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Awareness and Understanding of Climate Change for Environmental Sustainability Using a Mix-Method Approach: A Study in the Kathmandu Valley

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Abstract: Climate change is a global phenomenon having wide-ranging social, economic, ecological, and environmental sustainability implications. This study assesses climate change awareness, understanding, causes, mitigation measures, and practices among residents of the Kathmandu Valley through a mixed-method approach. Quantitative surveys with 433 respondents and four Focus Group Discussions (FGDs) are conducted with diverse demographics. Descriptive statistics is used to summarize quantitative data, and the chi-square (χ^2) test is used to measure the associations between awareness, understanding, causes, mitigation measures, and practices among various demographics. The analysis shows that respondents frequently link climate change to extreme weather events, particularly flooding, severe hot and cold waves, and changes in rain precipitation patterns. Furthermore, the respondents identify deforestation, industrialization, and fossil fuels as the primary causes, with mitigation strategies such as afforestation, recycling waste, and use of renewable energies for long-term environmental sustainability. Similarly, the survey analysis also revealed that greenhouse gases like carbon dioxide and methane are major drivers of climate change; individuals, industries, and governments are held accountable for climate change with industries as key polluters. Furthermore, individuals are self-aware to adopt sustainable practices, and the government can play a vital role through policies promoting renewable energy, afforestation, and waste management, alongside raising awareness. Other highlights of the analysis have been raising voices of collective action at all levels, which is crucial to mitigate the impact of climate change. The study also addresses the gaps in comprehensive climate literacy and underscores the need for targeted educational initiatives to foster informed climate actions within the community. Likewise, the study brings the findings that policymakers should prioritize inclusive engagement strategies, ensuring that climate policies and adaptation programs are accessible, particularly to those who are less represented in environmental discourse, such as older adults and unschooled individuals.

Keywords: climate change; awareness; mitigation; mixed method; environmental sustainability; multistage sampling; climate education; media preferences

1. Introduction

Climate change is one of the most pressing global challenges of the 21st century, with a severe impact on ecosystems, economies, communities, and environmental sustainability.

Climate change disrupts ecosystems by altering global thermal regimes and the water cycle causing acidification [1]. As the impact on the economies, it reduces agricultural productivity, leads to loss of land and capital due to rising sea level, causes capital damage due to natural calamities, and changes in labour productivity due to mortality and morbidity from infectious diseases [2,3]. Natural disasters also force the human population to move to new locations leading to human population displacement, social instability, loss of cultural heritage [4], and adding pressure to urban areas and resources [5]. All these interconnected effects contribute to environmental degradation, and resource depletion ultimately threatening environmental sustainability. Climate change has numerous reflective implications for society directly or indirectly in the form of rising temperatures, more frequent storms, irregular hydrological cycles, rising sea levels, and uneven precipitation patterns [6,7]. These changes profoundly impact public health, agriculture, energy production, water use, and biodiversity. Considering the severity of climate change, the United Nations (UN) is urged to take urgent actions to reduce the impact of climate change by setting it as one of the UN Sustainable Development Goals (SDGs) [8]. The 29th Conference of the Parties (COP29) conducted from 11th to 22nd November 2024 in Baku, Azerbaijan, brings together world leaders and negotiators from the member states of the UN Framework Convention on Climate Change (UNFCCC). The purpose is to review the success of the previous year and pave the way for future ambition to effectively tackle the global challenge of climate change. Business leaders, young people, climate scientists, indigenous people, and civil society also share their insights and best practices to strengthen global, collective, and inclusive climate [9].

Along with global concerns, Nepal has recognized climate change as a significant threat to its social well-being, environment, and economy [10]. It is also projected that by 2030, the number of people affected by flooding could be more than double in Nepal [11]. Considering environmental sustainability, Nepal has also prioritized climate concerns at the government policy level and incorporated them into planning, formulating, and implementing climate change policies [12,13]. With ongoing concern, climate change challenges humans' day-to-day lives, which requires mitigation strategies to minimize its impacts. It is essential to have a deeper understanding of the facts, attitudes, and perceptions of climate change among the public [14]. Nepal is highly dependent on traditional energy sources like firewood; however, in recent years, significant efforts have been made to implement multiple forms of renewable energy sources in both rural and urban areas, reducing greenhouse gas emissions and minimizing air pollution [15]. Climate change has impacted Nepal in several ways such as depletion of natural water resources, reduction in agriculture production, and hence, environmental sustainability [16,17].

Climate change is not only the consequence of climate catastrophe but also the result of human and natural systems, which requires awareness among the group of people [18–20]. In other words, the awareness of climate change among the public is essential to minimize the impact and also to persuade change in their attitudes and behavior [21,22]. Accessing programs on public awareness and community-led initiatives, intervention can promote the effectiveness of policies and address local climate issues, which can increase the engagement of stakeholders in climate and environmental sustainability [23,24]. During the last decade, Nepal has integrated climate change awareness into school education, ultimately increasing the level of awareness of students to 78% [25]. This number looks quite promising, but when it comes to awareness among farmers, it has only been 60% [26]. These prior studies have explored the level of awareness of climate change among various demographics; however, a deep-dive understanding of the reasons for climate change, mitigation strategies, and the role of government/communities/individuals has not been explored. This brings the need for a detailed study to understand its impact along with the effective adaptation,

implementation, and mitigation measures as awareness and understanding are vital since individuals can make informed decisions that can reduce the impact and enhance their resilience to climate-related risks. What this means is that despite the growing impacts of climate change, there seem to be significant research gaps in accessing the level of awareness, understandability, knowledge, and practices among Nepali citizens.

In this paper, awareness, understanding, causes, mitigation measures, and practices among the general public from the Kathmandu Valley of Nepal have been analyzed using the mixed method. The method comprises of survey questionnaire and Focus Group Discussions (FGDs) among the general public. The study adopts multistage sampling for the selection of the respondents for the quantitative survey. For the interpretation of the quantitative data, descriptive statistics and the chi-square (χ^2) test have been applied to reveal the awareness, understanding, knowledge, and mitigation measures across various demographic variables including age, gender, education, and occupation. For qualitative insights, four FGDs are performed with various gender and age groups. The results indicate a moderate level of awareness and understanding of climate change. Most of the respondents understand the impact of climate change primarily in the form of flooding, temperature fluctuations, and changes in rain precipitation patterns. The respondents perceive the top three reasons for climate change are deforestation, industrialization, and fossil fuel emissions, which can be significantly improved through afforestation, recycling, and promoting renewable resources. By identifying specific knowledge gaps and awareness, this research contributes directly to society by informing policymakers, educators, and environmental organizations about the need for community-based climate education initiatives to deepen understanding and address local impacts towards achieving environmental sustainability. This research introduces a contextualized approach to climate change awareness, integrating demographic-specific insights to develop targeted policy recommendations for effective mitigation and adaptation strategies.

The rest of the paper is structured as follows: Section 2 reviews recent literature in the research domain. Section 3 outlines the methodology employed. Section 4 presents the findings from the analysis. Finally, Section 5 offers concluding remarks and proposes directions for future research.

2. Literature Review

Climate change is not only the consequence of climate catastrophe but also the result of human and natural systems, which requires awareness to the public [27]. The degrading climate condition needs mitigation strategies and a deeper understanding of the facts, attitudes, and perceptions about climate change from the public to minimize the harmful impact [14]. In the last few years, awareness of climate change has increased [28]. Recently, individuals' environmental perceptions, risks, and knowledge have shifted towards sustainable energy consumption behavior [29]. Citizens who are personally concerned about climate change are emotionally engaged about its consequences, making them more motivated to act upon the climate change actions [30]. In other words, citizens are aware of climate change, experiencing its ongoing impacts as a threat to sustainable development that requires immediate and urgent concern [31].

