tour fare to any environmental project.
- Use part of the tax charged to tourist at the Leticia Airport, to support indigenous tourism initiatives or as payment to allow tourist to visit the indigenous reserves (a fee is payed to enter the NNP Amacayacu why not to do the same with Indigenous territories?).
- Create a programme where communities receive rights to manage local tourism initiatives in exchange for active protection of the aquatic biodiversity.

Working line 6: Stakeholders partnership enforcement

Medium priority must be given to this working line.

Project Title: Strengthening local and national stakeholders' bonds for more cooperative and successful conservation initiatives

Objectives

Strengthen the network of researchers and public and private institutions working on environmental research and conservation programmes.

Improve the relationships between governmental organizations and local communities.

Improve communication channels among stakeholders.

Activities

- Local, private and public organizations must participate more actively in the Amazonian Territorial Information System (SIAT-AC) to contribute to the National Environmental Information System and the Biodiversity Information System.
- Create a Regional Environmental Information System using the Amazonian Cooperation Treaty Organization as a platform.

[3] "Pro-Poor Tourism (PPT) is tourism that results in increased net benefits for poor people. PPT is not a specific product or niche sector but an approach to tourism development and management. It enhances the linkages between tourism businesses and poor people; so that tourism's contribution to poverty reduction is increased and poor people are able to participate more effectively in product development. Links with many different types of 'the poor' need to be considered: staff, neighbouring communities, land-holders, producers of food, fuel and other suppliers, operators of micro tourism businesses, craft-makers, other users of tourism infrastructure (roads) and resources (water) etc. There are many types of pro poor tourism strategies, ranging from increasing local employment to building mechanisms for consultation. Any type of company can be involved in pro-poor tourism - a small lodge, an urban hotel, a tour operator, an infrastructure developer. The critical factor is not the type of company or the type of tourism, but that an increase in the net benefits that go to poor people can be demonstrated". http://www.propoortourism.org.uk/

- Continue the mutual cooperation among local, private organizations, public institutes, the Academia and governmental organizations.
- The National Government and the National Environmental System (SINA) must be restructured to strengthen the presence of members of the Regional Environmental Authority (Corpoamazonia), the National Natural Parks Unit and the Fisheries and aquaculture Infirmary (INCODER) in the area.
- Create opportunities for local communities and organizations to share thoughts, problems, and initiatives and to discuss issues regarding project formulation, implementation and monitoring.
- Use current existing channels (WebPages, Institutions' Newsletters, TV Channels and local radio stations) to share conservation initiatives, results and monitoring reports.

Working line 7: Scientific research

Medium priority must be given to this working line.

Project Title: Conservation of endangered aquatic species of the South of the Amazon Trapezium

Objective

Maintain the population of stable but vulnerable species and restore the populations of heavily exploited species.

Activities

- Use surrogates of conservation as one of the tools implemented in the area to protect and manage the freshwater biodiversity. Increase the number of studies for the identification of new targets for conservation.
- Continue monitoring the numbers, movements and dynamics (using abundance estimation and mark and recapture techniques) of the two species of river dolphins throughout the study area with emphasis on the lake systems and island edges (low current areas).
- Increase effort throughout the year on protection of river turtles (maintenance of artificial beaches and translocation of nests during the low water period) and on education campaigns against the commercialization and consumption of turtle eggs and individuals.
- Monitor the populations of pirarucu in lakes systems.
- Abundance estimation of river otters (both species) and characterization of their habitats.

- Continue monitoring the recovering population of manatees in the area of Puerto Nariño and working together with the Peruvian government to stop the possession of individuals (not only manatees but all wildlife species) in captivity.
- Implementation of a regional strategy on the illegal possession and trade of wildlife species.

Project Title: Enhance research, information gathering and dissemination on freshwater ecosystem services of the study area to integrate this to a wider ecosystem management approach.

Objectives

Develop ecosystem indicators, inventory and monitoring systems for fisheries and aquatic biodiversity, as well as assessment of ecosystem functioning and health.

Collect and evaluate data on the value of fisheries, water for human consumption, carbon sequestration and biodiversity to the national and regional economies.

Continue research into environmental, biological and socio-economic aspects of the fisheries of the south of the Colombian Amazon Trapezium, with enhanced information gathering and dissemination to formulate the most appropriate strategies to manage the resource.

Activities

- .
- Measure, record and evaluate information required for effective management of the freshwater ecosystems of the area in conjunction with all stakeholders and communities.
- Conduct scientific research on the role of black water lakes as carbon ‘sequestrators’ and on climate balance in all black water lakes in the study area.
- Conduct an economic assessment on vital ecosystem services such as water for human consumption, dolphin watching and biodiversity maintenance.
- Create a system of discussing and disseminating management issues and research findings to improve flow of information and feedback among the stakeholders.

Project Title: Effects of climate change on the local freshwater ecosystems and peoples’ culture and dynamics.

