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RESEARCH PAPER

Developing Nature-Based Solution Pathways to New Layers of Complexities for Urban Communities Coping with Armed Conflict and Climate Change

Muluberhan Biedemariam, *Mekelle University*

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Abbreviations

NbS	Nature-based Solutions
CSV	Comma-Separated Values
SPSS	Statistical Package for Social Sciences
ERCS	Ethiopian Red Cross Society
FGD	Focus Group Discussion
NGOs	Non-governmental Organizations
FAO	Food and Agriculture Organization Key Informant Interview
AoR	Area of Responsibility
USD	United States Dollar
NGO	Non-Governmental Organizations
EES/NFI	Ethiopian Emergency Shelter and Non-Food Items
UN-Habitat	United Nations-Habitat
IUCN	International Union for Conservation of Nature
ICRC	The International Committee of the Red Cross
IPCC	Intergovernmental Panel for Climate Change
RCRCCC	Red Cross Red Crescent Climate Center
UNHCR	United Nations High Commissioner for Refugees

Abstract

Nature-based solutions are vital approaches for climate change adaptation as they enhance ecosystem resilience and support communities in coping with the impact of climate change. However, there is limited evidence on the nature-based solutions pathways to the resilience of communities impacted by new layers of complexities for communities coping with conflict and climate change. This study conducted to scientifically develop a pathway to urban climate resilience by exploring pragmatic approaches from communities and local humanitarian organizations experiencing the compounding risks of armed conflict and climate change in Tigray, Ethiopia. In this study, communities' perceptions of climate change, the potential of Nature-based Solutions (NbS) to address the perceived changes and the community participation s in NbS initiatives including during periods of armed conflict were investigated using descriptive statistics and econometric models. Moreover, stakeholder collaboration and coordination were assessed. Understanding the context, identifying and prioritizing key challenges, mapping and mobilizing stakeholders, and establishing strong coordination and collaboration mechanisms are essential approaches for transforming innovative ideas into tangible results by enhancing complementarity and mutual understanding among stakeholders. Many of the points discussed regarding the pilot experience of ERCS northwest Tigray branch office could be an important lesson/contribution to the revitalization of the natural resources' rehabilitation programs in Tigray with many transferable lessons to other local and international humanitarian organizations. The research provides a framework for NbS pathways to new layers of complexities for urban communities coping with climate change and armed conflict (UNID PRIM COC framework) and recommendations for future actions in Tigray and beyond.

Keywords: nature-based solutions, stakeholder coordination, framework, ERCS, Humanitarian organizations

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1. Introduction

Cities are home to more than half of the world's population and are important hubs of information and technological development. However, they are also hotspots of ecological disruption as a result of pandemics and shocks caused by conflicts and natural disasters. Wars and disasters displace people mostly to urban areas and within urban areas. For example, there were 83.4 million internally displaced people due to both conflicts and violence, and disasters at the end of 2024. Specifically, 73.5 million people were displaced due to conflicts and violence while disasters displaced 9.8 million (IDMC, 2025). Of these, the number of displaced people to urban areas reached 70% of the IDPs. On the 4th of October 2020, a war outbreak in Tigray (Birhane et al., 2025). The war was branded as the deadliest armed conflict of the 21st century and one of the bloodiest since the end of the Cold War (New Lines Institute, 2024). Unlike the start of the armed conflict, where many people including the urban residents sought refuge in forests far from urban areas, later a large flux of internally displaced people (IDPs) preferred sheltering in major cities in Tigray such as Shire-Indasilassie. This was with the intent to look for food and other services from humanitarian organizations, as the public services had been barred (Hishe et al., 2023). Though the IDPs and host communities receive limited food assistance and shelter, the IDPs and the host families faced significant challenges in accessing energy resources because of the blockage and suspension of public services and opted for collecting firewood from the mountain green frames (MGF) of the cities.

Mountain green frames are vegetative areas of cities including woodlots, exclosures, green belts, and watersheds in the hills and mountains parts of the cities including protected green areas. Cities established adjacent to mountain areas benefit from the mountain green frame-based ecosystem services. However, when reduction in the MGFs occurs because of various reasons, the negative impact on urban areas increases. Reduction of MGFs has been a critical issue in Tigray cities such as Shire-Indasilassie city, Sheraro and Selekleka towns in northwest zone of Tigray where a large flux of IDPs has been sheltered as the consequence of the conflict crowded in the already constrained living spaces of host communities. Trees of the MGFs of the cities and towns have been cut for firewood following the cut of electricity, especially in the cities and towns such as Shire-Indasilassie and Selekleka. While in the Tigray region, all the land rehabilitation efforts such as seedlings production, tree plantations and management, soil and water conservation programs and activities have been reverted by the war (Hishe et al., 2024; Negash et al., 2024; Birhane et al., 2025). Consequently, flash flooding is becoming a common incident in Shire-Indasilassie, Sheraro and Selekleka cities. According to Negash et al. (2024), the flash flood episodes in Selekleka and other areas in Tigray were caused because of the

destruction of conservation structures and cutting of trees as the consequence of the war on Tigray that broke out in November 2020. Cutting of trees caused forest degradation which in turn contributes to climate change and weakened climate resilience of communities (Nyika and Dinka, 2022).

In conflict contexts, the suspension of essential public services, notably electricity, significantly exacerbates the suffering of civilian populations, particularly in settings where alternative energy sources are unavailable and where there is a substantial influx of IDPs (World Bank, 2021; ICRC, 2022; UNOCHA, 2023; Hishe et al., 2024; Birhane et al., 2025). In the Tigray region of Ethiopia, the suspension of electricity in cities and towns led people to cut trees for fuel wood. Humanitarians believe this, in the era of climate change, has had a negative impact on the lives of the population, for instance, it can increase flooding frequences (personal communication with northwest ERCS branch office head). Climate change is impacting the globe and will continue to impact with increased flood intensity (Singh and Marghidan, 2025), social innovations that improve communities' resilience to the urban climate change will be vital in maintaining human quality of life in the coming periods. Nature-based Solutions (NbS) such as restoring degraded landscapes can help retrieval from pandemics, economic recessions, shocks caused by conflicts and natural disasters (Chausson et al., 2024; IUCN, 2020; Seddon et al., 2020). Nature-based Solutions are actions to protect, sustainably manage and restore natural and modified ecosystems in ways that address societal challenges effectively and adaptively, providing both human wellbeing and biodiversity benefits' (Cohen-Shacham et al. 2016). NbS like tree plantations can enhance climate resilience at local level in urban areas. However, the production of seedlings and activities of ecosystem restoration have been extremely affected in Tigray because of the war and its impacts. As a coping mechanism to this societal problem, Ethiopian Red Cross Society (ERCS) Northwest Tigray branch office established a new nursery site and produced seedlings where some of the seedlings were planted in the MGFs of the Shire-Indasilassie city and the rest seedlings distributed freely to the neighboring districts (Woredas).

However, the growing recognition of community-based approaches to nature-based climate solutions and their crucial role in enhancing urban sustainability and resilience, there remains a significant research gap regarding their effectiveness, and the approach and strategy for implementing and scaling NbS in specific contexts with new layers of complexities for communities coping with conflict and climate change, particularly in urban areas of developing countries such as Ethiopia. Also, the potential of local humanitarian organizations to nature-based climate solutions is overlooked and needs scientific evidence for impactful scaling and facilitating collaboration with potential international and local organizations for resources mobilization.

This study aims to fill this gap by examining the local urban communities' perception about climate change and the importance of NbS to mitigate the perceived change in climate. Moreover, the study discusses factors triggering local urban communities to participate in NbS to climate change such as seedlings production and plantation interventions during war and conflicts. Further, the study discusses the collaboration approaches between humanitarian organizations in NbS implementation during armed conflicts and after in recovery phase. Finally, by integrating the findings, this research develops NbS framework as a pathway to mitigate new layers of complexities for communities experiencing the compounding impact of armed conflict and climate change in urban communities.

2. Literature Review

Armed conflicts impact natural resources in different ways. For example, in countries such as Colombia and the Democratic Republic of Congo, conflicts have driven extensive deforestation, habitat destruction and ecosystem degradation (Butsic et al., 2015; Nackoney et al., 2014), exacerbate environmental damage in Iraq where water resources were contaminated by explosives (Zhiltsov et al., 2023), and in Ukraine where water access and food security were negatively affected (Shumilova et al., 2023). Likewise, in conflict affected regions in Tigray in northern Ethiopia, soil erosion, salinization and the loss of arable land as the consequences of the conflict reduced agricultural productivity (Hishe et al., 2024). The research on NbS is becoming a common hotspot in the era of climate change to understand various issues of climate change and to provide an ecological solution to ecological disturbance. Globally, over 75% of displaced both internally and across borders due to conflict and war are located in low- and middle - income countries with the majority exposed to severe climate events such as floods, among others (RCRCCC, 2025). Deforestation modifies natural drainage systems, increasing runoff and exposure to flooding (Roy et al., 2022), and this coupled with the impact of urban expansion which can increase built surfaces and stranded the absorption of water into the ground boom urban flooding (Singh and Marghidan, 2025). Nature-based solutions are increasingly recognized as crucial strategies for climate change adaptation and resilience building (Cohen-Shacham et al., 2016; Seddon et al., 2020). By harnessing the capacity of ecosystems to absorb shocks and regulate environmental processes, NbS provides sustainable and cost-effective alternatives to conventional engineering approaches (Raymond et al., 2017). The common nature-based solutions included land restoration and rehabilitation, planting of trees, area exclosures, and water and soil conservation among others (Goodwin et al., 2023; Birhane et al., 2025; Hishe et al., 2024). NbS such as restoring wetlands, conserving forests, and establishing urban green infrastructure not only mitigate climate risks like flooding and heatwaves but also deliver multiple co-benefits, including biodiversity conservation, carbon sequestration,

and improved human well-being (Kabisch et al., 2016; Frantzeskaki, 2019). Integrating nature-based solutions into planning and policy frameworks enhances the adaptive capacity of both ecosystems and communities, making them a cornerstone of sustainable climate change resilience efforts (Geneletti & Zardo, 2016; Nesshöver et al., 2017). Researchers like Goodwin et al. (2023) recommended studies in the Global South on urban nature-based solutions to address interconnected challenges of climate, biodiversity, and society.