2.1. Awareness of Climate Change

A study in the United Kingdom to understand public perception of weather-related changes concludes that perceptions and experiences of extreme weather are more recalled when they are associated with a stronger negative effect [32]. In another similar study, it has been observed that aware citizens recognize that they are accountable for climate change as

their actions and steps could minimize the impacts of climate change and environmental sustainability [33].

Climate awareness has also been increasing among the younger age group as well. A study [34] concludes that younger generations have a deeper awareness of environmental conditions and are committed to environmental sustainability by adopting "good ecological practices" and "active ecological behaviors". In another similar study [14], it has been found that students, teachers, and researchers are highly aware of climate change, because of their high concerns for the environment and society at large. A study in the UK [35] shows similar findings that evaluate the generational differences in climate-related beliefs, risk perception, and emotions. From this study, it is evident that younger generations strongly feel the negative impact of climate change compared to older generations. Similarly, countries with citizens having higher education are more likely to be aware and consider climate change as a threat in comparison to countries with less education [36].

Behavior change is crucial in addressing the climate change impacts, which have been in progress over the last several years. Earlier research has also indicated that knowledge of climate change is crucial for behavioral intentions and support for climate protection policy measures [37]. However, the lack of basic knowledge of climate change has been a barrier to mitigation measures. Therefore, it is important to investigate what the public currently knows about climate change [38–40]. A study focusing on youth attending secondary education concludes that youth have good knowledge of the impacts of climate change and behavioral change actions on reducing the use of fossil fuels and deforestation [41].

2.2. Understanding on Causes of Climate Change

Understanding the causes of climate change and its impact is crucial to addressing the climate crisis and adopting mitigation measures for climate change [42]. The current climate crisis comprises a set of complex and interconnected issues. One such is society's continuing dependence on fossil fuels for its main energy supply [43,44]. A cross-sectional study conducted in Bangladesh identifies the perceived causes of climate change among participants, with deforestation, population growth, and industrial effluents being the most commonly mentioned factors, while black smoke from vehicles is a less scientifically accurate cause due to their low levels of education and limited exposure to scientific information related to their occupations [45]. A study that assesses the awareness regarding climate change in an urban community concludes that deforestation contributes most significantly towards climate change, followed by vehicular pollution, burning of fossil fuels, and industrial pollution [46].

2.3. Understanding the Mitigation Measures of Climate Change

Considering the public's view on mitigation and adaptation measures is crucial. Individuals play a significant role in affecting climate change, considering their potential for reduction and mitigation measures [47]. Mitigation of global climate change not only requires government action but also needs cooperation from the citizens. Many studies conclude that citizens' perceptions and attitudes towards climate change risks are closely related to adaptive behavior and mitigation action towards environmental sustainability [41,48,49]. In terms of mitigation and preventive measures, studies have concluded that citizens recognize afforestation and environmental sanitation as the major factors [25]. Citizens also support afforestation programs as a mitigation measure, demonstrating their understanding of the role of forests in reducing air pollution and thus protecting the global climate [50].

2.4. Role of Entities in Tackling Climate Change

Furthermore, citizens also believe that there is still time to reverse the hazardous impact of climate change [51]. Citizens also advocate that it is everyone's job to mitigate climate change not just the role of world leaders and government [51]. People are ready to shift from the use of non-renewable resources to renewable resources for the betterment of global climate [52]. They are also willing to spend money to reverse the impact of global climate and switch to carbon-labeled products [53]. Similarly, a study [48] concludes that climate change is a worldwide challenge, and the impact of individual and national legislation alone is inadequate without international collaboration. Thus, it is crucial to create effective strategies, exchange knowledge, and enforce policies that tackle the interconnected and cross-border aspects of climate issues. Another similar study [54] concludes that the government plays an important role in addressing the impact, raising public awareness about climate change, and encouraging individuals and businesses to adopt sustainable practices that can play a major role in its mitigation and environmental sustainability.

These studies can be summarized as climate change is a global inevitable threat to our society and environmental sustainability [55,56]. Although there have been several studies on awareness and impact in different parts of the world, the research on highly prone zone countries such as Nepal is limited. Further research on public awareness and perceptions of climate change shall focus on understanding citizens' knowledge of its causes and consequences, and how this awareness influences policymaking and mitigation efforts.

3. Methodology

This section presents the methodology applied during this research work, focusing on the detailed approach used to investigate the research questions.

3.1. Research Design

This study employs a mixed-method approach, integrating quantitative and qualitative approaches to evaluate the research questions, an appropriate measure to get a comprehensive understanding as it uses multiple perspectives to validate findings through triangulation methods, participants, and sources [57,58]. The mixed-method study includes various designs: convergent, explanatory sequential, and exploratory sequential design. This study uses an explanatory sequential mixed-method design. This design was chosen since the subsequent qualitative data would help in explaining the initial quantitative results, which helps to provide a more in-depth understanding of the research questions [59]. There are two distinct phases: the initial phase is quantitative data collection using a structured survey questionnaire and the subsequent qualitative data collection through FGDs. Based on the findings of the survey data, the FGD guidelines are developed and four FGDs are conducted.

3.2. Instruments and Hypothesis

The questions utilized in the study, along with their attributes, are derived from an extensive literature review and presented in Section 2. Table 1 illustrates a summary of variables and attributes used in the study. A total of four hypotheses have been developed to measure the association of the awareness, understanding, causes, and reduction in climate change among various demographics. To validate the findings from the survey questionnaire, the FGD guideline is developed. The FGDs focus on acquiring an in-depth understanding of the subject matter and support the survey results.

Table 1. Variables proposed for the study.

Variables (References)	Attributes
Understanding of Climate Change [19,60–62]	Severe hot and cold waves, changes in rain (precipitation), severe droughts, flooding, rising sea levels, changes in plant growth, water scarcity, declining biodiversity, snow melting, increase in vector-borne diseases
Understanding on causes of climate change [62–65]	Burning fossil fuels, deforestation, storing waste in landfills, industrialization, intense farming, mining, overconsumption
Understanding the mitigation measures of climate change [63,66]	Afforestation, reducing burning fossil fuels, promoting renewable energies, buying eco-friendly products, recycling and reusing waste, optimal utilization of resources, adaptation to climate change, protection of water resources, and groundwater recharge
Greenhouse gases [67,68]	Carbon dioxide, methane, nitrous oxide, water vapor, chlorofluorocarbon
Accountable for climate change [69]	International Committee, the national government, industrialized country, business and industry, individuals
Responsible for tackling climate change [70]	International Committee, the national government, industrialized countries, business and industry, individuals, environmental organizations
Government action [63,65,66]	Awareness program, adaptation policies, protect key ecosystems, support small agricultural producers, promote green energy, carbon taxes
Responsible for tackling climate change [70]	International Committee, the national government, industrialized countries, business and industry, individuals, environmental organizations
Individual action [19,61,63,71]	Save energy at home, walk, bike, or take public transport, throw away less food, reduce, reuse, repair, recycle, switch to an electric vehicle, and awareness among friends and family
Media [61,71]	Television, radio, newspaper, word of mouth, social media, online media, internet search, specialist publication, government agencies

H1: *There is a significant difference in the awareness level of climate change among various demographics.*

H2: *There is a significant difference in the level of understanding of climate change among various demographics.*

H3: *There is a significant difference in the knowledge on causes of climate change among various demographics.*

H4: *There is a significant difference in the knowledge on reduction measures on climate change among various demographics.*

3.3. Sample and Sampling Method

The quantitative survey started with the development of the survey questionnaire followed by scripting and hosting in the digital data collection platform KOBO. All the questions in the survey questionnaire were made mandatory to remove the nonresponse bias in the survey. The pretest of the questionnaire was performed with 30 respondents in Kathmandu Valley. The pretest aimed to examine the clarity of the survey questionnaire for field researchers, the flow and skipping pattern of the questionnaire, the integrity, and

patterns of the data, as well as any technical or non-technical challenges encountered during the survey process.