Objectives

Conduct research on the current and future effects of climate change on the freshwater ecosystems dynamics and the local culture in the South of the Amazon Trapezium.

Activities

- Conduct scientific research on the impact of climate change on hydrological patterns locally and regionally but with emphasis on the upper Amazon River basin.
- Conduct social and anthropological research on the impact of climate change on indigenous culture and practices.

Project Title: Improving the efficiency of conservation initiatives by strengthening the bonds between natural and social scientist.

Objective

Increase participation of anthropologists and social workers in all biological and ecological investigations and vice versa.

Activities

- Use of anthropological knowledge and research on conservation initiatives and biological (scientific) information in social work.
- Conduct ethnographies of targeted groups such as indigenous communities, fishers and loggers to understand their current dynamics, their inclusion to the market system and motives and drivers that are shaping the way they are currently approaching the Amazonian ecosystems.

Working line 8: Spatial Planning

Medium to Low priority must be given to this working line.

Project Title: Improve land tenure by legalizing land ownership and improving land practices among indigenous and settlers' communities.

Objectives

Legalize land tenure for indigenous communities in the Municipal district of Puerto Nariño.

Improve private land farming and fishing practices.

Activities

- Legalizing the land ownership of the Partialities (indigenous communities with no legal titles over their land – Patrullero, 20 de Julio, Puerto Esperanza and Valencia) of the TICOYA Reserve in the Municipality of Puerto Nariño.
- Carry on with the work conducted with the TICOYA reserve regarding the issues arising from the overlapping land with the NNP Amacayacu.
- Make sure (by legal means) that no more land from the Amazonian Forest Reserves is extracted to increase urban development in the Leticia Municipality.
- Closer work with private land owners, training them on sustainable practices to avoid deforestation, water pollution and social conflict.

Project Title: Strengthening the SIRAP (Regional System of Protected Areas) in the South of the Amazon Trapezium.

Objectives

Position lake systems as areas of special management within the national environmental and development legislation.

Create conservation measures for river islands and their joint freshwater habitats (inner lakes, beaches, river pools and low current areas), including creation of new protected areas.

Activities

- Propose other lake systems, besides Tarapoto, as wetlands of special attention to the Ramsar Convention.
- Give river islands special protection status and define use areas: areas for agricultural practices only (*chagra*), research, conservation (forests and lakes) and controlled tourism (hiking). Note: islands should not be suitable for human settlements because of high floods.
- Identification of new areas for special protection in the southern bank of the River Amazon (Peru).
- Enforce the nomination of the three IBAs (Important Bird Areas) in the study area. Improve their management and use this status for fundraising and ecosystem management purposes.

Working line 9: Central and Local Governments' organization and primordial actions

High priority must be given to this working line.

Project Title: Improving local people's welfare, targeting vulnerable groups (children, women, indigenous), to ensure the success of implement freshwater biodiversity conservation strategies.

Objectives

Control human population growth in the area.

Improve local people's welfare.

Implement conservation mechanisms proposed in international treaties or by international organizations to improve conservation initiatives and practices.

Activities

- Enforce policies and set up education and health programmes to control birth-rates among the indigenous communities and in the urban population.

- Stronger policies and control campaigns to monitor the Israeli Movement in Peru and Colombia. Implement better and stronger policies, education initiatives and social work. Integrate them if possible to conservation programmes and educational campaigns.
- Overcome social disparities in other areas of the Colombian Amazon responsible of human displacement processes.
- Enforcement, improvement and formulation of new poverty reduction programmes focused on improving local community housings, medical institutions, childcare, health system, counselling, women and child violence, and food security.
- Give economic incentives to indigenous reserves that are working in environmental and cultural conservation programmes.
- Strengthen the implementation of Clean Development Mechanisms (CDM) proposed by the Kyoto Protocol and forest conservation and control of carbon emissions strategies such as the Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD-UN).

6.5.3 Implementation, management, evaluation and sharing

Strategies related to monitoring and evaluation of the outputs and outcomes of the actions are critical to ensure coordination of activities and programmes, assess whether targets are being achieved and allow adjustment of activities to support their continual improvement (adaptive management) (Cowx *et al.* 2011).

Most (if not all) of the management and action plans formulated and implemented in the area lack monitoring and evaluation reports. Little feedback is provided to communities or researchers and government institutions. Without this feedback stakeholders cannot see if shifts of targets or direction are needed as knowledge improves. For this Management Plan the main output of monitoring and evaluation must include:

- Monitoring and reporting the condition of the local freshwater biodiversity and pressures associated with their use.
- Evaluating and reporting on investments in natural resources exploitation and management activities, and the outcomes of those investments in effecting change in freshwater biodiversity condition.
- Reporting on regional and national economic development initiatives that might have an impact on the local or nearby freshwater ecosystems. Action and Contingency Plans need to be shared with the affected stakeholders.
- Investigations and actions to measure habitat degradation in freshwater ecosystems.

