

Impacts of Climate Change on Community and its Adaptation Strategies: The Case of Dukem Town Oromia Regional State, Ethiopia

^aDilu G. Desalegn, Ping Fang*, ^aMehari Mariye, ^aFekadu Ararsa, ^aWorkneh Furgasa, ^aSheref Abdela

^aTongji University, UNEP Institute of Environment for Sustainable Development (IESD): College of Environmental Science and Engineering, Shanghai 200092, P. R. China.

DOI: 10.29322/IJSRP.13.07.2023.p13916
<http://dx.doi.org/10.29322/IJSRP.13.07.2023.p13916>

Paper Received Date: 02nd June 2023
Paper Acceptance Date: 06th July 2023
Paper Publication Date: 14th July 2023

Abstract- Rural communities in Ethiopia are susceptible to climate change. As communities utilized additional adaptation technologies, the ability to manage climate change is growing. Climate change is posing the greatest environmental, social, and economic challenges to all of human in the world and across borders in many countries. It is also the most pressing environmental concern today and will remain so in the future on a global level. Climate change/ variability affect agriculture, health, water resources, and natural resource. The residents of Dukem town are facing the same challenge and are suffering from climate disruptions which have become common natural catastrophes in the country. Thus, this study was carried out in four kebeles of Dukem Town in the Oromia Regional State of Ethiopia to demonstrate the ways in which the local community in Dukem Town has adapted to the effects of climate change. Both qualitative and quantitative data collection and analysis methodologies were employed in this study. The primary data were gathered through the use of data collection tools such as interviews, observations, and household surveys. The study also analyzed historical rainfall and temperature data from 1992 to 2022 to examine the trend of climatic variability and change. A time series analysis was used to show the trend of temperature and rainfall.

Thus, in order to minimize the impacts of the change or variability in climate partly because of a lack of awareness and adaptive capacity, the most effective coping and adaptation strategies for farmers should be activities like afforestation, Terracing, rainwater harvesting, crop diversification, use of improved crops, income diversification, seasonal migration, and keeping livestock (destocking and feeding systems). As a result, farmers are adopting different adaptations mechanisms. For instance, providing training, increasing accessibility to infrastructure, credit services, and the market, and introducing new technologies are recommended.

Climate variability and change-induced threats such as drought, flood, pests, and landslides, as well as erratic and excessive rainfall, are seen by local people to have an impact on the environment and their livelihood. In response to the perceived changes, local residents implemented corrective measures to

mitigate the consequences of climate variability. The most common adaptation options include reforestation, terracing, rainwater harvest, change in cropping pattern, growing short-maturing crops, family planning, and diversification of income. However, poverty, water scarcity, land scarcity, market problem, lack of information about the weather or long-term climate change, forage and feed scarcity, lack of agricultural technologies and appropriate seed, and lack of health services were major constraints of adaptation for many people in the study area. Planning and implementing strategies to adapt to the effects of climate change will need global stakeholders' cooperation and contributions from diverse academics and experts, encompassing physical and environmental scientists and various fields of study. Thus, the study recommends a relentless need to address these challenges by the concerned body.

Index Terms- Adaptation, Climate change, Rainfall, Temperature

I. INTRODUCTION

In its sixth assessment report, the intergovernmental panel on climate change concluded that climate change is already happening with its multi-faceted effects on human society and the environment[1] An increased concentration of the so-called greenhouse gases (i.e. CO₂, CH₄, N₂O) in the atmosphere as a result of human activities and its possible consequence of climate change has been an international issue since the 1980s [2]. Climate and climate change will certainly have an effect on the future sustainable development of much of our planet's resources such as those relating to biodiversity, water, forests, land and oceans as well as in relation to various sectorial activities like agriculture, forestry and biodiversity[2]. The threat of global climate change has caused concern among scientist's livelihoods, agricultural production and food security of the smallholders could be severely affected by changes in key climate variables. Climate change is caused by both natural factors such as cycles and trends in the Earth's orbit, incoming solar radiation, the atmosphere's chemical composition, ocean circulation, the biosphere and volcanic eruption and much more, human induced causes like extensive use

of land, widespread of deforestation, the major technological and socioeconomic shifts with reduced reliance on organic fuel, and the accelerated uptake of fossil fuels that increases the emission of greenhouse gases concentration in the atmosphere [8]. In fact, it is not a new phenomenon, but the warming that is occurring today is unparalleled with respect to the rate of change.