An informed consent form was provided, and the signed forms were also collected from the respondents as an ethical consideration before starting the survey. The respondents were informed that the purpose of the survey was to measure the awareness and understanding of climate change for academic use, and their involvement was voluntary. The respondents were also informed that no personally identifiable information would be collected, their responses would be kept confidential, and the analysis would be performed at an aggregate level with all the responses without revealing or inferring their identities. Only the respondents above the age of 18 were interviewed in the survey as per the prevailing ethical guidelines of the Nepal Health Research Council [72]. The minimum sample size for the proposed study at a 95% confidence interval, 5% margin of error, and a response distribution of 50% was estimated using Cochran's formula [73]. This formula calculates the minimum sample size of 384 to be statistically significant. A total of 983 respondents were intervened where 433 respondents completed the survey, 97 partially completed, and 453 refused to participate yielding a response rate of 44.04%. The total completed samples of 433 are 12.76% above the minimum statistically required samples and were considered for data analysis [74].

The study adopted multistage sampling for the selection of the respondents in the Kathmandu Valley of Nepal. This capital city has the most ethnically diversified population with people coming from various parts of Nepal [75] and under the impact of climate change [76]. During the survey, firstly, two cities Kathmandu and Lalitpur of the valley were selected. Secondly, three prominent locations, New Baneshwor, Kalanki, and Maharajgunj in Kathmandu, as well as Patan, Bhaisipati, and Sanepa in Lalitpur within each of these cities were selected to capture diverse perspectives from different groups of people, ensuring a comprehensive understanding of climate change across various communities. An equal number of samples for males and females were collected as a proportionate quota sampling based on the National Population Survey 2021, Nepal [77].

The survey questionnaire was uploaded to the KOBO platform, and the sample data were collected using the KOBO app installed on smartphones. The fieldwork was the administered survey with six field researchers recruited for ten days in the Kathmandu Valley. For the qualitative data, four FGDs with six responses in each FGD were conducted. The FGDs include a separate male and female respondent group under the age group of 18–25 and 25–35. Gender-segregated FGDs were conducted to allow participants to express their views more freely, avoiding potential dominance by gender in mixed discussions, simply it is performed to minimize potential biases and encourage open dialogue. A screener was also developed to recruit the respondents for the FGDs. The screener criteria specify that respondents should not have any affiliation in the field of environment and forestry, have not participated in any similar environmental studies in the past six months, and have not been involved with the media industry. This was to ensure that individuals with specialized knowledge or insights in these areas did not influence the general citizens' awareness and understanding of climate change and environmental sustainability.

3.4. Data Analysis

The sample data are cleaned and uploaded to the Statistical Software for Data Science (STATA) version 16 for quantitative data analysis. Firstly, the demographic characteristics of the sample data are presented in tabular form using descriptive statistics. The demographic characteristic consists of age group, gender, education, and occupation.

Secondly, bar charts using the frequency distribution for the awareness, understanding, causes, and mitigation measures on climate change are presented. Furthermore, the

entities accountable for climate change, responsible units for tackling climate change, government and individual roles in reducing climate change, gases causing climate change, and preferred media in obtaining information on climate change have been presented in graphical form. Thirdly, the relationship between awareness, understanding, causes, and mitigation measures of climate change and demographic variables are assessed using the chi-square test.

In the qualitative part, the FGDs are recorded and transcribed. The thematic analysis of the transcript data is performed based on the objectives of the study. These data are then triangulated [78] with the quantitative findings to increase the credibility of the study and acquire an in-depth understanding of the subject domain.

4. Results and Analysis

In this section, descriptive statistics and the hypothesis testing of the quantitative data obtained from the survey are analyzed. Following this, the analysis of the qualitative data obtained through FGD is also analyzed.

4.1. Demographics of the Respondents

A total of 433 sample data are collected through an administered survey. The demographics of the participants are illustrated in Table 2. The sample consists of 220 females (50.81%) and 213 males (49.19%). The largest segment of the respondents falls within the 18–25 age group, comprising 115 individuals (26.56%), followed by the 26–35 age group with 93 respondents (21.48%). In terms of educational attainment, 186 participants (42.96%) hold bachelor's degrees or equivalent qualifications, while 21 (4.85%), report no formal higher education. The majority of respondents 108 (24.94%) hold regular employment followed by 71 respondents (16.40%) who are stay-at-home.

Table 2. Socio-demographic characteristics of the respondents.

Variables	Categories	Frequency	Percentage (%)
Age	18–25	115	26.56
	26–35	93	21.48
	36–45	76	17.55
	46–55	62	14.32
	Above 55	87	20.09
Gender	Female	220	50.81
	Male	213	49.19
Education	No formal education	21	4.85
	Primary education	58	13.39
	Secondary school	82	18.94
	Bachelor's level	186	42.96
	Masters level	86	19.86
Occupation	Unemployed	59	13.63
	Student	69	15.94
	Self-employed	62	14.32
	Retired	20	4.62
	Full-time employed	108	24.94
	Part-time employed	34	7.85
	Homemaker	71	16.40
	Casual labor/odd jobs	10	2.31

4.2. Awareness of Climate Change

Among the total respondents, 31.87% have heard a little bit about climate change, followed by a fair amount (36.49%) and a lot (30.02%), as plotted in Figure 1. The results indicate most of the respondents are aware of climate change. The findings of the FGDs entail that the respondents have heard about climate change, irrespective of demographics. The analysis also reveals that the issues of climate change have been discussed in school education and media content. Additionally, personal experiences on the environmental changes have provided tangible evidence of climate change effect, contributing to a deeper understanding of the issues among participants. Understanding the level of awareness of climate change is crucial as per the survey report of the Intergovernmental Panel on Climate Change (IPCC), adverse impacts of climate change are likely to impact Southeast Asia primarily, due to an increase in the occurrence of droughts, increase in the incidence of intense rains, and rise in temperature [79].
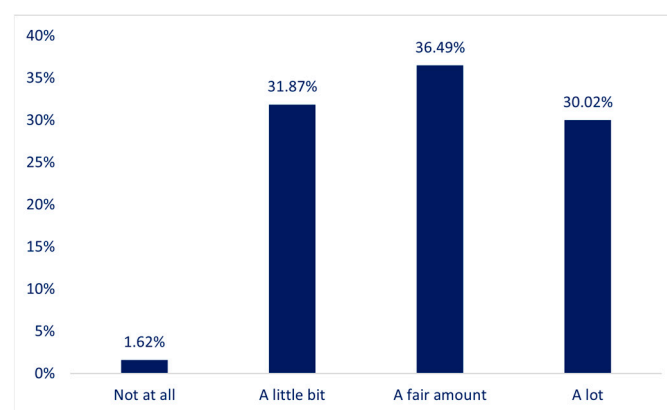

Figure 1. Awareness of climate change.