- Reporting against a scientifically established set of fishery and ecosystem health indicators.
- Provision of basis for decision-making to improve the management of the freshwater biodiversity of the study area.
- Document the role and responsibilities of all national and local stakeholders involved in the conservation of the freshwater biodiversity in the South of the Amazonian Trapezium.
- Document, provide feedback and disseminate results and lessons learned.

This Management Plan before being implemented needs to be endorsed by the local communities and environmental authorities and planners. The Management Plan will be put into consultation among stakeholders in 2012 and ideally it should be incorporated within updated regional development plans.

All local and national stakeholders mentioned in this study will take part of this consultation and clarity and transparency is expected in these processes, including implementation, monitoring and evaluation.

The stakeholders mentioned throughout this chapter and held responsible for the different proposed projects have been working either by themselves or in association with other stakeholders. However, despite working together in the same territory, the framework that should hold them together is weak.

An initial meeting needs to be conducted to prime this collaboration where the roles and tasks of all the stakeholders needs to be clarified. This meeting must have the endorsement of the Ministries of Environment and Agriculture so the decisions taken by the different organizations will be acknowledge and monitored by higher levels. Such an action should enhance commitments to the process. The meeting needs to include not only the environmental authorities (Ministries, Corpoamazonia, INCODER the National Natural Parks Unit), local and National NGOs (Omacha, Natutama, Codeba), Sinchi Institute and the National University, and the Indigenous Leaders, but also organizations that can provide support to all conservation initiatives. These include SENA as the National Learning Institute, DAFEC the Amazonian Department of Tourism, the Municipal Unit of Agricultural Technical Assistance, and representatives of the Administrative Department for the environment DABADE and the Municipal Secretary of Environment and Productive development of Leticia, as well as representatives of Leticia and Puerto Nariño Municipalities. The integration of these organizations will help to plan and develop conservation projects together with social, indigenous and economic development initiatives.

A stronger and more inclusive network of stakeholders needs to be consolidated for the area. Once this has been initiated, a monitoring process can be started. To make the

collection of reports and information possible one organization needs to be held responsible to lead the initiative. Previous experiences suggest that without a leader little can be achieved. The multiple responsibilities of all the people involved can interfere with the success of the network and therefore the implementation, monitoring, evaluation and sharing phases of any conservation initiative.

Six-monthly periods are recommended to report progress, outputs, deficiencies, constraints, actions to adjust failure to deliver, financial auditing and adjustments to management actions. All reports should be made publically available on websites of all stakeholders involved as well as on the Biodiversity Information System (SIB), the National Environmental Information System and the Amazonian Information System (SIAMAC).

It is important that progress and results from implementation of this management plan are disseminated within and beyond the region. Similar scenarios are found in widespread localities along the Amazon River basin and beyond, for this reason the outcomes of this plan will interest and benefit other parts of the world.

The aim of the management plan is to accomplish all the targets mentioned above by 2020, but it is likely that many bottlenecks will slow down progress to meet this target. Such a complex plan often takes longer to achieve its objectives than planned, but it is expected that by 2020 at least 85% of the recommendations proposed are running.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

7.1. General conclusions and recommendations

Water is vital for supporting life on earth and drives freshwater ecosystems, and it urgently needs to be given conservation status equivalent to terrestrial and marine ecosystems. The future of freshwater biomes in the South of the Amazonian Trapezium ecosystem relies in part on maintenance of connectivity (between aquatic ecosystems, within the riparian zone and floodplain and with subterranean systems, and along the river system from its source to its mouth) to support conservation of freshwater biodiversity. **Consequently, freshwater conservation initiatives must include an ecosystem vision where the conservation of ecological processes (important evolutionary phenomena and community assemblages) and singles species and habitats operate together. Conservation programmes in the area must also consider the division and management of the territory as a whole in all conservation and poverty reduction activities.**

Worldwide the lack of an appropriate classification of wetlands and water bodies, incomplete inventories of their flora and fauna, and insufficient knowledge about their ecology and species diversity is contributing to their rapid degradation and disappearance. The indirect drivers of these changes are population growth and an escalating economic development enhanced by direct drivers like the need for food, space, clean water, recreation, and alternative sources of income. In the Colombian Amazon, the high dependency on the freshwater ecosystems and the way this has changed through time need to be considered by decision makers and conservationist during their planning processes. **For this reason it is vital to integrate social initiatives into conservation programmes and to create new income and training opportunities to improve livelihoods.** Inclusion of local communities in the formulation, implementation and monitoring stages of all conservation initiatives is crucial to success. It has been proven that sustainable use of resources works best when working together with the resource users.

The use of environmental education constitutes one of the more powerful weapons for any society and especially in a developing region where rapid changes are taking place. Education should have a better place within the national and local governments. **It is urgent to formulate and implement educational policies especially for the local area.** Transfer of experiences with native communities from other parts of the country might not be successful where the realities of those communities differ enormously from the ones in the south of the Colombian Trapezium. **However, transfer of successful experiences with other communities within the Amazon region must be done.** More training experiences for the youth, adults and elders are needed. **More places in Amazonian and National universities and funding opportunities will give them the chance to improve their livelihoods and the life of their**

communities as well as giving them a greater representation in the national and regional government and enable them to be more influential in all decision making processes.