The sixth report of Intergovernmental panel on climate change [3, 4] and 13th [5] indicates that the least developed countries (LDCs) have contributed the least to the emission of greenhouse gases but the impacts of climate change are expected to be more pronounced in the developing countries particularly in Sub-Saharan Africa because of their livelihood is dependent on nature which is highly sensitive to climate change [6]. also indicates that African countries are prone to greater impacts of this change/variability in climate partly because of lack of awareness and adaptive capacity. However, Africa's total contribution to emissions of greenhouse gases which cause the change is less than 7% of the world's greenhouse emissions.

This low capacity is due to the extreme poverty situation of many Africans, and occurrence of frequent natural disasters such as droughts, floods, and agriculture, which are heavily dependent on rainfall. The Intergovernmental Panel on Climate Change [3] findings shows that, developing countries like Ethiopia will be more vulnerable to climate change. These extreme vulnerability to the impacts of climate change in Ethiopia is due to social, economic and environmental factors [7]. In specific, high levels of poverty, rapid population growth, and high level of reliance on rain-fed agriculture, high levels of environmental degradation, chronic food insecurity and frequent natural drought cycles are the major vulnerability drivers in the country [10].

Adaptation to climate change takes place in a dynamic social, economic, technological and biophysical context that varies over time, location, and sector [7, 8]. This complex mix of conditions determines the capacity of systems to adapt negative impact of climate change and variability [13]. In Ethiopia, different project identified by government and NGOs to address climate change adaptation needs of the country through the National Adaptation Program of Action (NAPA). The main focus of these projects is in the area of integration capacity building, improving natural resource management, green legacy, enhancing irrigation agriculture and water harvesting capacity, strengthening early warning systems and awareness raising quite relevant areas in improving dry lands livelihood systems [14] Peoples must build their resilience, including adopting appropriate technologies while making the most of local knowledge, and diversifying their livelihoods to cope the climate stress. These local knowledge and

local coping strategies need to be used in synergy with government and local interventions [9]. In Dukem town there is a claim on decreasing agricultural productivity and people failed in practicing adaptation strategies against climate change impact introduced by government. Therefore, the aim of this research is to assess the community's level of adaptation strategies, on impact of climate change, response to climate variability and change and factors that influences adaptation strategies used by local peoples of Dukem town of Oromia regional state of Ethiopia.

II. RESEARCH METHODOLOGY

1.1. Description of the Study Area

Dukem is town found in central Oromia regional state, Ethiopia (Figure 1). Geographically the study areas are located 37 kilometers south of Addis Abeba. It covers a total area of 9630.6 hectares and is located between latitudes 80 45'25"N and 80 50'30"N and longitudes 380 51'55"E and 380 56'5"E. It is 2100 meters above sea level on average. The boundaries of the study areas in southeast by Bishoftu town and in the majority of the north by Gelan town. The remaining eastern and western areas of town are surrounded by four Akaki district peasant kebeles. The areas have four kebeles namely Malka Dukem, Tadacha, Gogecha, and Dukem Koticha. Dukem is located along the western escarpment of the main Ethiopian rift. Volcanic rock materials of various compositions cover the area. Due to weathering of the rock, and subsequent erosion and deposition, thick residual clay and silty clay soil covers most part of the plain topographic landforms.

According to Dukem Town Environmental Protection Authority, it currently has about 383 manufacturing and 12 service sector industries. Out of these more than 118 industries are located within Eastern Industry Zone, which is now re-named as Eastern Industrial Park. Development of the town have been seen since a number of Industries, Hotel and other service sector and also different governmental and NGOs institutions have been flourished. The town is known as an industrial zone that invested by different investors around the world, Called Eastern Industrial Park which covers an area of 40 hectares is found in this town. The data obtained shows that the study areas have an estimated population of 132,000 inhabitants.