> *"The subject EPH, which stands for environment, physical health, and human health, is where I first learned about climate change in the eighth grade."* FGD 1, Participant 1

> *"I came to know about climate change in my school. Increased pollution, low visibility, and an increase in temperature are caused by the effects of climate change."* FGD 2, Participant 4

Table 3 presents the results of the χ^2 test between awareness and various demographics. The result reveals that there is a significant difference between the level of awareness and age (χ^2 = 56.26, $p < 0.001$), education (χ^2 = 56.55, $p < 0.001$), and occupation (χ^2 = 66.29, $p < 0.000$). However, the awareness level among males and females is the same. Respondents aged 18–25 demonstrate the highest awareness, with many identifying as "A lot" aware of climate change. This indicates that younger individuals tend to be more informed about climate issues, which is aligned with the research that while scientifically accurate knowledge increases with age, the younger generation expressed greater concern and is willing to take more action suggesting they are highly aware of the negative consequences of climate change [80]. Among education levels, respondents with a bachelor's degree exhibit strong awareness highlighting the role of higher education in fostering climate awareness. Similar are the findings from the study conducted to measure public awareness and perception of climate change, where awareness is greater in countries with more highly educated populations [81]. On the occupational side, individuals with a regular job show the highest level of awareness, with a significant number identifying "A Lot" aware. Similarly, self-employed respondents also demonstrate strong awareness, indicating that professional engagement may contribute to better climate knowledge.

Table 3. χ^2 association between awareness and demographics.

Demographics	Pearson χ^2	*p* value	Hypothesis Test
Age	56.2638	<0.001	Supported
Gender	6.0217	0.111	Not Supported
Education	56.5538	<0.001	Supported
Occupation	66.2961	<0.001	Supported

The findings indicate that the awareness level on climate change among people in Nepal varies across different demographic groups. Awareness among all demographic segments is crucial as it is a global issue that impacts all aspects of society regardless of demographic variation [82]. Among older age groups, they may have varying levels of access to information or differing concerns about climate change. Therefore, more targeted strategies should be developed focusing on diverse demographic groups. The varying levels of awareness within demographic segments underscore the importance of tailored communication strategies and educational initiatives that can effectively address the needs of diverse populations [83]. Acknowledging the level of awareness among the public is important since a well-informed public is more likely to support and participate in policy initiatives aimed at combating climate change and environmental sustainability. It is important to know what people think climate change is because their views are shaped by what they experience. Understanding their perspective helps in creating better awareness and solutions.

4.3. Understanding of Climate Change

Figure 2 shows how respondents recall and recognize different issues about climate change. This study applies a three successive questions approach to gauge how well participants recall and recognize climate change. The first approach is Top of Mind (TOM), where participants are asked about the first issue that comes to their mind when they think about climate change. The second approach is Spontaneous (SPON), where participants are asked to provide other issues that come to their mind. For TOM and SPON, no clues or prompts were provided. The final approach is Aided Recall (AIDED), where prompts or clues are provided to help participants recognize their understanding of climate change.
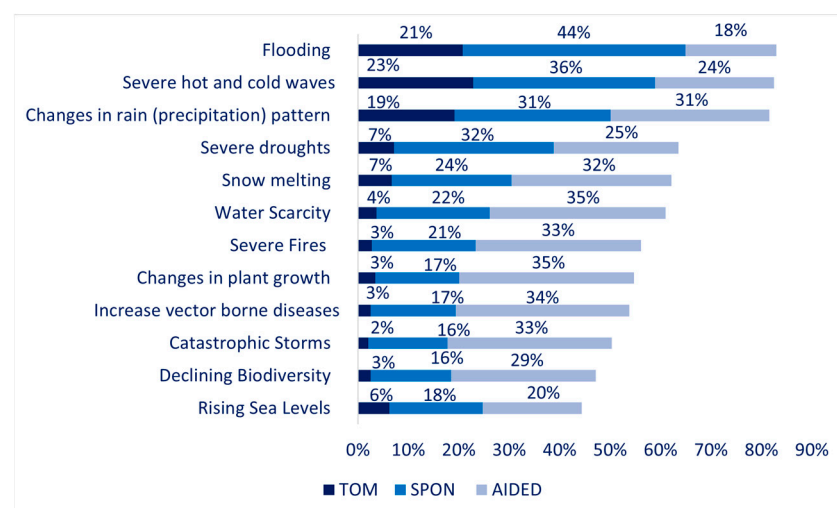
Figure 2. Understanding of climate change.

Among the total respondents of 433, 20.79% (TOM) state that the first issue that comes to their mind is flooding when they think about climate change. However, the remaining respondents mention other issues. For the SPON response, 44.11% mention flooding.

Finally, 18.01% recognize flooding as an AIDED recall. A total of 82.91% of the respondents understand climate change is the cause of flooding in the form of heavy rainfall that triggers the risk of flooding and landslides in Nepal every year. This concern is similar to concerns about climate change during the past decades, which has intensified the flood problem in Bangladesh and many other South Asian countries [84]. Also, severe hot and cold waves, changes in rain precipitation patterns, severe droughts, and many other issues are recalled and recognized as climate change. These are similar to the main consequences of climate change as predicted by the increase in global temperatures, changes in precipitation patterns, and sea level rise [85,86].

Valuable insights are gained from the FGDs. On TOM, almost all the FGDs' participants mention extreme weather events such as flash floods, catastrophic storms, and landslides along with changes in weather patterns like severe hot and cold waves and changes in rain precipitation patterns. Additionally, participants mention the impact of climate change on agricultural productivity, water scarcity, and shifting seasons affecting crop yields. The spread of diseases like COVID-19 is interlinked with environmental factors and improper waste management systems.

> "*Unpredictable seasonal patterns; for example, last year's April snowfall is unusual.*"
> FGD 3, Participant 2

> "*Climate change leads to an increase in new diseases like COVID-19. Inadequate waste management and population growth lead to the emergence of several diseases, some of which may be new variants of existing diseases.*" FGD 3, Participant 1

The top three climate change issues are flooding, severe hot and cold waves, and changes in rain precipitation patterns. Table 4 presents the chi-square test results of flooding, severe hot and cold waves, and changes in rain precipitation patterns among various demographics. The results indicate a statistically significant difference between flooding and age (χ^2 = 13.93, p = 0.008). This signifies that the level of understanding towards flooding varies with different age groups. Participants above 55 years recall flooding the highest with 75.86% on TOM data. The older participants are more likely to associate flooding with climate change than younger age groups. According to BMC (BioMed Central) Public Health [45], a significant portion of respondents observed an increase in episodes of extreme weather, including flooding in the past decades. This is consistent with the research, which highlighted river flooding in Nepal as a serious problem during the main monsoon due to intense rainfall [87].

Table 4. χ^2 association between understanding of climate change and demographics.

Demographics		Pearson χ^2	p Value	Hypothesis Test
Age	Flooding	13.93	0.008	Supported
	Severe hot and cold waves	25.14	<0.001	Supported
	Change in rain precipitation pattern	2.50	0.644	Not Supported
Gender	Flooding	2.74	0.097	Not Supported
	Severe hot and cold waves	1.18	0.277	Not Supported
	Change in rain precipitation pattern	1.020	0.321	Not Supported
Education	Flooding	9.42	0.051	Not Supported
	Severe hot and cold waves	25.65	<0.001	Supported
	Change in rain precipitation pattern	4.63	0.327	Not Supported
Occupation	Flooding	8.53	0.288	Not Supported
	Severe hot and cold waves	21.46	0.003	Supported
	Change in rain precipitation pattern	10.72	0.151	Not Supported

Furthermore, the results indicate that there is no significant difference between flooding with gender, education, and occupation. Likewise, there is a statistically significant difference between severe hot and cold waves and age (χ^2 = 25.14, $p < 0.001$), education (χ^2 = 25.65, $p < 0.001$), and occupation (χ^2 = 21.46, $p = 0.003$). However, no significant difference between the change in rain precipitation pattern and any of the demographics is observed. These findings highlight the need to explore the underlying causes of climate change which contribute to flooding, rising temperatures, and extreme weather patterns.