3. Materials and methods

3.1 Description of the study area

Tigray Regional State located in the northern part of Ethiopia has 7 zones (Southern Tigray, Southeast Tigray, Mekelle, Eastern Tigray, Central Tigray, Northwest Tigray and Western Tigray). Because of the geographical location adjacent to Western Tigray, where most people displaced from following the 2020 Tigray war, the Northwest Tigray zone have received most IDPs, particularly IDPs from Western Tigray and the IDPs have been sheltered in main cities and towns of the Northwest zone. Using purposive sampling technique, the study was conducted in three urban areas of Tigray regional state in Ethiopia, namely Shire-Indasilassie, Sheraro and Selekleka. These urban areas were selected purposely based on the responsibility areas of the Northwest zone Ethiopian Red Cross Society (ERCS) branch office in Shire. Shire-Indasilassie city, incorporating 5 Kebelles (sub districts) covers a total area of 3,471.8 ha, is the main city in the northwest zone of Tigray regional state. It is the center of the gold-mining business in Tigray and in Ethiopia in general. The active gold mining and marketing activities in the neighboring districts make Shire-Indasilassie a vibrant city. The city is young and is the second economic center next to Mekelle in Tigray; Mekelle is the capital of the Tigray regional state. Sheraro located at about 96 kilometers far from Shire-Indasilassie towards the border to Eritrea is the second city, next to Shire-Indasilassie in northwest zone of Tigray. Selekleka, one of the towns in the northwest zone of Tigray, is located about 28 kilometers far from Shire-Indasilassie. From January – December 2022, Northwest zone of Tigray hosts 478, 554 IDPs, which is 78.9% of the IDPs in the Tigray regional state (UNHCR, 2023).

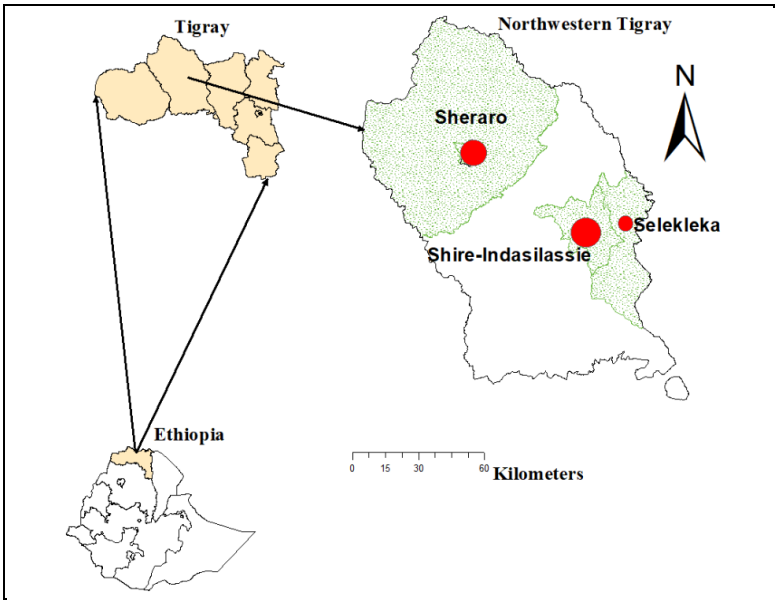

Figure 1: Location of study areas.

Ethiopian Red Cross Society Tigray branch office: Set up.

The Tigray Regional State ERCS branch is divided into five zonal ERCS branch offices: Central Tigray, Eastern Tigray, Mekelle City, Northwest Tigray and Western Tigray (this ERCS branch zonal office is not coordinated under Tigray ERCS branch currently after the breakout of the war in Tigray). The Northwest Tigray zonal ERCS branch further has coordination offices at the districts (Woredas) under its supervision. Shire-Indasilassie, Sheraro and Selekleka are among the districts of the northwest zone of Tigray regional state where the northwest ERCS branch has presence through its coordination office of the respective districts.

3.2 Study design and sampling framework

Context analysis was conducted for understanding the social, cultural, and political aspects of the communities to establish the enabling environment for the initiation of the National Red Cross Society's branch office to intervene in NbS activities. The study used a mix of qualitative and quantitative research methods. First, a desk study was carried out to identify NbS interventions at local level and to develop questionnaires. Next, semi-structured interviews comprised of professionals and practitioners at different levels both from the government and non-governmental organizations including experts and leaders from the humanitarian field working in emergency response activities, ERCS volunteer coordinator and community representatives. Then, focus group discussions were carried out systematically to understand the local urban communities' knowledge of NbS. After that, a household survey was carried out. The number of research participants from each research city/town for the household survey, key informant interviews, and FGDs were

determined using a probability proportional to size (PPS) sampling technique based on the population of each target city. Finally, a workshop was organized to validate the initial research findings and inputs from the workshop were integrated into the final report. The validation workshop participants were people that were neither part of the key informant interviews and the FGDs nor the household survey. For all types of research methods employed an interview protocol composed of questions on themes including overview of initiatives, motivation and goals, challenges and limitations, successes and outcomes, lessons learned, and recommendations for future initiatives.

3.3 Data collection methods

Semi-structured interviews with key informants (n=10) and focus group discussions were conducted systematically to understand the local urban communities' knowledge of NbS and participation in NbS such as tree planting and management. The FGDs were conducted separately with female and male participants for all the target segments of the population. Each group consisted of 6-11 people, with a total of 123 participants across 16 FGDs (n=10 in Shire-Indasilassie; n=6 in Selekleka; and n=6 in Sheraro).

Sample populations for household survey were determined using the Cochran (1977) sample size determination formula from all the selected study areas based on the formula

N = = = 385 individuals were selected for a survey questionnaire.

Where;

N is the sample size for the study,

Z is the selected critical value of desired confidence level (1.96),

P is the estimated proportion of an attribute that is present in the population, which is 0.5 in this study as there is no previous study to estimate variability thus, we take it 50%.

Q =1-p, that is 0.5 and

e is the desired level of precision which is 0.05 (5%).

We included 10 additional individuals, which made the total interviewed individuals 395, and the respondents were selected randomly from the target communities.

The household survey was carried out using Kobo toolbox by experienced researchers. The questionnaire was pre-tested with five individuals that are not part of the survey to see the survey questionnaire as a whole, and the individual questions make sense and are easily understood by the interviewee and the interviewers.

3.4 Data analysis

The data collected from the questionnaire using Kobo toolbox application were exported to comma-separated values (CSV) form and imported to SPSS for ease of coding and for descriptive and inferential statistics. Descriptive statistics were used to summarize and present the characteristics and frequencies of the variables in the dataset. Three constructs were used in the study. Based on a theory-based concept (Cronbach, 1955), questions were divided into three constructs. All constructs were scaled to the 5-point Likert scale (strongly disagree, disagree, uncertain, agree, strongly agree). The first construct was about the perception of respondents towards climate change in the last two decades. The second construct was used to scale the extent to which the local communities believe that NbS can mitigate the perceived climate change. Finally, the third construct was used to see the contribution of NbS as mitigation to climate change to the local community's wellbeing.

Logistic regression was used to evaluate the extent to which the local communities believe that NbS such as tree planting and management mitigate the perceived climate changes, and to evaluate how communities' characteristics influence their participation in NbS. We opted for the logistic regression model for analyzing independent variables influencing urban residents' participation in NbS provided that, the dependent variable, (whether a respondent participates) takes a dichotomous choice. In addition, an ordinal regression model was used to determine the effectiveness of mitigation to climate change using NbS to the local communities' wellbeing.

To develop a NbS pathway for mitigating the new layers of complexities for communities experiencing the compounding risks of armed conflict and climate change at local level in urban areas, first a draft framework was developed. The draft framework was presented for validation to various segments of the population. The inputs gained from the validation process were considered in the final report.

4. Results and findings

4.1 Socioeconomic characteristics

Sample respondents were from the general communities and some from various sectors including from and including natural resources management, health, education (University, College, High school), water supply, administrations, courts, and banks. The majority (55.4%) of the respondents are in the age range of 36 – 64 (Table 1). The average family size of the respondents is 3.96, with a minimum of 1 member and a maximum of 10 members per household. In terms of education, most of the respondents (90.4%) attended formal education, 18% respondents attended or completed elementary school, 30.6% attended or completed high school, 8.9%

respondents attended or graduated with a diploma, 25.6% respondents attended or graduated with a bachelor's degree, and 7.6% attended or graduated with a master's degree and above. Only 9.4% of the respondents had no formal education. Most (68.6%) of the surveyed respondents had no landownership. About half of the respondents have a monthly income of less than 38 USD.

Table 1: Overall socio-demographic characteristics of respondents.