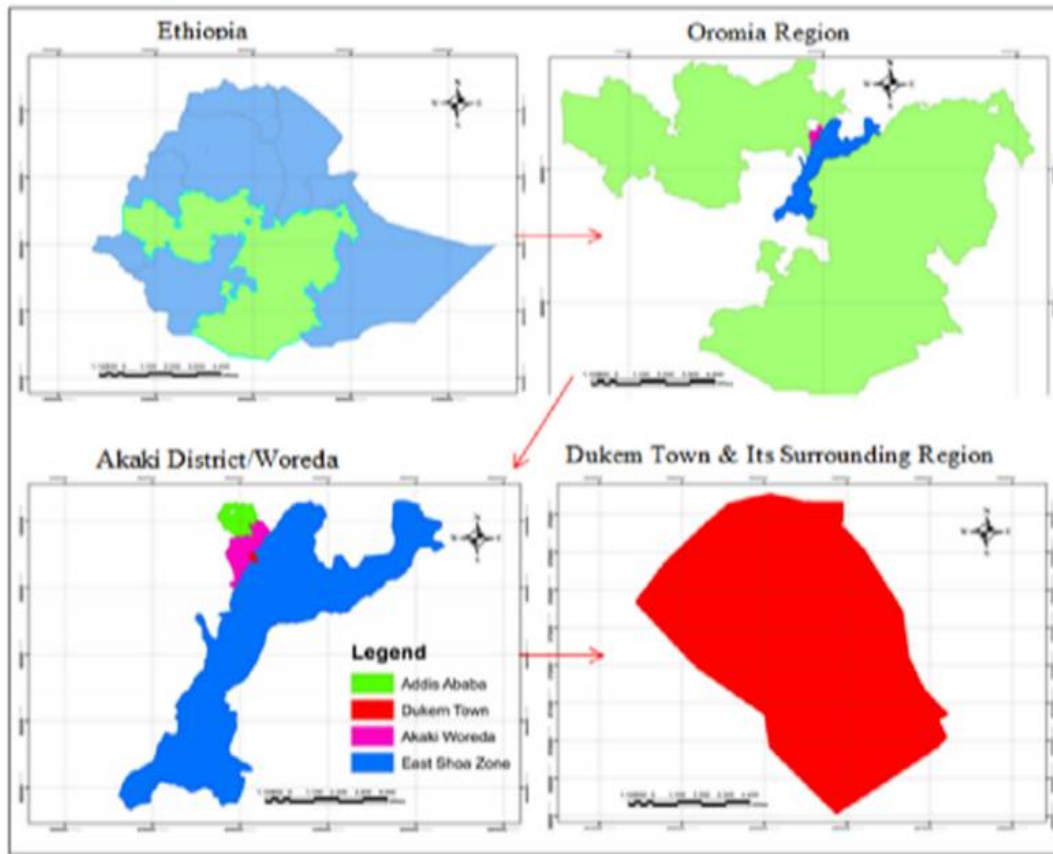


Figure 1. Location Map of the study areas

1.2. Soil Type

According to the National Soil Institute of Ethiopia, the dominant soil type in the study area is vertisol. Which has a property of cracking on dry season and swelling on rainy season as well as black in color. The swelling and cracking property of the vertisol during the dry season facilitates soil erosion. As a result, there are deep gorges in different parts of the town, especially along the courses of seasonal streams and Dukem river valley. Activities like quarrying and extraction of soil and also sand from the valleys of streams and river play their contribution for the formation of deep river gorges in different parts of the town.

III. METHODS

The study was assessing impact of climate change on people adaptation measures practices in the areas. To assess the all-activities purposive sampling techniques are used[10]. The sampling was done from (4) four kebeles and households of the town. Data gathering tools like questionnaire, interview, key informant interview (KII), Focus Group Discussion (FGD), and observations[11].

This study was including the four kebeles in Dukem town. These kebeles are purposively selected because of their vulnerability to shortage of rainfall, increasing of high temperature, vehicle emission from old vehicle and GHG emission. From the total population purposive sampling technique

was used to select the representative sample out of the total population.

The required input data of this study was generated from both primary and secondary sources. Primary data were generated from three groups of respondents and direct personal observation. The first group was selected households from the study area; the second group of data sources were key informants comprised of people who represent and reflect the opinion of the community member and expert interviewees. The third group was participants of FGDs. On the other hand, secondary data were generated by reviewing different relevant literature from books, research works, journals, published and unpublished documents, different activity reports of government and non-government institutions, and available rainfall and temperature records of Bishoftu station. Secondary data are means to augment the data to be collected from primary sources [12]. Statistical Package for Social Science (SPSS) EXCEL 2010 software and Arc GIS and Origin Pro 2023b were used as the tools of analysis.[13].

IV. RESULT AND DISCUSSION

1.3. Adaptation mechanisms of the Community's Climate Change

Climate change affects the livelihood of peoples of the study area recently. In order to overcome the impact of climate variability hazards, which are noted in the preceding sections, the communities have been applying different adaptation strategies.[14] However, increased intensity of climate variability

impacts has reduced the capacity of people to adaptation and to cope with the problems.

According to the findings of the household survey (Table 1 and Figure 2), it is possible to adapt to some of the effects of climate variability-induced hazards. As a result, home respondents were asked to take responsibility for the adaption procedure. About 33.33% of them thought it was the responsibility of the

governmental organization, and 45.94% thought it was the responsibility of the governmental organization (GO) in collaboration with the community; however, 20.72% of the respondents thought that it was the responsibility of the local community.