4.4. Causes of Climate Change

Figure 3 shows how respondents recall and recognize the factors that cause climate change. Among 433 respondents, 45.50% (TOM) of the respondents recall deforestation as the first cause. For the SPON response, 43.88% mention deforestation. Finally, 9.24%, recognize deforestation as AIDED recall. A total of 98.62% of the respondents identify deforestation as the main cause of climate change. Humans are identified as the main cause of climate change and are likely to remain so for the next few centuries; human-induced climate change is generally said to cause global warming [88]. The main cause of climate change deforestation as identified is also human-induced. In Nepal, forests are the main source of livelihood for millions of people, making deforestation a major environmental issue [89]. Likewise, industrialization, burning fossil fuels, storing waste in landfills, overconsumption, mining, and intense farming are also recognized as the causes of climate change.
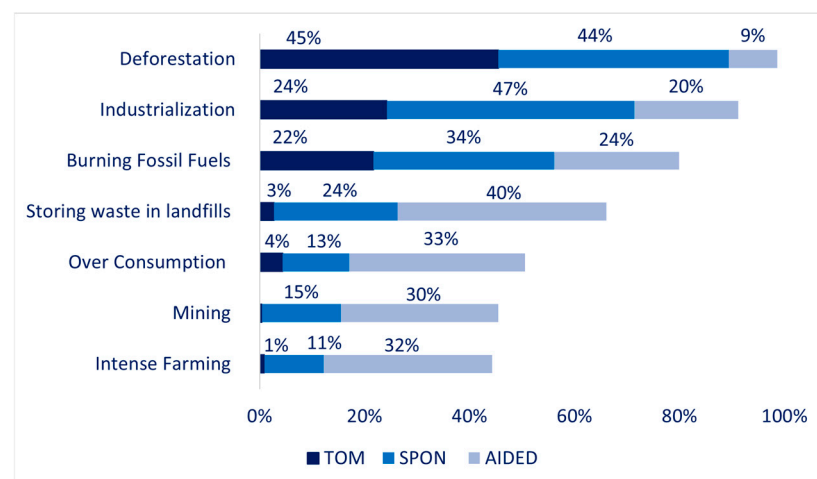

Figure 3. Causes of climate change.

From the FGDs, the participants mention water scarcity, excessive pollution, and inadequate waste management, as the key causes of climate change. Rapid industrialization and urbanization have also led to congested cities. Likewise, deforestation especially in rainforests disrupts natural cycles, exacerbating climate change. Inadequate waste management increases pollution and outbreaks of various harmful diseases. The burning of fossil fuels and harmful carbon emissions from vehicles worsen air and noise pollution necessitating protective measures like using masks in daily life. Along with worsening air quality, it changes the weather pattern leading to a decline in the fertility of the agricultural land, changing the crop growth and yield pattern, contributing to the decline of agricultural productivity over time.

> "*I think due to the increase of vehicles each year, we are facing a lot of air and sound pollution.*" FGD 2, Participant 1

"Deforestation and dumping waste in the river affects climate change. In the past, my family members including my mom, dad, and uncle used to enjoy bathing in the Bishnumati River. However, due to climate change and pollution, the river's water has become so dirty that we can no longer use it for any purpose." FGD 4, Participant 4

The top three causes of climate change are deforestation, industrialization, and burning fossil fuels. Table 5 presents the results of the χ^2 test of the TOM data of deforestation, industrialization, and burning fossil fuels among various demographics. The chi-square result indicates a statistically significant difference between deforestation and age (χ^2 = 12.73, p = 0.013) and educational level (χ^2 = 24.46, p < 0.001). Participants in the age group 18 to 25 recall deforestation the highest with 91.30% on TOM data. Likewise, participants with bachelor's degrees recall deforestation the highest with 93.01%. This signifies that educated people recognize deforestation as the major cause of climate change. Due to the reach of digital media, educated people are more aware of environmental challenges. Their education and experiences allow them to recognize how issues related to climate change are often interrelated.

Table 5. χ^2 association between knowledge on causes of climate change and demographics.

Demographics	Causes	Pearson χ^2	p Value	Hypothesis Test
Age	Deforestation	12.73	0.013	Supported
	Industrialization	4.69	0.321	Not Supported
	Burning fuels	15.24	0.004	Supported
Gender	Deforestation	0.18	0.670	Not Supported
	Industrialization	1.18	0.277	Not Supported
	Burning fuels	3.36	0.067	Not Supported
Education	Deforestation	24.46	<0.001	Supported
	Industrialization	3.27	0.513	Not Supported
	Burning fuels	10.70	0.030	Supported
Occupation	Deforestation	6.86	0.443	Not Supported
	Industrialization	22.70	0.002	Supported
	Burning fuels	19.60	0.006	Supported

Furthermore, the results indicate that there is no significant difference between deforestation with gender and occupation. Likewise, there is a statistically significant difference between industrialization and occupation (χ^2 = 22.70, p = 0.002). Self-employed people recall industrialization the highest with 85.48%. Finally, there is a significant difference between burning fossil fuels and age (χ^2 = 15.24, p = 0.004). The respondents in the age group 18–25 recall burning fossil fuels the highest with 63.48%. It is crucial to understand the level of knowledge people have on the causes of climate change as it will allow them to investigate an adequate level of risk perception which is important to develop adaptation and mitigation capacities [90]. After understanding the causes of climate change, it is equally important to explore people's perceptions of mitigation measures. Understanding these perceptions helps in designing effective policies and awareness programs that encourage proactive engagement in climate change mitigation.

4.5. Mitigation Measures for Climate Change

Figure 4 illustrates the participants' recall and recognition responses on the mitigation measures to climate change. About 52.42% (TOM) of the respondents state the first mitigation measure that comes to their mind is afforestation; 30.25% (SPON) recall afforestation, whereas 7.85% (AIDED) recognize it. A total of 90.52% of the participants identify afforestation as the top mitigation measure. Likewise, recycling and reusing waste, the promotion of renewable energies, reduction in the burning of fossil fuels, protection of water sources,

optimal utilization of resources, adaptation to climate change, and groundwater recharge are also considered as mitigation measures. Along with many mitigation measures, climate change adaptation has been one of the major mitigation measures. As observed in another South Asian Country, Sri Lanka, significant progress has been made in implementing climate change adaptation through a series of actions and plans [91].
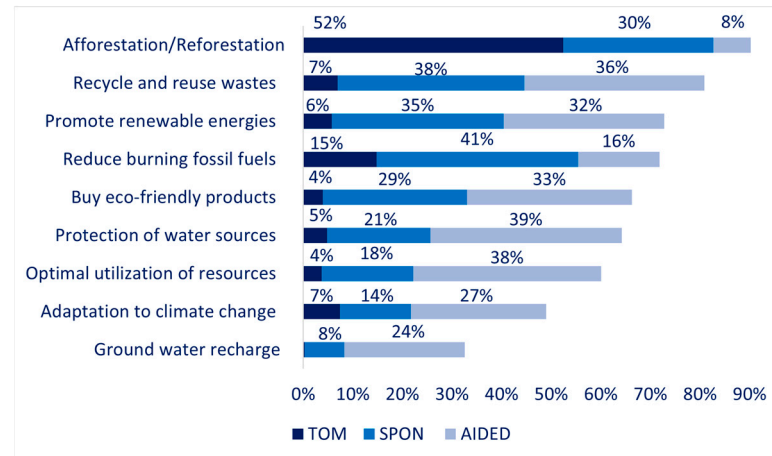

Figure 4. Mitigation measures for climate change.