Local communities' currently conduct their daily activities according to the ancestral knowledge they have inherited and Christian beliefs taught by missionaries centuries ago. Elders and adults try to maintain a little bit of both worlds, but the younger generation struggles to find a place where their indigenous life matches the western lifestyle. These situations are vital to understand the changes happening within these communities and that are driving the way they think and live. Assuming isolated, uneducated and pristine indigenous communities to formulate and implement conservation strategies is mistaken misconception. To protect the cultural heritage of the Amazonia and to ensure the survival of a culture **new and updated characterisation and anthropological studies of the current society and ethnicities of the south of the Colombian Amazon should be conducted** to understand their needs and aspirations for the 21st Century. The combination of ancestral knowledge and scientific information is a successful combination.

National and regional conservation strategies comprise the creation and implementation of management tools such as indigenous reserves, national parks, forest reserves and private protected areas that up to now have been managed to isolate some elements of the freshwater ecosystems from indiscriminant users. Possibly the story would have been different if these management tools had not been created in the first place. For local people the ownership of their territories reaffirms their culture and identity. However, multiple territorial divisions holding multiple and disorganized managers is something that stops these areas accomplishing their conservation aims. **Problems arising from overlapped territories (Ticoya/NNP Amacayacu – Ticoya/Puerto Nariño Municipality) and unclear stakeholders' jurisdictions are problematic. For this reason it is urgent to provide legal entitlement to those areas that are still waiting to be recognized as indigenous reserves and to enforce the current legislation regarding the conservation of the Amazonian Forest Reserve to ensure no further land is lost to human and economic development.** To help to close the conflict in the National environmental policy, **all territorial planning needs to be done based on ecological criteria.**

The Indigenous Territorial arrangement should be seen as a way to ensure the sovereignty and integrity of the Amazon region. Indigenous governments must be empowered to have complete control of their territories and resources (including the subsoil). The stronger the indigenous communities, the greater the opportunities to protect the environmental and cultural capital of the country.

To overcome problems related to stakeholders' performance and efficiency, **further strategies need to be formulated to facilitate stronger communication and exchange of experiences, ideas and information among stakeholders**. Maintaining strong networks of stakeholders (local communities, civil society, researchers, academics, volunteers, governmental personnel

and policy enforcers) is vital to protect (or prepare) the area from predictable and probably irreversible environmental and social changes.

Regional conservation initiatives like ACTO, the CBD, the Ramsar Convention on Wetlands, CITES and IUCN have the power and motivation to encourage governments and institutions work together towards the conservation of the Amazonian ecosystems and their cultural heritage. **National and local environmental, social, economic and development plans need to take this into consideration and drive their activities towards achieving goals established by international protocols**.

Amazonian and Colombian initiatives, regulations and policies must aim to achieve a balance among the agricultural production, the extension of the urban centres and the quality of the water, the exploitation of fish and freshwater biodiversity, and the development of tourism strategies as well as the maintenance of the cultural identity of the local peoples. **To ensure this, national (economic, social, educational, health and cultural) policies must be formulated using environmental criteria and based on the importance of Colombia as a mega-diverse country to the world.**

Finally, as a continuous system, the River Amazon and its freshwater habitats in the South of the Trapezium are more vulnerable to changes taking place upstream in Peru, Ecuador and Colombia and downstream in Brazil. So far there are few common policies and regulations applicable to the Trapezium Area (Colombia/Brazil/Peru) regarding fisheries management, endangered species conservation, water quality and infrastructure development. **The future of the area is therefore dependent on collaboration among the three governments and formulation and application of policies and management plans to control the impacts generated by infrastructure development initiatives (navigation channels and dams) and to regulate daily activities like fisheries, logging and navigation**.

7.2. Elements of the local freshwater biodiversity (species, habitats and ecosystem services).

Difficulties generated by the nature of freshwater biodiversity (being submerged and highly mobile) complicate efforts to estimate their abundances or understand their populations, habitat use or conservation status. The identification of conservation surrogates has proven to be an effective conservation tool (when it is part of a wider conservation strategy considering social, cultural, economic and historical dynamics). Their link to other less visible or charismatic species, and to their habitats, constitutes an advantage that needs to be further exploited. **It is recommended to conduct more visual and 'aggressive' campaigns with these conservation surrogates as protagonist at national and regional levels; typically the campaigns remain local, but** conservation of the freshwater biodiversity of the South of the Colombian Trapezium cannot be only maintained by local communities alone.

The specificity of some species to certain habitats makes it a priority to establish conservation initiatives to protect island systems (Patrullero and Vamos Islands, and Mocagua Island),

beaches (Mocagua and Patrullero) and macrophyte patches (in lakes and river shores). Their conservation status will influence populations of highly endangered species like the Amazonian manatee, the black caiman and the Charapa Turtle.