Table 1. Responsibility for adaptation practices

Who is responsible for the adaptation practice	Frequency			%		
	Male	Female	Total	Male	Female	Total
Governmental Organization	46	28	74	32.85	34.14	33.33
Local community	24	22	46	17.1	26.82	20.72
Governmental Organization and Local community	70	32	102	50	39.02	45.94

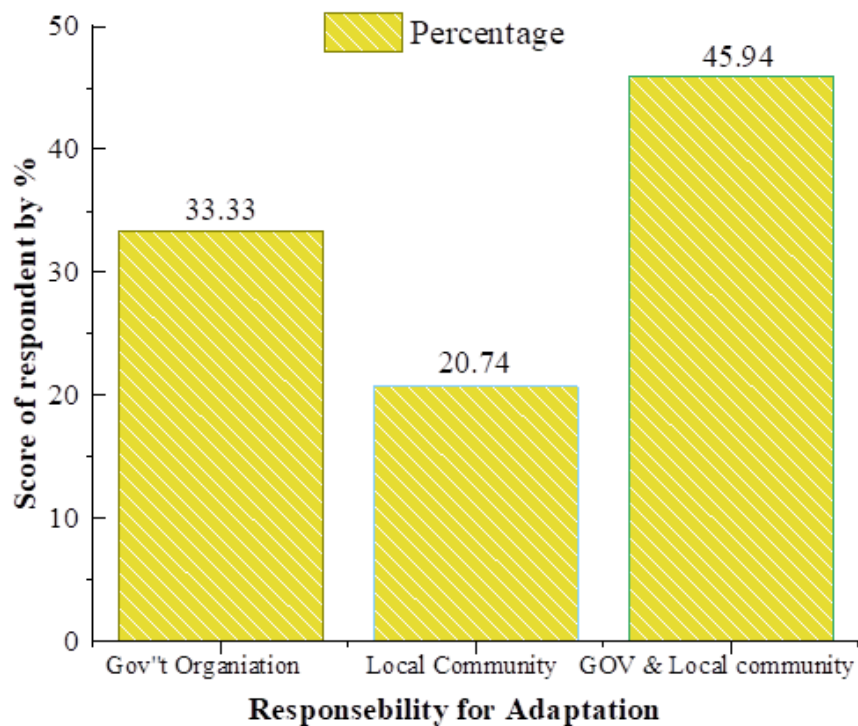


Figure 2. Responsibility for the adaptation practice

More specifically, more than 25% engaged in reforestation, cultivating short maturing crops, and, while 14.5% abandoned cultivation of steep, 16.7% changing cropping patterns, 1% harvested rainwater, and 5% diversified their household income.

Borrowing from families and credit institutions accounts for 16.4% of respondents' terracing 20.8 (Figure 3)