Socio-demographic characteristics	Number	Percentage
Gender		
Male	199	50.4
Female	196	49.6
Age group		
15 – 35	160	40.5
36 – 64	218	55.2
> 64	17	4.3
Family size		
1-2	75	19
3-5	259	65.6
6-8	53	13.4
9-10	8	2
Level of education		
None	33	8.4
Elementary	71	18
High school	121	30.6
Diploma	35	8.9
Bachelor's degree	101	25.6
Master and above	30	7.6
Other (Religious)	4	1
Occupation		
Employed government	116	29.4
Non-employed	279	70.6
Monthly income in ETB		
< 5000	201	50.9
5000 – 10000	142	35.9
10000 – 15000	47	11.9
15000 – 20000	5	1.3
Land ownership		
Own land	124	31.4
Does not own land	271	68.6

Note: The total number of respondents is 395. The average family size in the urban areas of Tigray is set to 5. One US dollar was approximately 131 ETB (Ethiopian Birr) during the data collection.

4.2 The status of mountain green frames and their benefits

The first question addressed to the research participants examined their understanding of the common urban green infrastructure forms present within their

communities. Street trees and roadside green, trees in both public and private compounds, worship and cemetery, and mountain green frames (MGFs) are the top four green infrastructure identified by 98.7.9%, 98.5%, 95.2%, and 85.3% of the respondents, respectively. Congruently, 97.2% and 53.9% of the respondents ranked these because of the easy access and the contribution to the microclimate of their cities than other green infrastructures. The decline of the mountain green frames (MGF), as reported by almost all (99.5%) of the cities' respondents from all cities, was primarily attributable to trees cutting. However, local climate regulation was identified by 97.7% of the respondents as the topmost important ecosystem service provided by mountain green frames, among the 16 types of ecosystem services considered based on the literature review and the insights gained during the pilot testing of the survey questionnaire (Figure 2). The cutting of trees from the MGFs was mainly for firewood (99.24%,), followed by construction materials (27.34%), the establishment of quarry sites within the MGFs (19.24%), and the construction of buildings inside the MGFs (0.76%), as reported by the respondents. Almost all respondents (93.6%) identified human activity as the main factor affecting the MGFs. Among them, 51.1% believed that the reduction of MGFs was entirely caused by human activities, while 42.5% considered human activities to be the primary contributor to the reduction of MGFs. Regarding potential risks associated with the presence of dense MGFs in their respective cities in general and within their neighborhoods in particular, 91.9% of the participants reported that they did not perceive any potential risks. Likewise, FGD participants from all segments of the population reported that the war that broke out in Tigray in November 2020 negatively affected forest areas, particularly the trees within the MGF. Following electricity outage, both IDPs and host communities cut trees for firewood armed actors in the conflict relied on fuel wood from the MGFs during their presence in the cities and the cities' surroundings. The fuelwood was sourced from the MGFs of the cities, which, unfortunately, were also the primary locations where IDPs evacuated from Western Tigray were sheltered. The war also halted soil and water conservation and other land rehabilitation initiatives for years, which in turn exacerbated flooding in the cities. The research participants noted that, prior to the Tigray war, cutting trees from the MGFs was strictly forbidden. Flooding before the conflict was limited and less severe, as the trees helped retain runoff and reduced its impact. In recent times, however, increased rainfall intensity, combined with tree cutting for firewood, has exacerbated runoff and worsened flooding.

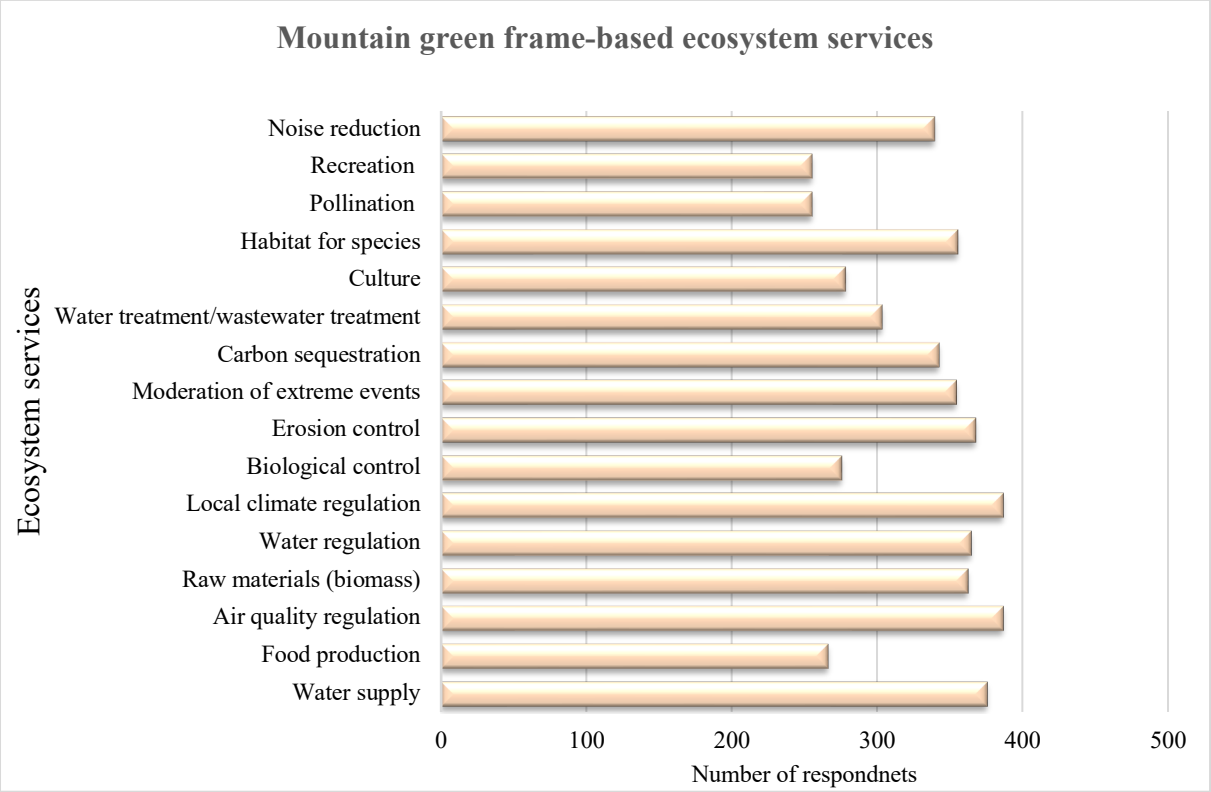

Figure 2: Mountain Green Frame-based ecosystem services.

4.3 Climate change perception and contribution of NbS in mitigating climate change

This section presents results in tables and graphs showing the climate change perception of various segments of the population across the target communities. In addition, the tables and graphs show respondents' trust about the role of NbS in mitigating to perceived climate change. The assessment includes 395 individuals from the communities. Respondents were asked to rank the top five challenges in their cities. The majority of the respondents ranked housing, housing, water, unemployment, and climate change as the 1st, 2nd, 3rd, 4th and 5th top challenges in their cities, respectively (Table 5). Almost all (99.7%) of the respondents had perceived the change in climate through time (Figure 3), and with no difference between females and males (x^2 = 0.9874 and *Pr*= 0.320). Likewise, 100% of both female and male groups of the FGD reported a clear perception on climate change without difference within groups and among the different segments of the population (Table 4). Most participants of the research reported that the perceived change in climate is caused mainly by the increase in the warmness of their city's environment (99.2%) and by the presence of unseasonal rainfall (78.7%). The decrease in duration and the increase in intensity of rainfall was also reported as factors for the perceived climate change by 26.1%, 11.9% of respondents, respectively. Assessment of NbS revealed that planting of trees and reafforestation, soil and water conservation, area exclosure,

development of green spaces, and planting of trees in individual and private compounds are among the common NbS practiced in the communities.

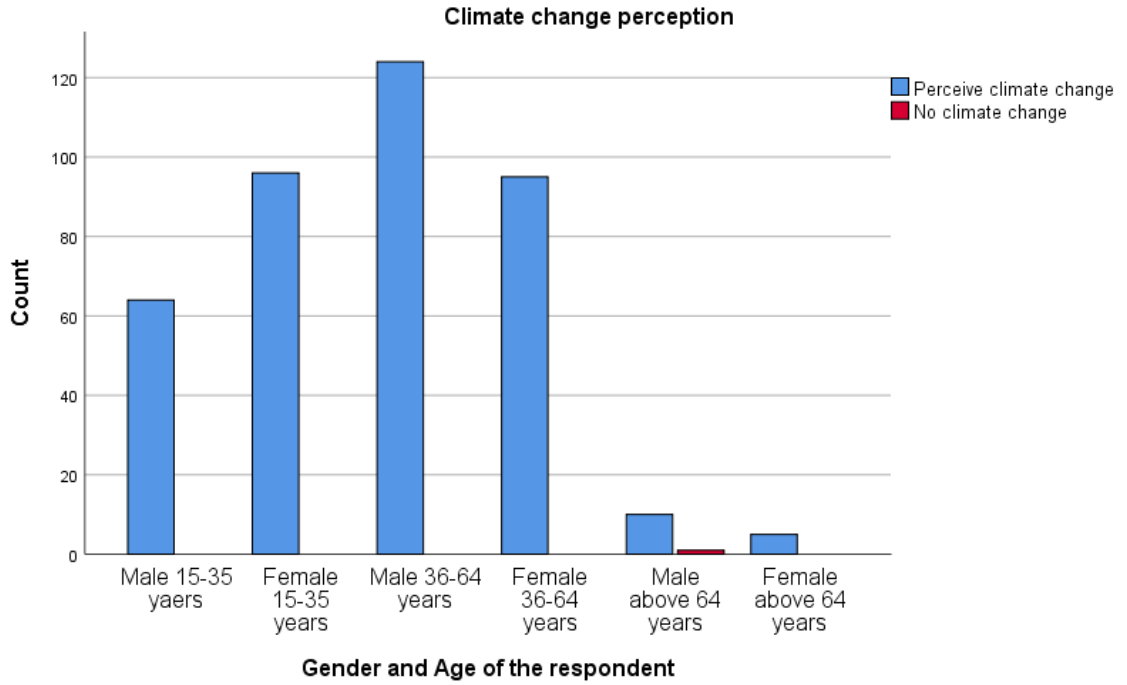

Figure 3: Climate change perception.