The local freshwater ecosystems are still capable of adapting to change and to recover from disturbance, but their degradation and disappearance will reduce their capacity to mitigate impacts provoked by natural or anthropological causes, therefore causing a reduction of the services and benefits for human welfare. **It is essential that stakeholders move towards the ecological and economic valuation of ecosystem services as a new conservation strategy, and to integrate them into socio-economic decision making rather than consider them separately.** The integration of all conservation strategies, education, alternative income opportunities, territorial planning, stakeholders networking, surrogates of conservation, and valuation of ecosystem services will tackle all environmental cultural, social, political and economic sectors needed in an integrated management strategy.

Fisheries in the Colombian Amazon need to be assessed always from a multi-species, multi-gear approach. The fish species selected in this research can be used as indicators of fish assemblage and therefore the status of the local fisheries and aquatic ecosystems. **Conducting multi-species stock assessments is a priority to implement proper conservation initiatives and to monitor** changes in species composition, length of individual, biomass and catch per unit effort.

Commercial, ornamental and subsistence fisheries, as the most important cultural and economic activities and ecosystem service for the region, are in need of a better management infrastructure and authority that represents and regulates them, as well as the fishermen. To achieve this, there is a need to understand how these activities and their users exploit the common pool resources of the region. **Consequently there is need to restructure the fishing authority.** More people are needed in the field interacting with the fishers and their families, listening to their needs and working with them directly, and not just through other researchers and institutions. The authority should co-ordinate this and have a permanent presence in addition to providing money. They are also a need to exercise their role as controllers and protectors of the resource, and enforcers of legislation that is binding for everyone, including outsiders and strangers to the areas dynamics who have had a disproportionate influence over legislation.

7.3. Key conservation areas

Lakes systems have been recognized as important refuges for all conservation surrogates and for the provision of vital services like clean water for the largest cities and towns in the area; Puerto Nariño (Tarapoto Lakes System), Caballo Cocha (Peru) (Caballo Cocha Lake) and Leticia (Yahuarcaca Wetland System). **As key conservation areas, these three systems need to be upgraded to areas of special protection and recognized as such by the National Governments and international organizations like the Ramsar Convention on**

Wetlands. Conservation of the three lakes system depends enormously on protection of their surrounding systems. **For that reason, conservation of areas like the Loreto-Yacu River and area of the Mocagua Island and their biodiversity components should be included in the protected areas**.

The corridor created by the Amazon River upstream to the Naranjales Community constitutes a vital area for protection. This area is a corridor used by people and migrating species moving to and from the areas of Caballo Cocha Lake, the Atacuari River, the Loreto Yacu River, the Tarapoto Lakes System and the Patrullero and Vamos islands. **It is recommended that rivers, especially the segments of the Amazon River, are considered objects of conservation rather than simple border lines or navigation paths.**

Co-management projects need to be established all along the study area. International experiences need to be learned and implemented in the area. Stronger collaboration with Brazilian researchers is needed to improve local community based conservation approaches. The support of the Ministry of Environment and the Fisheries Authority is essential as well as the commitment of local people for the success of this strategy.

7.4. The methodology – Multi-criteria approach

The Multi-Criteria Approach (MCA) is shown to be a useful technique to identify key conservation areas and enable stakeholders to disaggregate the elements of the freshwater ecosystems to identify their importance within the ecosystem. However, the accuracy of the results will depend on collaboration with stakeholders and the knowledge they have to evaluate the criteria. The selection and active participation of stakeholders is crucial in the MCA approach; the more people involved the better and the more reliable the results. This research did not account for participation of all environmental authorities of the area, and it will not be known if the results would have been different with their inclusion. **Implementation of a multi-criteria approach is recommended for all conflict resolution initiatives proposed in highly dynamic and complex areas, but must involve stakeholders; these evaluations need to be conducted together with the with local communities and decision makers.**

The results of this research express the opinion of the local stakeholders, and as the main decision makers and lobbyists, this work will constitute an important foundation, especially for politicians and policy makers. **However, it is vital to adapt this methodology and apply it to local communities and resources users. The results obtained in these evaluations should be contrasted with the outputs of this research to formulate and implement more accurate, complete and alternative conservation strategies**.

The methodology also constitutes an important tool to evaluate the way different stakeholders know, perceive and assess their natural resources. This research exemplifies how governmental representatives tend to under rate vital elements of the biodiversity, either through a lack of knowledge regarding the particularities of each variable or a lack of knowledge

about their role within the ecosystems and the benefits provided to human welfare. **Environmental education must not only be part of schools' curricula but also disseminated to resource users. Politicians, decision makers and the general society need to be educated about their local and national elements of the biodiversity: species, habitats and ecological processes, and more information about the importance of ecosystem services needs to be shared with all citizens. The inclusion of politicians in conservation initiatives can be thought of as a possible solution to overcome this situation**.