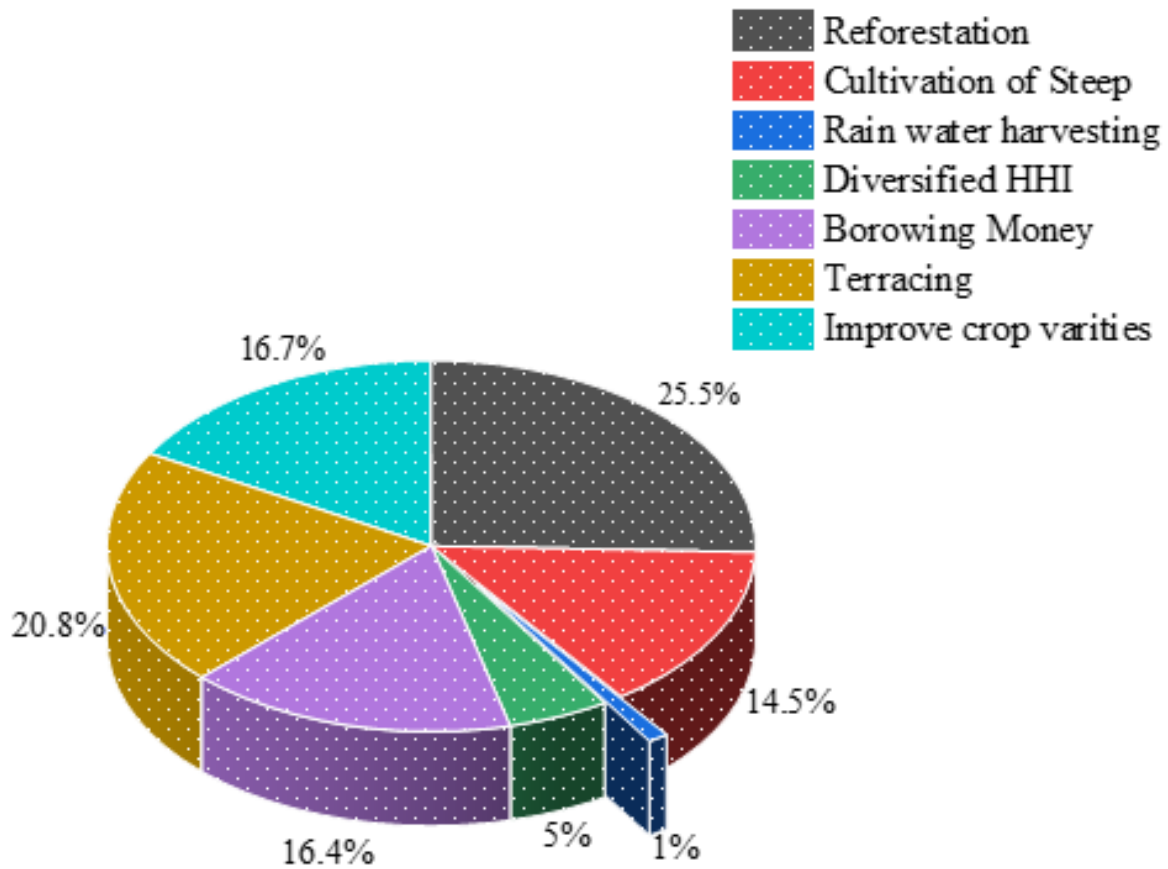


Figure 3. Farmers adaptation option on Climate change

Terracing: Participants in focus groups and key informants confirmed that soil erosion caused by running water affects them by reducing land fertility and leading to poverty; additionally, rising temperatures forced them to reforest hilly areas in order to protect their farm land from soil erosion caused by flash floods. Such a strategy is viable for enhancing agricultural yield and assisting in temperature control. Furthermore, more than 14.5% of respondents said they use terracing along steep areas and on farm

property to control soil erosion. Approximately 20.8% of those polled said they practiced reforestation and terracing by prohibiting unrestricted grazing in sloppy areas (Figure 3 & 4).



Figure 4. Farmers adaptation option on Climate change

Reforestation: The establishment of a forest on formerly forested terrain is referred to as reforestation[15]. In this regard, 25.5% of respondents indicated they had reforested hillsides and deforested areas in their neighborhood. They explained that flood-induced soil erosion, variable rainfall, and rising temperatures are all severe issues. As a result, the sole answer to this problem would be to protect their environment from deteriorating, reforest the deforested parts, and afford the newly planted areas.

Change in cropping pattern: According to the results of the household survey, 16.7% of respondents believe that farmers in the area implement crop rotation. Rainfall in the study area has recently been variable. As a result, even when the rain started, farmers couldn't be positive of the rainfall conditions. According to them, even when the rain begins, it may be strong or mild, or it may end sooner than expected. Farmers gain knowledge of the type of crops to plant based on the characteristics of the rain via experience. As a result, the cropping pattern of the research area grew in decreasing order of significance, with teff, wheat, barley, and bean dominating [16]. However, previous to 10- and 15-years, farmers' priority

Diversification of income sources: Diversification of household income is a method used by local people to increase their income to compensate for the amount of earnings lost due to decreased agricultural productivity. Climate change impacts were addressed by various respondents, including diversifying sources