The FGDs' findings support the quantitative data with strong opinions of individuals on the mitigation measure. The discussions majorly emphasize the importance of afforestation in improving air quality by mitigating natural disasters like flash floods and the drying up of water sources. Since plastics are non-biodegradable, reducing their use in daily life requires everyone to adopt recycling and reusing practices for waste materials. The participants also express the need to formulate regulations to protect resources and ensure timely garbage collection with appropriate waste management protocols. The city area in Kathmandu is overly crowded and the overpopulation density exacerbates environmental pressures. The participants mention formulating policies to manage urban overcrowding and waste production effectively. Participants express their desire for greater government action by prioritizing renewable energy sources, improving waste management infrastructure, and collaborating with international organizations for technical assistance and funding.

> *"In my opinion to reduce the impact of climate change, we must start working from our house. We can reduce the use of plastic and segregate the waste. People should be strictly informed not to mix all the waste from the latrine to the nearby river or stream."* FGD 3, Participants 1

> *"The government should be vigilant and enact laws to lessen industrial pollution since large enterprises pollute the air and dump dangerous chemicals into adjacent streams and rivers. Dumping sites must be managed properly so that the waste can't pollute the air and nearby communities which ultimately brings a lot of harmful diseases that will directly affect the human population."* FGD 4, Participants 4

The top three mitigation measures for climate change are afforestation, recycling and reusing waste, and promoting renewable resources. Table 6 presents the χ^2 results of afforestation, recycling and reusing waste, and promotion of renewable resources among various demographics. The chi-square result indicates that there is no statistically significant difference between afforestation and any of the demographics. Likewise, there is a statistically significant difference between recycling and reusing waste and gender ($\chi^2 = 4.47$, $p = 0.034$). Female participants recall recycling and reducing waste the highest

with 49.55% on TOM data. Finally, there is a significant difference between the promotion of renewable energies and age (χ^2 = 18.67, p = 0.001), educational level (χ^2 = 13.53, p = 0.009), and occupation (χ^2 = 17.13, p = 0.017). Participants under the age group 18–25 recall promoting renewable energies the highest with 51.30%. Similarly, the highest for secondary level education with 46.34% and employed people with 46.30% for promoting renewable energies. The study [92] concludes that education prepares individuals to evaluate the risks of global warming and climate change, enabling them to address and adapt to its consequences. These studies have also shown that people who are educated are willing to engage more in climatic action and adapt to the reduction factors [93].

Table 6. χ^2 association between climate change knowledge on mitigation measures and demographics.

Demographics	Reduction Factor	Pearson χ^2	p Value	Hypothesis Test
Age	Afforestation	4.27	0.370	Not Supported
	Recycle and reuse waste	8.23	0.083	Not Supported
	Promote renewable energies	18.67	0.001	Supported
Gender	Afforestation	0.98	0.323	Not Supported
	Recycle and reuse waste	4.47	0.034	Supported
	Promote renewable energies	0.92	0.336	Not Supported
Education	Afforestation	8.6	0.072	Not Supported
	Recycle and reuse waste	8.4690	0.076	Not Supported
	Promote renewable energies	13.53	0.009	Supported
Occupation	Afforestation	10.13	0.181	Not Supported
	Recycle and reuse waste	11.71	0.110	Not Supported
	Promote renewable energies	17.13	0.017	Supported

4.6. Greenhouse Gases Affecting Climate Change

Figure 5 illustrates the SPON and AIDED responses to the various greenhouse gases that lead to climate change. Due to rapid economic growth, the countries are emitting more GHGs [94]. Burning of nonrenewable energy boosts GHG emissions whereas renewable or clean energy supports to reduce GHG emissions [95]. Big economies are producing more GHG emissions, while developing countries are seen to be more vulnerable to GHG emissions leading to extreme events, especially given the current climatic instability, which can cause substantial damage [96]. Among 433 respondents, 50.35% (SPON) of the respondents recall carbon dioxide as a major greenhouse gas that leads to climate change, and 8.31% (AIDED) recognize it. A total of 58.66% recall and recognize CO_2 as a major greenhouse gas that leads to climate change. A total of 35.80% (SPON) of the respondents cannot recall the greenhouse gases that lead to climate change indicating their lack of awareness and limited knowledge.

From FGDs, participants mention carbon dioxide, methane, and chlorofluorocarbon as the primary contributors impacting climate change. Greenhouse gases have many harmful impacts like degradation and thinning of ozone layers, and an increase in UV rays exposure leading to harmful skin diseases. The rise in the global temperature causes the drying up of water sources, changes in seasonal patterns, and a rise in the earth's temperature. The discussion calls for immediate action to address the mitigation measures of greenhouse gas emissions in minimizing their severe impacts on climate change and the environment.

> *"I believe that the greenhouse is having a variety of negative effects, resulting in climate change. More and more ultraviolet radiation is entering the greenhouse, and we are seeing an increasing number of skin-related issues."* FGD 3, Participants 2
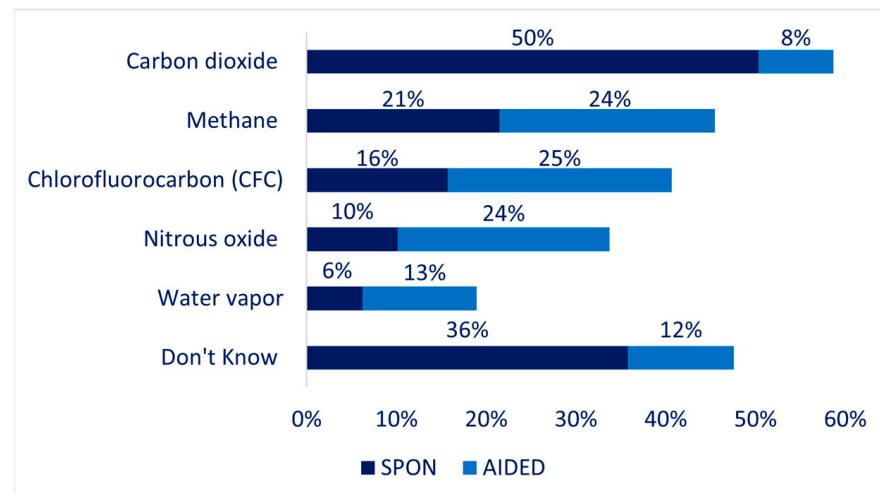
Figure 5. Greenhouse gases affecting climate change.