It is important to keep in mind that a computation is not a decision. The results obtained in this research must form the basis of decision making processes and not be the final answer. The relevance and strength of the MCA depends ultimately on knowledge and experience of the people analysing the results, and questioning whether, in some cases the, results are biased. Another flaw of the methodology is that ranking methods may not be discriminatory enough. In cases where variables are little known or their role in the system is poorly understood the decision maker might opt out by giving equal assessments. MCAs need to be formulated and adapted every time to the particularities of the area, the ecosystem and the evaluators.

Mapping the results obtained in the literature review and the assessment of the multi-criteria matrix was shown to be indispensable to visualise key biodiversity areas, areas for special use and areas that need special attention and management. Maps also make easier to explain conservation priorities to policy makers and people with little knowledge of the elements assessed and in charge of important management, developing and investing decisions.

Information provided in this dissertation can provide a management framework to those coordinating and planning new and existing initiatives to conserve the local and regional biological, cultural and social diversity.

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APPENDIX 1.

Indigenous Reserves of the South of the Amazonian Trapezium.*

Indigenous Reserve	Communities	Municipal District	Ethnic groups	Creation law	Year	Size (Ha)	Population
Ticuna de Arara	Arara	Leticia	Ticuna	Res. 092	1982	12.308,0	672
Ticuna de El Vergel	El Vergel	Leticia	Ticuna	Res. 060	1983	2.525,0	202
Cocama de Ronda Isla	Ronda	Leticia	Cocama	Res. 042	1996	60,2	408
Ticuna Uitoto Km. 6 and Km 11	Km 6 San Jose Km 7 Km 11	Leticia	Ticuna – Uitoto	Res. 005	1986	7.540,5	313
Ticuna Cocama de La Playa	La Playa	Leticia	Ticuna	Res. 00009	1999	246,9	388
Ticuna de Macedonia	Macedonia	Leticia	Ticuna	Res. 060	1983	3.410,0	567
Ticuna de Mocagua – Isla de Mocagua	Mocagua	Leticia	Ticuna	Res. 060	1983	5.255,0	371
Ticuna de Nazaret	Nazareth	Leticia	Ticuna	Res. 081	1982	1.367,0	605
Ticuna Cocama Yagua de Puerto Nariño	Palmeras, San Martin de Amacayacu, Valencia, Puerto Rico, Pto. Esperanza, 20 de Julio, Patrulleros, Puerto Nariño,	Pto. Nariño	Ticuna, Cocama, Yagua	Res. 021	1990	86.871,7	6670

	Pozo Redondo, Naranjales, Tres Esquinas Boiauassu, 7 de Agosto, San Juan de Atacuari, Santa Clara de Tarapoto, San Francisco, Nuevo Paraíso, Santa Teresita, San José de Villa Andrea, San Juan del Soco, Santarém, San Pedro de Tipisca,						
Ticuna Cubeo de Pto. Triunfo	Puerto Triunfo	Leticia	Ticuna, Cocama	Res. 076	1999	1.129,7	121
Ticuna de San Antonio y San Sebastián de Los Lagos	San Pedro and San Antonio de los lagos	Leticia	Ticuna	Res. 087	1982	188,8	406
Cocama de San José del Rio	San José del Rio	Leticia	Cocama	Res. 043	1996	548,6	229
San Juan de los Parentes	San Juan de los Parentes	Leticia	Ticuna	Res. 075	1999	46,1	76
San Sebastián	San Sebastián	Leticia	Ticuna	Res. 087	1982	58,9	168
Yagua Ticuna de Santa Sofía y El Progreso	Los Yaguas, Santa Sofia and El Progreso	Leticia	Ticuna, Yagua	Res. 080	1982	4.209,0	817
Ticuna Yagua de Zaragoza	Zaragoza	Leticia	Ticuna	Res. 060	1983	5.560,0	377
Total						**131.325,4**	**12.390**

* Riaño-Umbarila 2003 and Castellanos *et al.* 2009.

APPENDIX 2.