Approximately 98.5% of the sample households easily feel climate change and an increase in temperature now than 10–20 years ago. About 68.4% of the respondents agree with the decrease in rainfall and its intensity over a period of 10-20 years and 23.3% are uncertain about the increase in rainfall intensity. On the flooding incidences, about 88.9% of the respondents reported frequent flooding incidences during rainy seasons recently than 10 – 20 years ago because of the decrease in the vegetation coverage of the MGFs. It is fortunate that 96.5% of the respondents recognized the cause for the increase in temperature is the reduction of vegetation coverage of the mountain green frames. About 69.4% of the respondents indicated a decreasing trend in rainfall intensity as a consequence of the deterioration of the MGFs, while the rest were uncertain about this relationship. Nearly all respondents (99%) acknowledged the role of trees in mitigating perceived climate change, highlighting the need for tree planting in urban areas and MGFs. This could be linked to the respondents who believe that planting trees inside urban areas and MGFs would certainly mitigate the urban flooding of their cities experiencing recently, as reported by 92.4% of the respondents. Key informant interviewees reported climate change over time because of deforestation following the cut of trees for fuel wood by both IDPs and host communities in their cities.

Elderly FGD participants described the manifestations of climate change as the occurrence of unseasonal rainfall, rising temperatures, and the loss of indigenous tree species. A major concern raised was the increasing unpredictability of rainfall, which they noted could lead to reduced agricultural production negatively impact community livelihoods, including their own. Key informants similarly expressed that climate change is evident, emphasizing temperature increases as a primary driver of the observed changes.

Two key informants stated that they feel warmer now than they did in the early hours of the day in the past. They noted that the evenings are now warmer than they were a few years ago. They feel warm starting around 9:00 AM, which was uncommon some 10-20 years ago.

The academic FGD participants explained about the climate change indicators in the area including irregular rainfall, increase in temperature, emerging of new diseases of animals, human beings and plant diseases, and complicated cases, highlighting with an example of the increase in the aborting of animals. These participants shared their own experiences such as the loss of interest to work from offices because of depression as the result of the increase in temperature. These participants further reported that their office windows were broken as the result of the uncommon rainfall with strong snow which led to frequent flooding incidents in Shire-Indasilassie city. According to the academic FGD participants, unlike a few years ago people are not using blankets to keep them warm recently. In their perception, this is the result of the increase in temperature because of the deforestation in the city's catchment – the trees of the MGFs are almost non-existent. Ground water is getting low and drying in the catchment as reported by the academic FGD participants. Male academic FGD participants believe that approximately 80% of climate change impacts can be mitigated by implementing NbS such as tree plantations with sustainable management while female academic participants deemed that NbS can mitigate 60% of climate change impacts. Hundred percent of FGD participants from the academic, humanitarian workers and elderly people said, 'I feel a change in climate now than 10-20 years ago' compared to 87.5% and 82.5% of the young volunteer and non-volunteer FGD participants. The Pearson correlation coefficients revealed a significant positive relationship between temperature and occupation, and frequent flooding and residency exhibit a significant positive relationship (Table 2).

Table 2: Relationship of socioeconomic factors with perception on climate change indicator variables

	Residency	Family size	Gender	Age	Education	Occupation	Land ownership	Income
Temperature								

Pearson Correlation	0.002	-0.090	-0.024	0.050	-0.005	.123*	0.016	0.063
Sig. (2-tailed)	0.968	0.076	0.637	0.321	0.927	0.014	0.755	0.214
N	394	394	394	394	394	394	394	394
Rainfall intensity								
Pearson Correlation	-0.028	0.008	-0.019	-0.021	0.011	-0.076	0.029	0.022
Sig. (2-tailed)	0.585	0.879	0.701	0.676	0.823	0.132	0.560	0.657
N	395	395	395	395	395	395	395	395
Frequent flooding								
Pearson Correlation	-.143**	0.003	-0.037	-0.002	-0.090	0.016	0.009	0.020
Sig. (2-tailed)	0.004	0.956	0.464	0.970	0.076	0.748	0.865	0.697
N	395	395	395	395	395	395	395	395

**Correlation is significant at the 0.05 level (2-tailed)*

***Correlation is significant at the 0.01 level (2-tailed)*

Results of the logistic regression model is portrayed in Table 3, for the parameter estimates of factors affecting the influence towards the perception about the potential of NbS in mitigating perceived climate change. Variables including residence, changes in temperature and rainfall and the frequency of flooding incidences significantly increase the likelihood of urban residents' enthusiasm of the potential of NbS in mitigating climate change ($p < 0.05$).

Table 3: Parameter estimates of the logistic regression model affect the influence towards the potential of NbS to mitigate the perceived climate change.

Variable	**B**	**S.E.**	**Wald**	**df**	**Sig.**	**Exp(B)**	**95% C.I.for EXP(B)**	
							Lower	Upper
Residence	-2.665	1.220	4.767	1	0.029	0.070	0.006	0.761
Family size	-0.126	0.088	2.055	1	0.152	0.881	0.741	1.048
Gender	-0.465	0.284	2.673	1	0.102	0.628	0.360	1.097
Age	-0.570	0.891	0.409	1	0.522	0.566	0.099	3.240
Educational level	1.098	1.376	0.637	1	0.425	2.999	0.202	44.492
Occupation	-0.167	0.445	0.142	1	0.707	0.846	0.354	2.022
Land ownership	-0.185	0.354	0.274	1	0.601	0.831	0.416	1.662

Income	0.447	0.269	2.753	1	0.097	1.563	0.922	2.650
Temperature	2.651	0.308	73.878	1	0.000	14.171	7.742	25.940
Rainfall	0.463	0.109	17.902	1	0.000	1.588	1.282	1.968
Flooding	0.457	0.208	4.849	1	0.028	1.580	1.052	2.373

4.4 Local urban communities' participation in NbS

Respondents have been participating in NbS such as tree planting and management for an average of 4.08 years and a maximum of 30 years. All participants are worried about the tree loss of the MGFs with 2.1% fairly worried, 60.5% very worried, and 37.2% extremely worried. Most sample households (68.1%) participate in tree planting. People in the order of 36-64 years old (men), 15-35 years old (men), 15-35 (women), and 36-64 (women) had been participating most in tree planting and management (Figure 4). The top three main purposes outlined by the respondents for participating in tree plantation and management campaigns, as Table 7 shows, are to improve the microclimate of their city, followed by the need to mitigate increased temperature, and to protect flooding, respectively.

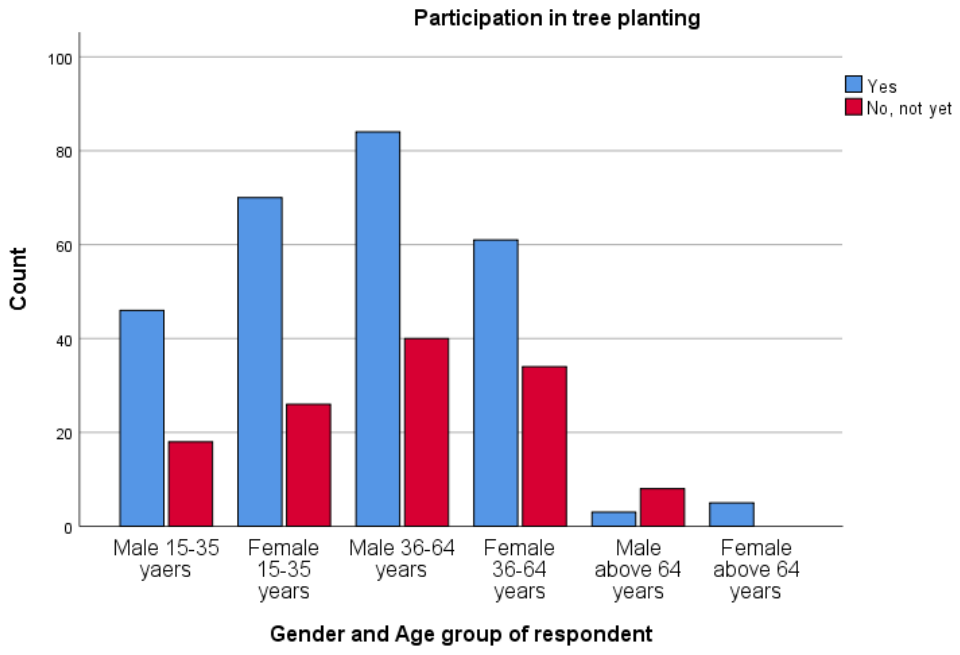

Figure 4: Participation in tree planting.

Participants were asked to identify whether there are negative consequences of involvement in tree planting. Accordingly, no negative consequences, restrictions in other economic activities, affecting educational involvement, and the creation of

conflicts between neighbors were reported by 96.5%, 2.8%, 2%, and 0.5% of the respondents, respectively. Lack of awareness (97.7%), lack of commitment (97.5%), lack of financial support

Table 4: Percentage evidence of climate change perception and the probability of mitigating the change using NbS by various segments of the population based on the FGDs.