4.7. Accountable and Responsible for Climate Change

After understanding people's awareness, knowledge, perceived causes, and mitigation measures for climate change, it is important to analyze who they believe is responsible for addressing it. Examining public perceptions of responsibility provides valuable insights into how respondents view accountability and the role of different stakeholders in combating climate change. Figure 6 presents SPON and AIDED responses to the various groups accountable for climate change; 64.90% (SPON) of the respondents recall individuals as accountable for climate change, and 23.33% (AIDED) recognize it. A total of 88.23% of respondents inform individuals accountable for climate change. Similarly, respondents also recognize national government, business and industry, industrialized countries, and international committees/organizations accountable for climate change.
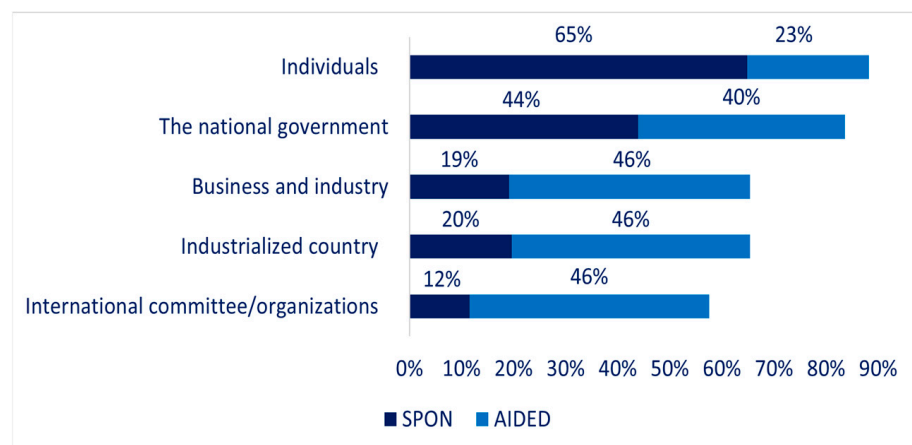
Figure 6. Accountable for climate change.

From FGDs, businesses and industries are held more accountable for climate change, as they are major contributors to air and water pollution. Factories emit hazardous gases and chemicals that are harmful to both people and the environment. Participants also emphasize the need for stricter rules and regulations to ensure that these industries are located far from residential areas. Individuals are also recognized as being equally responsible for climate change. Individuals need to stop using plastic products to address climate-related issues. These qualitative data align with quantitative data, reinforcing the idea that businesses, individuals, and large nations play a critical role in addressing climate change and environmental sustainability.

"International industrialized countries are accountable for climate change, these countries are more responsible as they are testing new things for experiments like atomic bombs, missiles, etc. *which are the activities that account for climate change."* FGD 1, Participants 2

"The individuals are accountable for climate change, we use plastic-related products and forget to bring our bags when we go shopping. Products made of plastic are now an essential part of our lives. Until and unless we stop using plastic products, we should be held accountable for climate change." FGD 3, Participants 1

Addressing the impact of climate change requires actions at many levels such as the international, national, local, and individual as well as from NGOs [97]. Figure 7 reveals SPON and AIDED responses of the various groups that are responsible for tackling climate change; 60.97% (SPON) of the respondents recall the national government as being primarily responsible for addressing climate change, and 26.33% (AIDED) recognize it when prompted. A total of 87.30% of respondents recall and recognize the national government as responsible for climate change. A study in the USA, Australia, India, and Nigeria shows that people often believe the government should take more responsibility for addressing climate change and environmental sustainability because it can pass laws to reduce greenhouse gas emissions and support the use of renewable energy [98]. Similarly, respondents also recognize individuals, industrialized countries, international committees/organizations, and environmental organizations as groups responsible for tackling climate change.
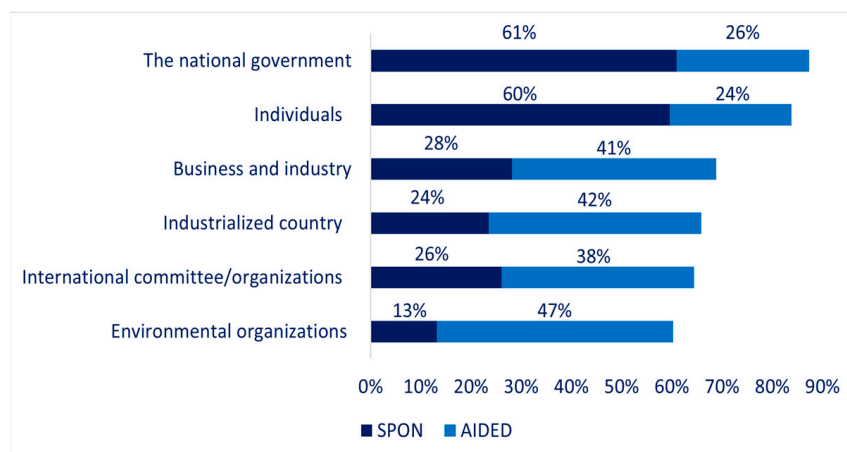

Figure 7. Responsible for tackling climate change.

From the FGDs, participants highlight that industrialized countries are responsible for emitting harmful gases that contribute to global pollution. These countries should be made liable to compensate for the environmental degradation caused by the emission of harmful gases. Individuals are responsible for climate change, and hence, participants emphasize the importance of individual actions, such as waste segregation, minimizing the use of plastics, and adopting eco-friendly products to mitigate climate change. The national government also plays a crucial role, as it has access to resources and the ability to implement large-scale policies. Participants advocate for stricter policies for industries to reduce emissions, promote electric vehicles, and implement carbon taxes on old vehicles.

"I think the government is responsible. The government should take demanding steps to reduce the infectious gas or chemicals from the industry. Government should prioritize more on electric vehicles and renewable energy. Old cars and buses should be checked for how much gas they emit each day and made accountable." FGD 2, Participants 1

> *"We as an individual are also responsible as we can contribute to various activities inside and outside our home to tackle climate change."* FGD 1, Participants 2

4.8. Addressing Climate Change: Role

Figure 8 presents the SPON and AIDED responses on the role of government in tackling climate change. The results indicate that the introduction of an awareness program to the public is the highest with 76.21% (SPON) and 15.70% (AIDED). A total of 91.91% of the respondents were informed about the role of government in the introduction of awareness programs to the public. Likewise, respondents also advocated for the adoption of policies, promotion of green energy, protection and restoration of key ecosystems, support of small agricultural producers, and carbon taxes as the role of government in tackling climate change. This finding is similar to the other study, which highlighted the role of government in mitigating its climate effect by implementing deforestation, promoting green energy, reducing the use of private vehicles, and expanding the use of public transport [63].
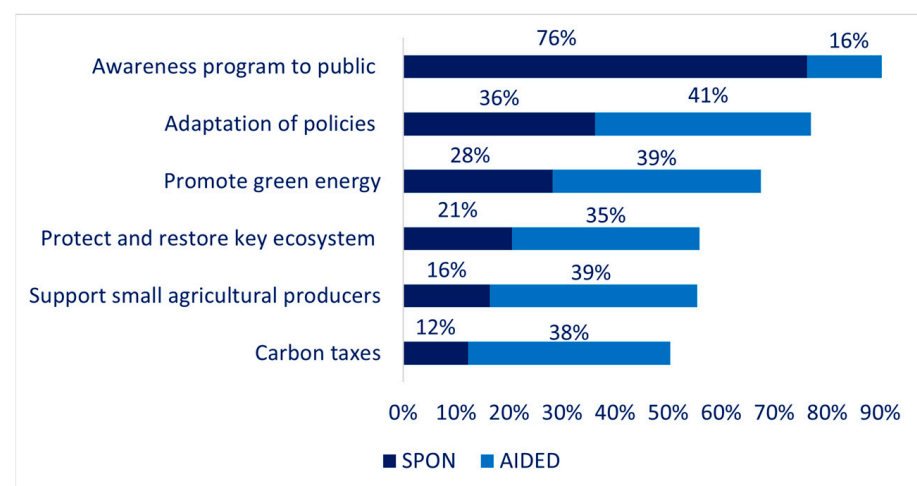

Figure 8. Government role in tackling climate change.