List of stakeholders and institutions involved in this research

Name	Organization	Type of organization	Type of contribution
Fernando Trujillo	Foundation Omacha	NGO	Multi-Criteria matrix and documentation
Luisa Castellanos Mora	Foundation Omacha	NGO	Multi-Criteria matrix and documentation
Catalina Trujillo	Foundation Omacha	NGO	Documentation
Sarah Kendal	Foundation Natutama	NGO	Multi-Criteria matrix and documentation
Alejandra Galindo	Foundation Natutama	NGO	Documentation
Santiago Duque	Universidad Nacional de Colombia – Leticia	University / Academia	Documentation
Camilo Torres	Jorge Tadeo Lozano University	University / Academia	Multi-Criteria matrix and documentation
German Ochoa	Universidad Nacional de Colombia – Leticia	University / Academia	Multi-Criteria matrix and documentation
Jaime Alberto Celis	Special Administrative Unite of National Natural Parks of Colombia -UAESPNN	Research. National Protected Area.	Multi-Criteria matrix
Alexander Alfonso	NNP Amacayacu	Research. National Protected Area.	Documentation
Edwin Agudelo	SINCHI Institute	Research Institute	Multi-Criteria matrix and documentation
Juan Carlos Alonso	SINCHI Institute	Research Institute	Multi-Criteria matrix and documentation
Juan Carlos Arias	SINCHI Institute	Research Institute	Multi-Criteria matrix
Marcela Núñez	SINCHI Institute	Research Institute	Multi-Criteria matrix
José Zoria	SINCHI Institute	Research Institute	Multi-Criteria matrix
Alvaro Gomez	Commerce Chamber of Amazonas	Governmental institution	Multi-Criteria matrix
Jenny Lorena Ortiz	Ministry of Production - Produce (Peru)	Governmental institution	Multi-Criteria matrix
Ricardo Sanchez	Environment and Tourism Department. Leticia City	Governmental institution	Multi-Criteria matrix
Jhon Jairo Cruz	Corporacion CODEBA	NGO	Documentation
Bernardo Corrales	Colombian Institute of Rural Development - INCODER	Governmental institution	Documentation
Oscar Tamayo	Colombian Private Natural Reserves of the civil society Network -	Private organization	Documentation

	RESNATUR		
Thomas Walshburger	TNC Colombia	NGO	Documentation
Carlos Rodriguez	Tropenbos International Colombia	NGO	Documentation
Ivan Dario Melgarejo	Puerto Narino City Council. Planning Depertment.	Governmental institution	Documentacion
Argemiro Perdomo	Leticia City Council. Planning Depertment.	Governmental institution	Documentation
Andres Rendon	Accion Social - Leticia	Governmental institution	Documentation
Sergio Silva	Ticuna Cocama Yagua Reserve -TICOYA	Indigenous Reserve	Casual chat
Jhon Jairo Leon	Macedonia Reserve	Indigenous Reserve	Casual chat
Ms. Serafina	Puerto Nariño	Indigenous Reserve	Casual chat
Don Ruperto	7 de Agosto Reserve	Indigenous Reserve	Casual chat
Don Delfino	San Pedro de los Lagos Reserve	Indigenous Reserve	Casual chat

APPENDIX 3.

Multi-Criteria Matrix

	Yahuarcaca Lake YAH_L	Yahuarcaca Creek YAH_C	River Amazon San Jose AMA_1	PNN Amacayacu buffer area MOC_I	Tarapoto Lakes TAR_L	Loreto Yacu River LOR_T	Patrullero and Vamos Islands PAT_L	River Amazon Naranjales. AMA_2	River Atacuari ATA_T	Caballo Cocha Lake CAB_L
Fine Filter Targets										
River Dolphins										
Black Caiman										
Amaz. Manatee										
River Otters										
River Turtle										
Pirarucu										
Fish: Scale and leather fish										
Birds: Migrant and aquatic										
Sp. with nutritional benefits										
Sp. with pharmaceutical purposes										
Disease Controllers										
Primary Production										
Coarse Filter Targets										
Flooded Forest										
Floating meadows										
Beaches										
Confluences										
Main river										
River pools - *Remansos*										
Ecosystem Services and Societal Benefits										
Scientific and Social Research										
Transportation/Navigation										
Sport Fishing										
Local Fishing										
Commercial Fishing										
Ornamental Fishing										

Water for human consumption										
Waste deposition										
Climate balancing										
Water for agriculture										
Dolphin watching										
Indigenous communities - Handicrafts										
Landscape viewing										
Threats										
Overfishing										
Illegal use of fishing gears										
Water pollution										
Logging										
Hunting										
Conflict dolphins/ fisheries										
Abstraction of water for agriculture										
Dams										
Lack of income alternatives										
Lack of law enforcement										
Failure of River Planning strategies										
Problems among stakeholders										
Border conflicts										
Boat traffic										
Tourism										
Climate change										
Human population growth										
Mining										
Changes in aquatic bodies										
Changes in land use										

APPENDIX 4.

Logical Framework Approach (LFA).