Description	Youth Volunteer		Youth non-volunteer		Communities		Humanitarian workers		Academic		Average	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	F	M
Climate change is clear now than 10-20 years ago	100	100	100	100	100	100	100	100	100	100	100	100
The change in climate is more visible from year to year by the increase in unseasonal rainfall overtime	100	100	90	70	90	80	65	80	100	100	89	86
The increase in climate change is caused by the increase in temperature from time to time	90	80	95	90	80	75	90	70	65	70	84	77
NbS like tree planting can mitigate the perceived climate change	100	30	80	60	80	80	60	70	50	80	74	64
Climate change mitigation using NbS is effective to human wellbeing	100	70	80	80	80	90	100	100	70	80	86	84

Table 5: The five most important challenges of the cities.

1st choice		2nd choice		3rd choice		4th choice		5th choice	
Challenge	%	Challenge	%	Challenge	%	Challenge	%	Challenge	%
Housing	33.67	Housing	18.23	Water	20.76	Unemployment	17.97	Climate change	18.99
Poverty	18.48	Unemployment	17.72	Unemployment	20	Water	14.68	Environmental pollution	12.91
Water	11.9	Water	16.2	Housing	13.16	Climate change	11.9	Water	11.14
Health	9.87	Poverty	14.94	Poverty	11.39	Crime	10.89	Unemployment	10.63
Crime	8.61	Health	8.61	Health	10.63	Poverty	10.13	Poverty	10.13

(95.2%), and shortage of budget (86.8%) were among the major obstacles to the implementation of NbS such as tree planting and management as identified by the sample population. The relationships and associations between the socioeconomic factors and the perception on climate change indicator variables are presented in Table 6.

Table 6: Relationship of socioeconomic factors with perception on climate change indicator variables

	Residency	Family size	Gender	Age	Education	Occupation	Land ownership	Income
Temperature								
Pearson Correlation	0.002	-0.090	-0.024	0.050	-0.005	.123*	0.016	0.063
Sig. (2-tailed)	0.968	0.076	0.637	0.321	0.927	0.014	0.755	0.214
N	394	394	394	394	394	394	394	394
Rainfall intensity								
Pearson Correlation	-0.028	0.008	-0.019	-0.021	0.011	-0.076	0.029	0.022
Sig. (2-tailed)	0.585	0.879	0.701	0.676	0.823	0.132	0.560	0.657
N	395	395	395	395	395	395	395	395
Frequent flooding								
Pearson Correlation	-.143**	0.003	-0.037	-0.002	-0.090	0.016	0.009	0.020
Sig. (2-tailed)	0.004	0.956	0.464	0.970	0.076	0.748	0.865	0.697
N	395	395	395	395	395	395	395	395

**Correlation is significant at the 0.05 level (2-tailed)*

***Correlation is significant at the 0.01 level (2-tailed)*

The key players of tree planting activities in the study areas are the government, individuals, private companies, humanitarian organizations, donors (NGOs) and others as reported by 98.2%, 83.3%, 11.1%, 3%, and 2.3%, respectively. More than 86.8% of the research participants knew about tree planting campaigns in their communities, highlighting that most of them (81.5%) had participated at least once in the importance of tree planting briefs or sessions in their communities. The participants of the research have been motivated to participate in tree planting because of government mobilization (64.8%), personal interest (48.9%) and their wish to see a beautiful urban area (25.8%). Participants reported that seedlings have been mainly

produced by government (98.7%), and individuals (70.1%), where the government is the main seedlings supplier (99%) followed by individuals to some extent (29.1%) for community tree planting initiatives in communal lands. Sample households can get non-fruit seedlings for planting in their compounds from government for free (47.6%) and at reasonable prices (36.5%) and buy from individuals (59.5%). While planting fruit trees, individual households can get seedlings from government supply for free (4%) and government supply at reasonable prices (19.7%), but the majority buy from individuals (61.8%). Likewise, 47.8% of participants showed interest in in-cash contribution for proper management of the MGFs, and of those who did not show interest in contributing in-cash, 92.2% decided this because of the absence of enough budget for contribution.

Table 7: Purposes to participate in tree planting activities.

Purpose for participation	Number of respondents	Percent
Producing fuel wood	13	3.3
For the sake of participation	11	2.8
To protect flooding	181	45.8
To improve the microclimate of their city	373	94.4
For return, e.g., cash from the urban safety net program	24	6.1
To mitigate increased temperature	364	92.2
other	22	5.6

Volunteer FGD participants reported that their participation in seedlings production and plantation activities is because of the awareness raising sessions provided by the ERCS office. According to their reflection, the understanding and internalization of the challenge, after the awareness sessions, added to their motivation to engage in the NbS mentioned above. Above all, the ERCS volunteers reported that the engagement in NbS during and after the two-year war on Tigray, enabled to get free from stress for the conflict traumatized volunteers.

Results of the logistic regression model on the parameter estimates of factors influencing participation in NbS such as tree planting activities (Table 8) show that age, education, occupation, land ownership, rising temperatures and change in rainfall influenced urban residents' decision in tree planting participation.

Table 8: Parameter estimates of the logistic regression model of factors influencing participation in NbS.

Variable	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
							Lower	Upper
Residence	1.584	1.175	1.819	1	0.177	4.876	0.488	48.750

Family size	-0.100	0.077	1.702	1	0.192	0.905	0.779	1.052
Gender	0.067	0.259	0.067	1	0.796	1.069	0.644	1.775
Age group	-1.280	0.692	3.420	1	0.024	0.278	0.072	1.080
Educational level	-1.175	1.197	0.963	1	0.000	0.309	0.030	3.226
Occupation	1.159	0.455	6.469	1	0.011	3.185	1.304	7.778
Land ownership	-1.013	0.364	7.740	1	0.005	0.363	0.178	0.741
Income	-0.335	0.262	1.645	1	0.200	0.715	0.428	1.194
Temperature	0.907	0.241	14.219	1	0.000	2.477	1.546	3.969
Rainfall	0.235	0.108	4.726	1	0.030	1.265	1.023	1.564
Noticed frequent flooding in city	0.123	0.191	0.416	1	0.519	1.131	0.778	1.646

4.5 Ethiopian Red Cross Society Northwest Tigray branch participation in NbS

The ERCS northwest zonal branch office has been participating in tree plantation interventions and management through youth volunteer mobilization in Shire-Indasilassie city since 2012. This was started after the 2012 flood effect on the Shire Suhul General Hospital, the largest public hospital in the northwest zone of Tigray. The 2012 flood incidences in Shire-Indasilassie city affected inpatients and the dispensary section of the hospital. The flooding of the hospital and the city in general was a big issue at that time. The flooding was caused by climate change and the consequences of the degradation of the vegetation of the MGFs of the city. The city council requested the northwest zone ERCS branch office to take care of the catchment area through soil and water conservation, tree plantation and management, with the purpose of protecting flooding. The ERCS accepted the city council's request, and the city council handed over part of the MGFs. The ERCS then started intervening mobilizing volunteers and assigned guards for improving the management of the MGF properly through the protection of animals and human disturbance, and reafforestation programs until the Tigray 2020 war.

However, following the 2020 Tigray war, trees in the MGF were cut for fuelwood by both host communities and IDPs during the conflict. The armed conflict contributed to climate change impacts in the area. A Suhul hospital key informant interviewee mentioned that

'Recently, vegetation in the upper catchment area of the hospital- which forms part of the city's MGF - has been cleared,) including tree roots, for fuelwood by both host communities and IDPs as a consequence of the armed conflict. The hospital is at risk, especially this coupled with the effect of climate change and its impact on increasing frequent flood incidences. In explaining about the change in climate, this key informant said that Shire-Indasilassie city was midland but now he is not quite sure whether it is still categorized in the same agroecology, it is getting warm and warm'. Some years ago, residents walked on foot from place to place in town, but now it is difficult to walk because of the warm temperature.

The ERCS noticed the impact of flooding in the cities as the consequence of the cut of trees for firewood following the 2020 Tigray war coupled with the change in rainfall intensity. People moved to firewood because of the cut-off electricity. The absence of essential public services such as electricity and telecommunication services was suspended during the war. Moreover, the suspension of the production of seedlings by the government. The ERCS branch office also assessed and found no stakeholders including NGOs were participating either in seedlings production in its AoR. Further, the ERCS aimed to enable communities including ERCS volunteers to think about life after a devastation war. The ERCS, considering its auxiliary role to the government, established a temporary nursery site to engage in seedlings production to supply seedlings for plantation in the MGF parts of the cities located in its AoR in general and the MGFs in the target areas in particular. In implementing the seedlings production project, the ERCS branch office mobilized resources from different stakeholders.

The trust that ERCS built through its contributions during emergencies, together with the seedlings production project innovativeness, enabled the organization to mobilize resources from various actors. Some stakeholders were asked for technical support, others for resources that the ERCS did not own. The ERCS opts for organic fertilizer such as compost from individuals who had livestock, plastic seed pollen tubes from the public agriculture and natural resources offices of the different districts of the northwest zone. The local government had no budget except these mentioned seed pollen tubes. Seed was collected by the youth volunteers, and farmers were asked to help the volunteers by training on how to collect the seeds. FAO and the natural resources utilization and management departments of the government provided regular technical support throughout the project life – from preparation to plantation phase. According to the key informants, ERCS started seedlings production because of the prevailing challenges during the armed conflict. This was because the trees in the MGFs of the cities were continuously cut for firewood by both the IDPs and the host communities.