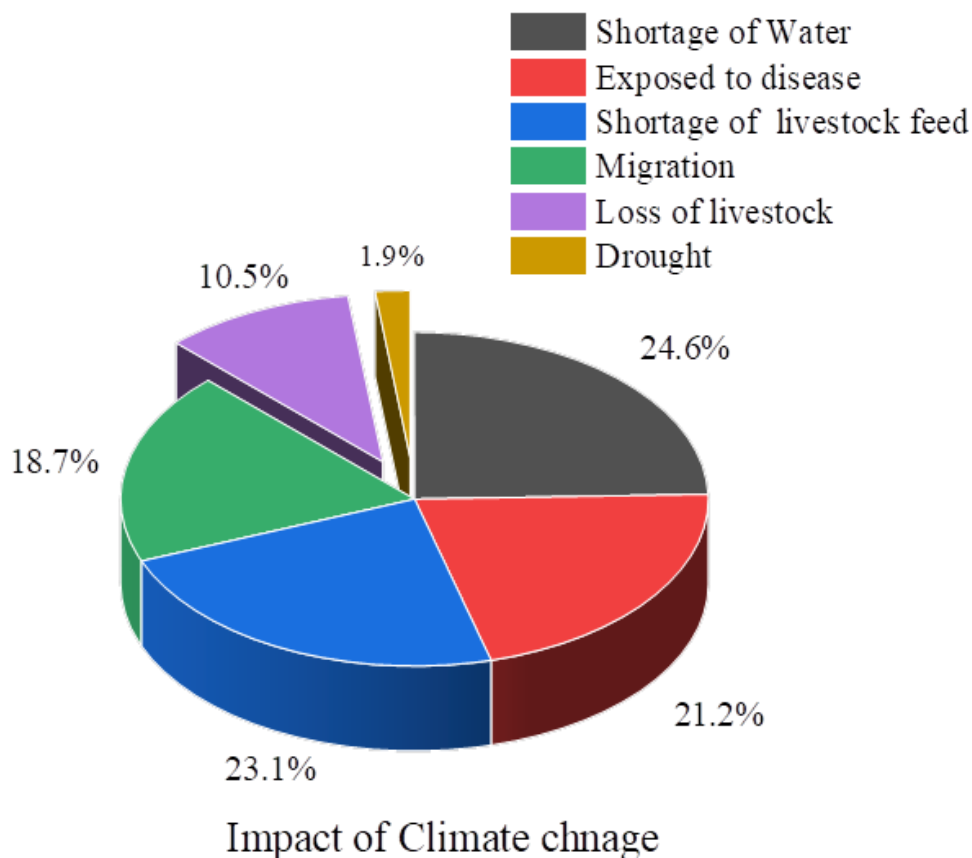
of household income or not. 5% of households reported that they had diversified their income sources.

Livestock management: In relation to the change of rainy season, early and late planting, and the rising depletion of grasses, 66.3% and 33.7% of respondents practice lowering the number of livestock and feeding their animals using a cut and carry system of tree leaves and branches, respectively. Acacia pods are also a valuable source of dry season fodder for goats and calves. When there is a scarcity of forage, some better-off people buy hay from the poor and give it to their animals.

1.4. Coping mechanisms

Borrowing funds from financial institutions: - To cope with the effects of climate change, 16.4% of respondents borrowed money from institutions and families. have so many restrictions for receiving and repaying money. (Figure 3)

People's Seasonal migration: One option for coping with the effects of climate change is to migrate. The majority of people in study areas choose to migrate to Bishoftu and Addis Ababa to work as daily laborers. Around 18.7% of respondents said migration was their coping mechanism to climate change.



Government Responses

lack of infrastructure and technologies, affected developing countries to respond impacts of climate change. changes hindered long-term global efforts to create a healthier, prosperous and sustainable world. planning and implementing strategies to adapt to the consequences of climate change will require worldwide stakeholders' collaboration inputs from different scholars, and scientists, including physical and natural scientists and different disciplines. To overcome the impacts of climatic change, the government of Ethiopia has adopted national policies and 10 years national strategies plan. As a result, climate variability and adaptation issues are frequently addressed indirectly strategic plan, because climate impacts are viewed as a sub-component of the overall development goal, particularly in terms of natural resources and environmental protection (NMI, 2007). Climate variability and its influence in the study area have resulted in government actions such as the dissemination of energy-saving technology, emergency help, protection and livelihood enhancement, and catastrophe risk reduction.

Asset protection and livelihood enhancement: - By preserving their assets, people and communities can reduce their vulnerability to climate change and variability. Households may suffer major hardships as a result of droughts and disease outbreaks, potentially leading to destitution[17] and [18]. Ethiopia's government sought to address the issue by establishing a veterinary facility and treen expertise to provide extension

services to the local community. However, 85% of respondents said they were unaware about climate change and other adaption methods.

Disaster prevention and management: - According to the majority of respondents, government responses to climate variability have been ineffective. Participants in focus groups and key informants indicated discontent with the government's answers, notably on climatic variability, disease, and land degradation. These problems affect the livelihoods of community in the area. They also show that the early warning system is inadequate, informing individuals only after they have already been impacted by climate variability. In fact, the Agricultural Development Office implemented disaster preventive and preparedness programs to reduce disaster susceptibility due to climate change, as well as environmental rehabilitation initiatives to improve natural resources. However, because to material and capacity constraints, as well as a lack of sustainability, the majority of these efforts were ineffective.

Barriers to Adaptations to climate change

As stated in in above, there are numerous elements that influence people's perceptions of climate change. The purpose of this section is to analyze the hurdles that local people perceive to employing the various adaption alternatives. According to the findings from household respondents, focus groups, experts, and key informants on the hurdles to pursuing adaptation alternatives, gender of household, age of household, and education level were major adaptation restrictions for many people in the study area,

[19] and [20] reported that lack of access to information and land scarcity are the main impediments to climate change adaptation.