Project Summary	Measurable Indicators	Means of verification	Important assumptions
Goal: To enable the South of the Colombian Amazon Trapezium to contribute to the local and national economy, and provide goods and services that enhance the social wellbeing for current and future generations without compromising environmental integrity by 2020			
Sub-Goal: To formulate a Management Strategy for the freshwater biodiversity of the South of the Amazon Trapezium	Management Strategy formulated and published.	Strategy endorsed by the Environmental Authority. The published Strategy available online and in hard copy.	The document resulting from this dissertation will be reviewed by several organizations that have to be involved in the process: MAVDT, Corpoamazonia, INCODER, Sinchi, Universidad Nacional de Colombia, Fundacion Omacha, UAESPNN, Indigenous and local communities, city council. Consultation with international experts on freshwater biodiversity, fisheries and management will take place.
Purpose: To conserve and protect the freshwater biodiversity of the South of the Amazonian Trapezium, this includes species, habitats and environments	Maintenance in the abundance of strategic conservation surrogates like river dolphins. Reduction of the number of annually deforested ha. and an increase in area of flooded forest along the Amazon River. Waste management strategy for the urban centres and rural communities. Increment in size of the sewerage network and a recycling strategy formulated and implemented.	Abundance estimation reports every two years. Available reports and data provided by the regional and national environmental authorities as well as other organizations involved in reforestation initiatives. Improvement of the facilities of the dump located near the city of Leticia including the creation of infrastructure to process recycling materials. All households in rural communities connected to a sewerage network. Recycling strategy implemented along the south of the Trapezium. Educational material distributed and visible across the area. Recycling bins distributed across the area.	Information needed to monitor populations; ecosystems and human activities will be available online in the different stakeholders' web-pages and the Biodiversity Information System. Due to the importance given by the National government to the area and the plans that it has to make it an important touristic destination, the formulation and implementation of a recycling strategy should be adopted easily by the Regional and local governments.

		Effective changes introduced in the policies regarding waste collection and disposal.	
Outputs: 1.To ensure the continuity of the freshwater ecosystem processes and services vital for the biodiversity maintenance and the local communities' livelihoods, the Amazon region and the country.	Continued research on endangered species by the organizations that so far have been in charge of studying and monitoring the different animal and plant species in the area. Economic and non economic appraisal of the ecosystem services and societal benefits provided by the freshwater ecosystems in the area. Creation of a base line that will help to monitor these service in the future	Reports, peer-reviewed articles, dissertations and other documents, available on the Biodiversity Information System of Colombia (SIB). A Freshwater Ecosystem services and societal benefits assessment published and endorsed by the local research institutions.	Species and ecosystems are currently monitored by the different stakeholders.
2. To enhance the livelihoods of local rural communities, ensuring food security and income opportunities through the proper use and management of the freshwater resources.	At least half of the rural population engaged in any type of sustainable productive project. More involvement of women. Reduction in the number of cases of malnourished children or women in indigenous communities. At least 5 local schools have introduced in their curriculum a module on Freshwater biodiversity use and management.	Creation of new social organizations, cooperatives or groups as a requirement for better management and results of the different sustainable productive projects. All groups must be registered in the Leticia Chamber of Commerce. Available (online) reports regarding children and women nourishment by the Colombian Institute of Family Welfare (ICBF). Addition of the new module on Freshwater biodiversity use and management approved by the Ministry of Education and in motion in all five schools.	All local and national organizations working in the area are uploading the final reports of their investigations, conservation strategies and poverty reduction schemes into the different Information Systems available to the Amazon region and the country.
3.To promote sustainable exploitation of the fisheries resources of the area.	Current formulated fishing agreements implemented in their totality. Formulation of fishing agreements in areas in communities settled along the Amazon river. A complete economic and environmental	Increment in individual size of commercial catfish in landed yield. Reduction in number of dolphins and caimans reported to be killed as bait for the mota fishery in brazil. Creation of a 'sustainable fishery'	Due to the importance of fisheries in the region and its meaning to local communities as well as the role they play in the current degradation of the local freshwater biodiversity, efforts focused on its management will continue to be implemented. Current changes implemented by the national

	assessment of the ornamental fishery in the area: characterization, current status and future potential.	certificate to all commercial species exported to other areas of Colombia and the Amazon region. Economic Assessment of the ornamental fishery activity formulated and published.	government in terms of a new Environment Ministry and regional environmental authorities, more funds and human resources are expected to be available to the South of the Colombian Trapezium.
4. To provide stakeholders information to improve decision making processes regarding the conservation and sustainable use of freshwater biodiversity as well as the development, investment and improvement of indigenous communities, areas of special management and urban centres.	Management Strategy socialized within the different social, governmental and non-governmental organizations. Changes in regional and local policies regarding freshwater resources access and exploitation, rural and urban development.	Stakeholders meetings Attendance list Letters of acceptance signed by Indigenous leaders from all indigenous reserves. Expedition of new policies and regulations that aim to the sustainability of the territory, its resources and peoples.	Stakeholders will use the Strategy as a key document in their decision making processes. Stakeholders will also contribute to its improvement and implementation.
6. To contribute to the agreements signed by the Colombian Government regarding biodiversity conservation (CBD, CITES), freshwater and wetland conservation (Ramsar Convention), and indigenous communities (OIT) as well as to what it has been stated in the different national biodiversity policies and national, regional and local development Plans.	The results obtained with the implementation of the Strategy will be reflected in the periodic reports the National Government has to submit to the international Conventions.	Reports available and public to all stakeholders in the region.	The study area will keep bringing the attention of the National Government and national and international sponsors due to its ecological, social, political and economic importance, therefore more money will be invested making possible the implementation of the Management Strategy.