The output was very successful. Especially, participation in seedlings production and management enabled volunteers to hope for future through the morale creation, not

only the incentives provided to volunteers to engage fully in the activity. The key informant participants mentioned the seedlings production practice as a social laboratory. The project's inspirational nature during the armed conflict was reported by the participants of the FGDs. Key informants and FGD participants underlined the importance of the pilot project in terms of its contribution to the treatment of the war victim population of the area as it made traumatized persons think about life after the war. According to the ERCS office, tree plantation and management of MGFs as a greening program is now integrated into its regular activities. The branch believes that rehabilitation activities including the management of the MGFs is a crucial mitigating approach, i.e., better to mitigate rather than to respond to flooding emergencies in addition to its contribution to rehabilitate war traumatized persons.

4.6 Effect of NbS to climate change on human wellbeing

Addressing questions like the effect of climate change on communities' wellbeing is important for understanding the contribution of NbS to the survival of communities. All the participants value the contribution of involvement in tree planting and management to their physical activity and mental health with 46.6% strongly agree, 52.9% agree, and only 0.5% are uncertain (Figure 5). However, female and male FGD participants stated that NbS such as tree planting and management can solve about 74% and 64% of the perceived climate change challenges, respectively (Table 4). As portrayed in Table 4, FGD participants believe that NbS to climate change are 86% and 84% effective as reported by female and male participants, respectively. Almost all (99.5%) of the sample respondents would like to change the way they value green infrastructure, including the MGFs. The main purpose of the interest for changing the way people value urban green infrastructure is to improve the microclimate of their city and to see a better environment (Table 9). Both genders of the ERCS volunteers who engaged in the seedlings production activity confirmed that their involvement in seedlings production, and tree plantations and management enabled them to aspire to a new life, contained their conflict related stress, became mentally healthy relative to the youth who did not participate. Above all it provided them with hope for the future that would help them to think life will sustain after war.

Table 9: Reasons for the interest of respondents to change the way they value their city's green infrastructure.

Reason	Number of respondents	Percent
Existing coverage does not protect flooding	145	36.7
The green infrastructure coverage is very small	185	46.8
To improve the microclimate of the city	387	98
Desire to see a better environment in their city	386	97.7
To contribute to the development of green spaces	256	64.8
To improve means of livelihood	175	44.3

Purposely, a question was included to know the willingness of the local community members for better management of the MGFs in terms of in-kind and in-cash contributions. With regards to an in-kind contribution, 93.9% of the surveyed individuals showed an interest in involvement. Among respondents who were not interested in an in-kind contribution, 72% cited the lack of sufficient budget, 16.7% believed that the municipality instead has enough budget, and 8.3% pointed to initiatives that overlook grassroots needs. The response to the question on willingness to contribute in-cash for the management of the MGFs varied, and 52.2% of the respondents indicated that they were not interested in making an in-cash contribution. The top three main reasons outlined by the respondents who did not show an interest to contribute in-cash are lack of sufficient budget (92.2%), the thought that their support may not be used for the purpose (24.3%), and the belief that the municipality already has enough budget (7.8%).

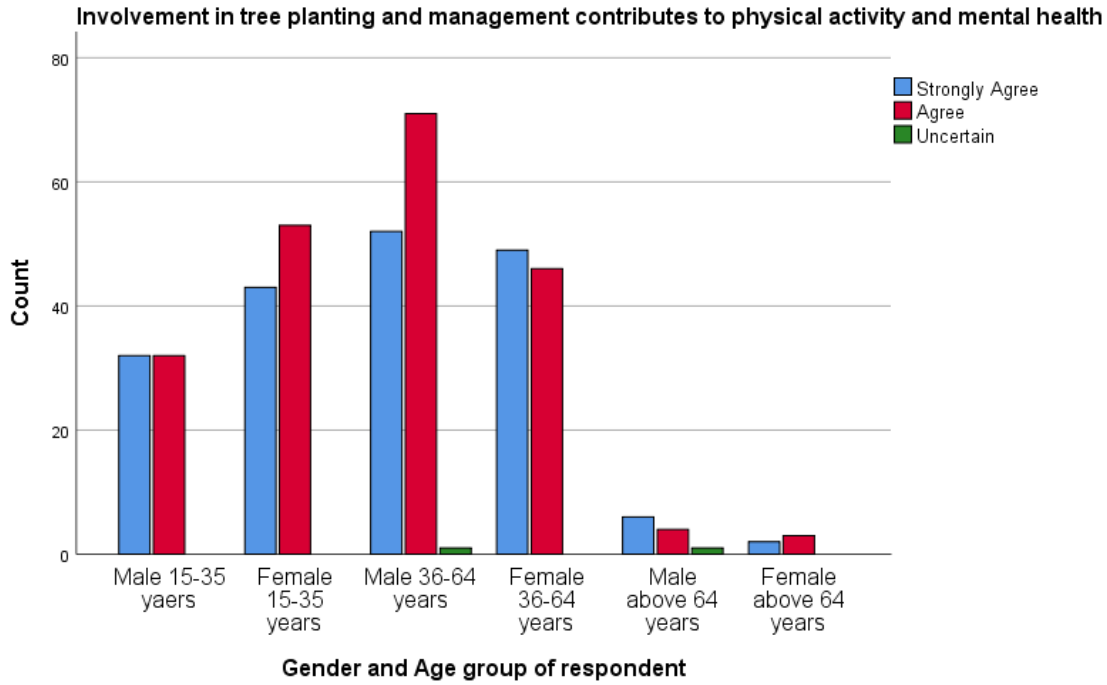

Figure 5: Involvement in tree planting and management.

Table 10 indicates parameter estimates of the ordinal regression model, where we regressed the perception of urban communities about the potential of the NbS to climate change on human wellbeing against a range of independent variables. The regression analysis result indicated that the dependent variable was significantly affected by family size, the experience in tree planting (participation), income, occupation, and residence.

Table 10: Parameter estimates of the ordinal regression model affect the influence of NbS to mitigate climate change effectiveness on human wellbeing.

Variable	Estimate	S.E.	Wald	df	Sig.	95% confidence interval	
						Lower	Upper
[ITPMPAMH = 1]	11.958	2.924	16.728	1	0.000	6.228	17.689
[ITPMPAMH = 2]	19.297	2.482	60.424	1	0.000	14.431	24.162
[Participation=1]	-1.814	0.288	39.562	1	0.000	-2.379	-1.249
[Participation=2]	0[a]			0			
[Residence=1]	-3.891	1.378	7.969	1	0.005	-6.593	-1.189
[Residence=2]	0[a]			0			
[Familysize=1]	21.910	1.056	430.579	1	0.000	19.841	23.980
[Familysize=2]	21.615	1.036	435.243	1	0.000	19.584	23.646
[Familysize=3]	21.385	0.984	472.681	1	0.000	19.457	23.312
[Familysize=4]	21.544	0.980	482.790	1	0.000	19.622	23.466
[Familysize=5]	20.849	0.980	452.929	1	0.000	18.929	22.769
[Familysize=6]	20.785	1.029	408.382	1	0.000	18.769	22.801
[Familysize=7]	20.531	1.294	251.602	1	0.000	17.995	23.068
[Familysize=8]	19.359	1.489	169.053	1	0.000	16.440	22.277
[Familysize=9]	20.397	0.000		1		20.397	20.397
[Familysize=10]	0[a]			0			
[Gender=1]	0.048	0.255	0.035	1	0.851	-0.453	0.549
[Gender=2]	0[a]			0			
[Age=1]	-0.687	0.710	0.938	1	0.333	-2.078	0.704
[Age=2]	-0.607	0.662	0.842	1	0.359	-1.905	0.690
[Age=3]	0[a]			0			
[Education=1]	2.590	1.419	3.334	1	0.068	-0.190	5.371
[Education=2]	1.756	1.401	1.571	1	0.210	-0.990	4.502
[Education=3]	2.611	1.416	3.399	1	0.065	-0.165	5.387

[Education=4]	1.428	1.437	0.988	1	0.320	-1.389	4.245
[Education=5]	1.724	1.414	1.488	1	0.223	-1.046	4.495
[Education=6]	2.266	1.479	2.346	1	0.126	-0.633	5.164
[Education=7]	0[a]			0			
[Occupation=1]	-1.422	0.405	12.324	1	0.000	-2.216	-0.628
[Occupation=2]	0[a]			0			
[Landownership=1]	-0.131	0.319	0.169	1	0.681	-0.757	0.494
[Landownership=2]	0[a]			0			
[Income=1]	-4.567	1.741	6.880	1	0.009	-7.980	-1.155
[Income=2]	-4.499	1.705	6.963	1	0.008	-7.841	-1.157
[Income=3]	-4.164	1.733	5.772	1	0.016	-7.561	-0.767
[Income=4]	0[a]			0			

Note: ITPMPAMH – Involvement in tree planting and management contributes to physical activity and mental health.

5. Discussion and implications

5.1 General discussion

As mentioned above, unlike in other major cities of Tigray, Shire-Indasilassie and Sheraro sheltered the majority of IDPs in the region, which in turn increased heavily the demand for livelihood including energy resources. The absence of government regulations and the cut off electricity resulted in a free cut of trees from the nearby woody vegetation areas – the MGF areas of the cities. A study conducted by Birhane et al. (2025) in three districts (Woredas): Abergelle-Yechila, Samre and Atsbi in Tigray reported the cutting of trees for firewood from the woody vegetation during the Tigray conflict as the consequence of the collapse of local bylaws and government regulations. Similarly, Rotherham (2024) in a historical review of forests and warfare documented that in the Horn of Africa, where there are frequent conflicts and sustainable energy alternatives are limited, absence of abuse in local regulations led to accelerated destruction of natural resources. IDPs depend on natural resources for their livelihoods (Erenstein et al., 2021; Birhane et al., 2025). In the urban areas of Tigray, the increased dependency on firewood and charcoal as the consequence of the suspension of public services including essential services such as electric power caused deforestation (Solomon Hishe et al., 2023). According to this research, respondents further indicated that the increase in population could increase the warmness of the cities, highlighting the complicated impact of the conflict and climate

change. However, this study has limitations in identifying the attributing impacts to climate change. Thus, a study that would conduct an attribution study to differentiate the attributing impacts on climate change will be important.