Poverty: - Adaptation comes at a cost. As a result, disadvantaged households have limited adaptive potential. Poverty was cited as a major barrier to implementing the following adaptation options by the locals: changing crop patterns, diversifying crop cultivation, digging water wells and rainwater harvesting, implementing various soil conservation measures, transitioning from dominant crop cultivation to livestock rearing, and adopting non-farm activities. To engage in petty commerce, for instance, the availability of money is a basic prerequisite. It is not available to many people.

Land scarcity: - Another important major problem of adaptation to impacts of climate change noted by the respondents was land scarcity. Many household heads indicated that diminutive (very small) land holding size was reported as the main cause. Farmers explained that a decrease in their respective land holdings size and farm fragmentation made traditional soil conservation techniques such as fallowing became economically not viable.

Water Scarcity: - Water scarcity was mentioned as one of the most critical constraints to climatic change adaptation. Irrigation, digging water wells, rainwater harvesting and putting trees for shade were potential adaptation measures to reduce climate related impacts especially rainfall variability. Although the peasants are well aware of the importance of application of small-scale irrigation, digging wells, etc., most farmers could not employ them because of scarcity of water in the area.

Lack of Access to market: - A significant proportion of respondents identified the market as an issue, citing limited access to market facilities and the need to pursue adaptation alternatives such as changing cropping patterns, increasing crop diversity, and reducing animal numbers. Access to and knowledge on diverse crop types that may better survive rainfall shortage and variability, drought, and fertilizer use, according to local peoples, is only available through one route. A quota system distributes (delivers) the best quality seeds (crop) and fertilizer to them. Such materials are typically scarce and unavailable in local markets. Respondents also noted a lack of customers (local market demand) for crops that are new to the area's local populations but have been discovered to be more productive and can better adapt to changing climate. Farmers confront a similar dilemma with inadequate demand: reducing livestock numbers during periods of forage or feed scarcity, water scarcity, hunger, or drought due to market inaccessibility.

Problem of meteorological information: - absence of rainfall and temperature data information is one of the most important barriers to adapt in the study area. One of the most important constraints for making adjustments to unpredictable or reduced rainfall to change planting data, according to respondents and agricultural specialists in the area, is a lack of timely meteorological reports (information). Weather forecasts for the beginning and/or end of rain were never communicated. They also mentioned that the meteorological data that is rarely provided to them for pre-harvest reasons is hazy and unclear. This has a negative impact on the accuracy, dependability, and acceptability of meteorological reporting.

Lack of agricultural technologies and inputs: - Agriculture is one of the sectors most vulnerable to climate

change impact. Therefore, it is crucial to increase the understanding of the actual climate change dynamics on agricultural activities and on the societies at the lower levels[21]. A significant number of respondents stated a lack of appropriate agricultural technologies and inputs as a barrier to changing cropping patterns such as introducing new and high-value crops, diversifying crops on their farms, improving farm productivity, planting trees for shade, and changing the use of chemicals and high price of fertilizers.

Lack of Health services: - A considerable proportion of the respondents and FGDs participants indicated lack of animal health care centers, lack of new variety of animals, skilled human power and poor service in the area as one major constraint to adjust and improve livestock management.

Other barriers: - The survey results showed that among the issues mentioned by respondents and members of the local community were a lack of relevant institutions that may aid and enable desired changes, a lack of employment opportunities, a heavy reliance on rain feed agriculture, and food scarcity. Participants in FGDs often made exaggerated comments about their local circumstances and the inexperienced extension programs run by government and NGO employees, which made it difficult for them to receive assistance from the appropriate agency.

Gender of household heads: - [22] claim that female-headed families in study are less likely to adapt because they have less access to information, inputs, and other resources due to social and traditional constraints. According to [23], male households are more likely to adapt than female-headed households because they are more likely to learn about new technologies and engage in hazardous commercial ventures. Additionally, [24] contend that male-headed households are more likely than female-headed households to adapt to climate change. The study also identifies a negative relationship between household head gender and adaptation. The negative results indicate that the responses of female headed household participants. The reason for this is that much of the farming activities are done by male while female is more involved in processing different activities in the house.

Age of Household heads: - Age has been found to have a favorable and significant impact on the decision to implement climate change adaptation measures in the research area. It enhances the likelihood of employing crop diversification, enhanced crop types, and early maturing crop varieties.