From the FGDs, participants emphasize the government's role in promoting renewable energy initiatives and conducting public awareness programs. The overpopulation in urban areas has caused environmental challenges such as increasing air pollution, waste management problems, water scarcity, and water pollution. The government should address this by promoting equal opportunities across all regions, which will decrease migration to urban centers. Participants also mention the importance of increasing taxes on private vehicles and encouraging the use of public transportation, which could help reduce air and noise pollution. For that, the government should implement policies to decrease the use of petroleum vehicles and promote electric vehicles. Policies should mandate planting at least one tree per household and prioritize the preservation of national parks to maintain ecological balance. Strict enforcement against deforestation and wildlife haunting in protected areas is crucial.

> *"I believe the government can help reduce population density in major cities by providing equal opportunities in rural areas, such as access to education, healthcare, and jobs. This would encourage people to remain in their hometowns, ultimately decreasing urban population pressures and addressing issues like pollution, waste management, and the loss of fertile agricultural land to urban development."* FGD 1, Participants 3

> *"The government has to make strict policies to reduce petroleum vehicles and promote electric vehicles. The government has to emphasize renewable energy."* FGD 3, Participants 4

Figure 9 illustrates the SPON and AIDED responses on the role of individuals in tackling climate change. The results indicate reducing, reusing, repairing, and recycling the highest with 51.04% (SPON) and 33.95% (AIDED). A total of 84.99% of respondents recall and recognize reducing, reusing, repairing, and recycling as an individual's role. Raising awareness among friends and families, saving energy at home, switching to electric vehicles, throwing away less food walking, biking, or using public transport are also recognized as individuals' roles in tackling climate change.
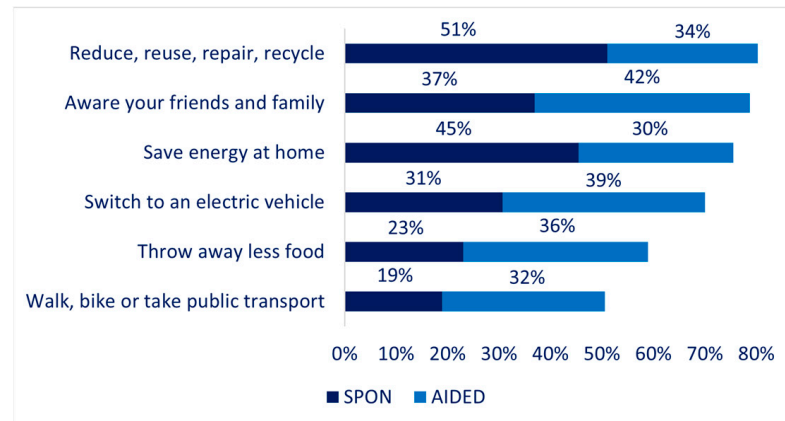
Figure 9. Individual role in tackling climate change.

From the FGDs, participants express diverse opinions on the role of the individuals. The government has established policies to combat climate change, but individuals are not supportive of these measures. Everyone should follow the rules and regulations set by the government. For example, the Kathmandu Metropolitan's ban on tobacco-related substances in public areas has effectively reduced public smoking, demonstrating the positive impact of such initiatives. Similarly, community-based efforts can help mitigate climate change. Awareness programs are essential to educate the public about the impact of climate change. Individuals can further contribute by segregating waste at home, creating compost from kitchen waste for gardening, and engaging in small-scale rooftop farming. Reporting and banning old vehicles that emit harmful gases is also crucial.

> *"We as an individual can contribute to reducing the impact of climate change from our home itself by segregating the waste as disposal and non-disposal. We can make a compost organic fertilizer from the disposal waste from the kitchen and use it in kitchen gardening. The community should also work towards waste management."* FGD 2, Participants 2

4.9. Climate Change: Media Preferences

The data reveal the diverse sources through which people acquire information about climate change. Social media stands out as the most influential, with a significant 75.52% of respondents relying on platforms like Facebook and Instagram for news and discussions. About 64.67% of the respondents acquire information through television, as shown in Figure 10. Likewise, online media follows closely behind, encompassing news websites and blogs, attracting 58.89% of respondents, followed by word of mouth, newspaper, radio, internet search, specialist publication, and government agencies/information. Overall, the data underscore the multifaceted nature of information dissemination on climate change and environmental sustainability, highlighting the importance of various media platforms, interpersonal communication, and official sources in shaping public perception.
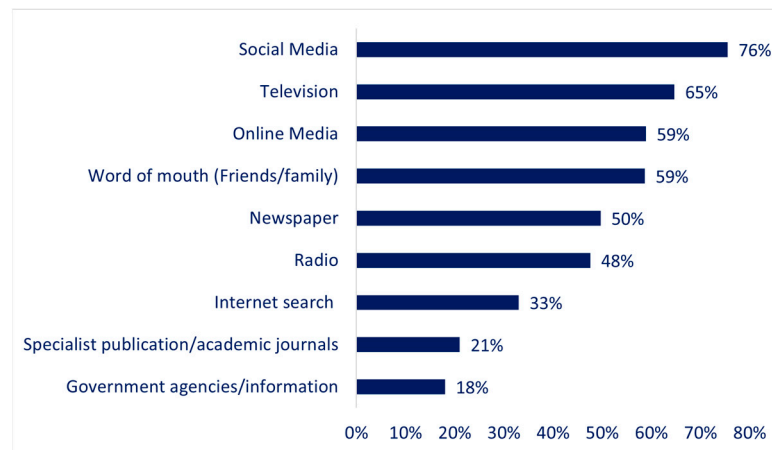
Figure 10. Media for information on climate change.

5. Conclusions

This study examines public awareness, understanding, causes, mitigation measures, and practices on climate change by employing both qualitative and quantitative approaches and hence adding some useful findings to the existing limited study in the Nepalese perspectives in the domain of climate change and sustainability. The study underscores a robust level of awareness regarding climate change among respondents. FGDs further validate this awareness. The respondents primarily link climate change with observable extreme weather events like flash floods, severe hot and cold waves, and changes in rain precipitation patterns. The respondents also perceive the key causes of climate change such as deforestation, industrialization, and burning fossil fuels, which can be reduced through afforestation, waste recycling, reusing, and promoting renewable resources along with the role of media. To conclude, the study finds that education plays an important role in shaping informed attitudes and sustainable practices, emphasizing the need for targeted awareness campaigns, particularly among the undereducated and older generation population. Furthermore, industries are identified as the contributors to GHG emissions, and carbon dioxide and methane are recognized as the main contributors to climate change. Therefore, there should be policy innervation to acknowledge climate change, and the policies should be translated into behavioral change through incentives and regulations. The findings also provide valuable information for policymakers on where to focus and dedicate more efforts to tackle climate change. Hence, policymakers should focus more on formulating policies targeting creating awareness and more effective intervention strategies such as financial incentives, sustainable transportation, resource conservation, and circular economy [99,100]. Policies should be designed to align with the specific needs of the country, ensuring effective implementation.

Additionally, policies developed in Nepal can be adapted by countries with similar economic, geographical, and climate conditions, particularly those experiencing the indirect effects of industrialized nations' environmental impact. This study has some limitations in terms of covering the geographical, demographic, and cultural diversity of Nepal. The limitations can be adopted with further research to expand the scope of climate change awareness initiatives. Future studies could focus on other cities and regions with distinct characteristics such as tourists and industry-oriented cities to understand how awareness programs can be effective in those contexts. Additionally, comparative studies can be conducted in urban and rural areas, providing valuable insights into the challenges and opportunities faced in adopting climate change policies. Such comparative studies would help identify region-specific needs and help develop more tailored and effective policies and strategies for policymakers.

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