The results of this study, in three urban areas of Tigray, revealed that various segments of the population easily perceived climate change now than 10-20 years ago because of the increase in temperature and the frequent flooding incidences in the areas. Flooding has become a recurrent incidence in cities and towns of Northwest Tigray including in the study areas that are under the AoR of the ERCS northwest branch in Tigray. This perception in climate change could either be associated with the loss of lives because of flooding in their communities and/or the change in temperature. The result of the analysis indicate that residency and occupation of respondents positively influence the perception of climate change, persuading the likelihood of perception in climate change. That is the likelihood of perceiving climate change is more easily reported by people living in urban areas than those living in the per-urban areas.

During the Tigray conflict, the political system was disrupted, and essential services like electricity broke down among other essential services in the area. The interruption in electricity obliged the IDPs and host communities to cut trees from the vegetated areas of the cities' catchment, which in turn speeded up the runoff, resulting in consequent flooding. The cut of trees from the MGFs has contributed to the increased runoff, in turn, coupled with rainfall variability accumulated and created high flooding in Shire-Indasilassie and Selekleka. For instance, in the last rainy season (northwest Tigray has only rainy season, i.e., Mid-May – Mid September), the life of one resident lost because of flooding in Shire-Indasilassie. Selekleka town of Northwest Tigray, located 28 kilometers of Shire-Indasilassie, lost 12 residents, several inhabitants injured, and 103 houses damaged because of flash flooding on June 25, 2022 (EES/NFI, 2022). Similarly, according to the Ethiopian Emergency Shelter (EES/NFI, 2022), a flash flood caused damages to 73 houses in 2022 in Sheraro town of Northwest Tigray.

Table 11: Constructs designed in the survey instrument (household survey) that justify respondents' perception of climate change, the perception towards the role of NbS in mitigating the perceived climate change and the effectiveness of NbS to human wellbeing

Construct name	Description	Groups of Questions on Survey	Response					Cronbach's Alpha
			Strongly disagree	Disagree	Uncertain	Agree	Strongly agree	
Perception of local communities about changes in climate change	Whether the respondents believe the presence of climate change	Local communities easily feel the increase in temperature now than 10-20 years ago	0	0.3	1	46.3	52.2	
		Local communities easily gauge the increase in rainfall intensity now than 10-20 years ago	2.3	66.1	23.3	8.1	0.3	
		Local communities easily gauge the increase in rainfall duration now than 10-20 years ago	2.3	66.1	23.3	8.1	0.3	
		The city/town is facing frequent flooding now than 10-20 years ago	0	5.3	14.2	70.9	9.6	
		'The temperature is affected by the decrease in the vegetation coverage of the MGFs	0	0	1.5	65.8	32.7	0.615
		The flooding incidence in the city/town is affected by the decrease in the vegetation coverage of the MGFs	0.5	0.5	10.1	74.2	14.7	
		The decrease in rainfall intensity is affected by the decrease in the vegetation coverage of the MGFs	0.5	2	28.1	59.5	9.9	
		The decrease in rainfall duration is affected by the decrease in the vegetation coverage of the MGFs	1.3	48.4	8.9	37.2	4.3	
NbS as mitigation of the perceived climate change	Whether local communities believe that NbS mitigate the perceived	Planting of trees would certainly mitigate the perceived climate change	0.5	0	0.5	61.3	37.7	
		Planting of trees with sustainable management would certainly mitigate the perceived climate change	0.5	0	0	64.1	35.4	0.702

	Effect of climate change mitigation using NbS	Planting of trees with sustainable management would certainly mitigate the urban flooding that we are experiencing recently	0.5	0.5	6.6	74.9	17.5	0.704
		Involvement in tree planting and management contributes to physical activity and mental health	0	0	0.5	52.9	46.6	

Natural disasters such as flooding as the impact of climate change would need an emergency response, and the northwest Tigray Red Cross branch office is the first responder in the study areas. The ERCS started to intervene in NbS such as seedlings production and tree plantation activities, to sustainably respond to the prevailing challenges of flooding in the cities and towns. The nursery production and plantation activities, distribution of seedlings to nearby districts (Woredas) has been seen as the way to the post conflict rehabilitation and recovery efforts. Thus, participation in such innovative activities that would result in benefiting the population and the environment sustainably make the ERCS the real emergency responder. It was also a special privilege to strategically think and act to avert natural disasters by solving the root causes for the natural disasters including the flooding incidents in the study areas. Most participants of the research believe in the great role of planting and properly managing MGFs to mitigate the perceived and future unpredictable effects of change in climate. According to a key informant from the natural resource's utilization and management of the government department, one of the key stakeholders of the project under consideration of the study, explained about the initiatives of the northwest ERCS branch office as follows.

"This kind of motivation and engagement for ERCS is prepared for disaster management. The public was generally inspired by the ERCS as it was mobilized for plantation, and the people were amazed to learn about the availability of seedlings from the ERCS temporary nursery site. The ERCS is now following up and monitoring planted seedlings to see the trees grow and contribute to the protection of flooding incidences to the city. The government-based mass mobilization plantation schemes mainly reported the number of planted trees while the ERCS is looking for a better way and monitors the survival of the planted trees.'

In this perspective, the role of humanitarian organizations and other development organizations is key in taking responsibilities in NbS such as tree planting activities during armed conflicts and post conflict times. This is because they can take the opportunity of access they could have during conflicts and war as well as the better resources humanitarian originations could have than local governments, limited though.

Results of the study show the contribution of the ERCS's seedlings production and plantation intervention in fostering the social healing and resilience of the community members. Similarly, empirical results of the study indicate the perception of residents on the effectiveness of the NbS to mitigate climate change interventions on human wellbeing, suggesting the health and wellbeing contribution of community members involvement in NbS during and post-conflict.

Resources mapping, establishing coordination from humanitarian activities during emergencies and involvement in NbS to climate change such as seedlings production and tree plantation activities were among the critical activities the ERCS carried out as a contribution to minimizing the compounding effects of climate change and conflict. During the armed conflict, the ERCS mapped local resources from various stakeholders including the submissive government sectors, humanitarian organizations, development actors, and communities in general. Collaboration approaches between ERCS and other humanitarian organizations, ERCS and Governmental sectors resulted in a fruitful accomplishment of the project though there were ups and downs as reported by the ERCS office. This would build the capacity of local communities to mitigate climate change impacts in the future. Climate change mitigation is the responsibility of everyone; however, key players play a great role in mobilizing and designing implementation approaches. Researchers recommend multi-stakeholder partnerships in post-conflict reconstruction for restoring the natural resource damage through integrated restoration programs based on environmental assessment, sustainable resources management, community engagement, and capacity building (Birhane et al., 2025). Hishe et al. (2024) similarly come up with the recommendation for a grass-roots level formal and traditional institutional development and donor involvement for the post-war recovery and reconstruction to restore the conflict impacted degraded environment of Tigray.

The findings of this research advocates not only for post-conflict implementation of NbS but also for trying to adopt practices to develop a framework for scaling the human wellbeing impact of engagement in NbS to the war-affected population during the latent period of conflicts in situations of an unstable power shifts among actors to a conflict. This could be achieved if guided by the principles one organization is committed for, for instance, for the case study the ERCS achieved this because of its commitment to respect the Red Cross fundamental principles. The ERCS branch office has implemented seedlings production project in the absence of institutional structures such as bylaws and community governance (Birhane et al., 2025). What matters is the understanding of climate change, the impact of conflict on natural resources, and designing of mitigating solutions to the compounding effects of climate change and armed conflict. Above all, the potential component is the ability to engage in conflict-affected areas and the impact of insecurity on participation. Especially, this is vital in urban areas where the majority of the population is living (Zhang et al., 2013; UN, 2015) and is projected to increase up to 668 million (UN-Habitat, 2022), presence of more than 120 conflicts exist (ICRC, 2024) and the increase impact of climate change happened (IPCC, 2022).

5.2 Nature-based Solutions Framework – UNID PRIM COC

A draft UNID PRIM COC [1]framework of the below nature-based solutions pathways to new layers of complexities for urban communities coping with conflict and climate change outlining different issues presented to participants for validation. Participants provided valuable inputs to shape the framework. In the framework, different factors including the communities perceived knowledge of climate change, other stakeholders understanding of the prevailing impact of climate change like flooding, importance of NbS in mitigating impacts of climate change, collaboration approaches between ERCS and other humanitarian organizations and the public sectors in seedlings production and plantation as a NbS during conflict and after in rehabilitation and recovery phase, and the limitations learned. The framework has considered various experiences from the ERCS pilot project and supported with other experiences. The research participants (participants of the validation workshop) including researchers believe that the UNID PRIM COC framework (Figure 6) can be suitable for their contexts in Ethiopia and beyond.

[1] UNID PRIM COC (you need prim code of conduct) is an abbreviation for the phases of the proposed NbS framework for communities coping with conflict and climate change. UN for UNderstanding the context, I for identifying main challenges, PR for PRoposing solutions, I for Identifying opportunities, M for Mobilizing stakeholders, and COC for coordination and collaboration.

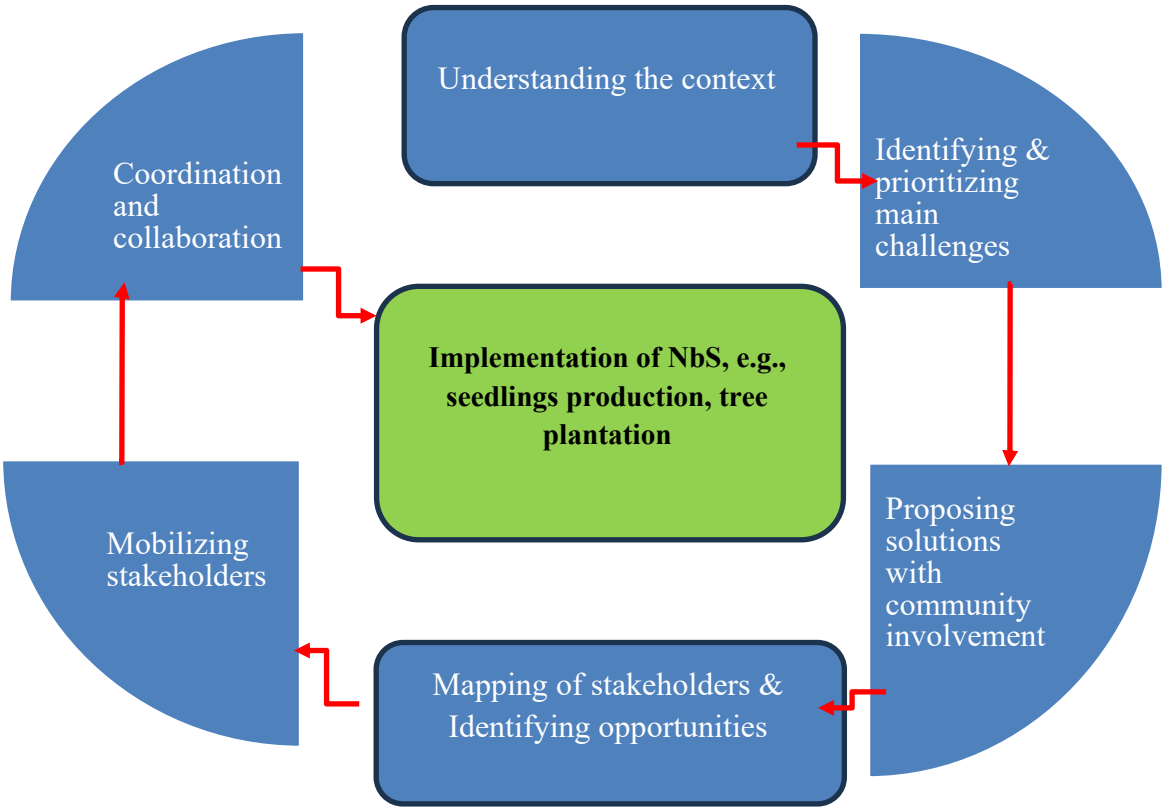

Figure 6: Phases of a framework for NbS by humanitarians for coping with new layers of complexities for urban communities coping with conflict and climate change.

Key points of the proposed nature-based solutions framework – UNID PRIM COC framework
Considering that humanitarians work in a fragile context with repeatedly shifting in power, different actors overtaking the same area interchangeably, it is crucial to clearly understand and consider the various bullet points mentioned under each phase of the proposed nature-based solutions framework.
Understanding the context
Humanitarian volunteers should consider the context in all their movements. They should be very disciplined and act in an ethical manner. Proactively think of approaches that could facilitate smooth plantation of the seedlings. Seedlings should be planted on time.

Identifying and prioritizing main challenges

Humanitarians should identify the main challenges in the context of the humanitarian field.

Discuss in detail with community members if the identified challenges are among the key challenges.

Humanitarians should discuss the challenges and the suffering of the communities with actors to the conflict in a professional and neutral way.

Proposing solutions with community involvement

Discuss with local communities and ask them to propose possible solutions to the prevailing challenges themselves and guide them to consider the current situation.

Always remember why you are proposing the solution for the prevailing challenges.

It should be a venture that can easily convince any actor to the conflict.

The proposed nature-based solution should indicate continuity.

Mapping stakeholders and identifying opportunities

You should know that humanitarian volunteers have limited resources, and there may not be resources for substituting in the middle of the project.

Try to identify different stakeholders, not only because they can contribute either in-kind or in monetary terms but also to give better attention to their interest and influence in your proposed NbS.

Sometimes, NbS may not be valued as important as rapid emergency responses during armed conflict by actors to the conflict and community members.

Identifying opportunities should be a continuous process. Mobilizing during implementation by inviting different actors could also give opportunity for sustainable resources to other NbS.

Mobilizing stakeholders

Mobilize all potential stakeholders to the proposed NbS intervention and try to get their support and go-ahead response, at least from the military and civil authorities.

Invite potential stakeholders to visit and even monitor the intervention, leave alone those who contribute to resources to invite those who may influence the implementation of the project.

Coordination and collaboration

Coordinate and collaborate with all stakeholders including the military and civil authorities' circles for the smooth implementation of the project, to protect unintended repercussions.

Need for further coordination and collaboration for preparing local authorities and other stakeholders for plantation and management and follow-up after plantations.

Coordinate and try to link your project with potential stakeholders that could involve in or fund solar powered electricity to provide IDPs with alternative energy resources.

6. Conclusions and recommendations

6.1 Conclusions

In this study, communities' perception of climate change and the potential of NbS to the perceived changes as well as the participation of communities in NbS during armed conflict and post-conflict were investigated based on descriptive statistics, logistic regression and ordinal regression models. Communities face various challenges during armed conflict and the effect of climate change such as flooding added other layers of challenges, and is the critical concern of the communities, government officials, humanitarian workers, and the academics. Collecting firewood has been the main means of energy resources for both the host communities and IDPs through free cutting trees from the MGFs. The cutting of trees correlates with recurrent flooding incidences in the cities. The presence of climate change is perceived because of unseasonal rainfall and increase in temperature as the consequence of deforestation. On another note, participants, however, obviously believe that NbS such as tree planting with sustainable management can mitigate the perceived climate change impacts and are key in

addressing to the new layers of complexities for communities experiencing compounding risks of armed conflict and climate change. Participation in NbS such as seedlings production and tree plantations and management can not only contribute to maintain flooding and improve microclimate of cities but can also make crucial contribution to the wellbeing of community members through physical activity and mental health. Also, it can help traumatized people to get free from stress and enable them to think about survival after armed conflict. The NbS framework (UNID PRIM COC framework) is developed through examining the coupled ecological, socioeconomic and institutional dimensions of NbS fostering social healing and resilience, the study can contribute to the sustainability of science perspectives. Many of the points discussed regarding the pilot experience of ERCS northwest Tigray branch could be an important lesson/contribution to the revitalization of the natural resources' rehabilitation programs in Tigray with many transferable lessons to other local and international humanitarian organizations. Thus, the developed NbS framework can be useful in NbS programs and projects implementation during conflict and post-conflict, in recovery, reconstruction, and of course during normal situations.

6.2 Recommendations

It is important to understand the perception of communities and other stakeholders about the prevailing challenges and opportunities for NbS implementation framework development that considers the ecological, socioeconomic and institutional aspects as a pathway to new layers of complexities for communities coping with conflict and climate change. The following specific recommendations are extracted from this study.

Humanitarian actors like the local ERCS branches with local level established structures would help mobilize more people and thus government and other stakeholders should support local ERCS branches to involve not only in delivering a temporary intervention as an emergency responder but also sustainable solutions to mitigate compounding impacts of conflict and climate change.

Involvement of traumatized youth in seedlings production and plantation activities is not only crucial for land rehabilitation but also for social healing. Thus, given much of the population in Tigray is youth, who are supposed to have scars of the 2-year armed conflict and its impact, NbS to climate change projects should continue in massive in Tigray's aftermath rehabilitation and recovery programs.

Understanding factors that trigger or limit humanitarian organizations' role in continuing implementation of NbS is crucial for emergency response to prevailing challenges of both conflict and climate change. For example, financing to the local Ethiopian Red Cross

Society northwest zone branch office could have resulted in halting the degradation of the mountain green frames in the study areas, through providing alternative energy resources to the communities using the resources that it would have got from possible financing institutions. Again, this would have paused the flooding in the areas, and the lost lives by the flooding survived. Further, the urban ecosystems, especially the ecosystems of the mountain green frames, should not have been disturbed.

Considering the long-term impact of cutting trees from mountain green frames of cities that would result in continuous suffering of the population, local and international humanitarian organizations should take into consideration renewable energy solutions for IDPs and host communities to fully protect the on-going degradation of the mountain green frames.

The ERCS should also consider mobilizing local institutions to contribute their corporate responsibility in NbS projects.

Tigray is in a period of needing resources and approaches to revitalize from the scars of the 2-year active armed conflict and the no war no peace phase that has been ongoing since the Pretoria agreement signed in November 2022. Thus, the contribution of local and international humanitarian organizations is crucial in the post-war rehabilitation and recovery phases. Their support can consider the dual benefits of NbS, supporting programs and projects that can engage more people to benefit people and the environment.

The ERCS should also consider mobilizing local institutions to contribute their corporate responsibility in NbS.

A breakthrough changes of mind with support through awareness raising program should be drafted and approved technically to support the on-going tree plantation activities. Urban residents should also be aware of the importance of mountain green frames to their wellbeing to contribute to sustainable management.

Other civil society organizations (in Tigray, for example, civil society organizations such as Tigray Youth Association and Tigray Women Association) can learn from the ERCS even during conflict the contribution of neutrality in implementing NbS projects that would contribute to the social healing of traumatized communities.

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