Education level of household heads: - Access to information on climate change, improved technologies, and productivity repercussions is connected with a high degree of education [25] and [26]. Evidence from many sources suggests a favorable association between the education level of the household head and the adoption of enhanced climate change technology [27]. Farmers with a higher degree of education are so more likely to adapt to climate change. Farmers with greater levels of education, according to the study, should be more likely to adapt to climate change. According to the findings of this study, education has a good and significant effect on adaptation.

V. CONCLUSIONS

From the study the following major conclusions were made possible:

- Age, Educational status, access to extension, Farm experience and extra income, gender, farm land size, Access to credit, access to information and access to market has a positive and negative impact on adaptation to climate change impact.
- Communities of Dukem town have been facing climate variability impacts like environmental pollution, drought, pest and disease, landslide, environmental degradation, flood, decreasing agricultural output etc.
- Poor, landless, disabled's, women's, children's, and elders are among the most vulnerable social groups in the community.
- Women and children are the most affected Group

Recommendation

Based on the outcomes of the study, the following recommendations are forwarded to local communities and government representatives.

- The government should increase local people's adaptation strategies on climate change through different training on FTC (farmers training center) at kebele level and demonstration site.
- To improve their adaptation capacity, they the government introduced and enforced the community to use new agricultural technologies inputs, fertilizer supply and different medias.
- The government should increase the integration between different institutions, NGOs and also with the communities.
- The government should increase meteorological station, infrastructures, and make Weather and climate information (forecasting the weather condition) available to local community.
- To conserve and restore natural resources and protect the environment the government should assert the ownership of the community towards natural resources.
- Improve the accessibility and services of institutions to solve problem of the farmers.

Finally, I would like to recommend similar studies to be conducted which adequately address the issue of vulnerability to climate change, and the relative value of each adaptation option to better guide policy options for adaptation to climate change and to develop a locality specific adaptation menu, which is able to account for impacts of climate change and variability.

ACKNOWLEDGEMENTS

First of all, I would like to thank the Almighty God for giving me the opportunity and guidance to achieve my goal and to be successful in this part life journey so far. Then I would like to thank my mother and family for their upbringing of me and their tireless efforts and support in every path.

I want to give my deepest appreciation, deep gratitude, and respect for my thesis and research advisor, **professor Ping Fang**. She has devoted her time to follow up via different ways of communication, valuable guidance, and intellectual encouragement, critical comments from the early design of the proposal to the final write up of the final. She has inspired me to become an independent researcher and helped me realize the power of critical reasoning. She also demonstrated what a brilliant and hard-working scientist can accomplish.

I want to thank Mr. Abebe Abay, soil science researcher at Ethiopian Forest Development, for being cooperative with my study project. I am forever thankful and indebted to you for sharing your knowledge, expertise, guidance, and consistent encouragement from the beginning up until the completion of my final research thesis.

In addition, I would like to express my gratitude, appreciation, and deepest respect for my colleagues Hunda'ol Gemechu and Kidus Workineh, for giving me their unwavering personal and professional support.

I would also like to extend my thanks to Dukam town Environmental Protection Authority office and National Meteorology Institute for their support in providing necessary information, different resources, and relevant data collected from the study site with their valuable advice and assistance.

Finally, but most importantly, I would like to thank my spouse Hiwot Kora, daughter Bewengle Dilu and mother Solome Belihu and my sister woderalesh Belachewu. it would be an understatement to say that, as a family, we have experienced some ups and downs in the past two years. Every time I was ready to quit, you did not let me and I am forever grateful. This thesis stands as a testament to your unconditional love and encouragement.

Thank you all for supporting and guiding me to where I am today. May the Almighty God continue to bless you all!

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AUTHORS

First Author – Dilu G. Desalegn, Ping Fang, Tongji University, UNEP Institute of Environment for Sustainable Development (IESD): College of Environmental Science and Engineering, Shanghai 200092, P. R. China.

Second Author – Mehari Mariye, Tongji University, UNEP Institute of Environment for Sustainable Development (IESD): College of Environmental Science and Engineering, Shanghai 200092, P. R. China.

Third Author – Fekadu Ararsa, Tongji University, UNEP Institute of Environment for Sustainable Development (IESD): College of Environmental Science and Engineering, Shanghai 200092, P. R. China.

Fourth Author – Workneh Furgasa, Tongji University, UNEP Institute of Environment for Sustainable Development (IESD): College of Environmental Science and Engineering, Shanghai 200092, P. R. China.

Fifth Author – Sheref Abdela, Tongji University, UNEP Institute of Environment for Sustainable Development (IESD): College of Environmental Science and Engineering, Shanghai 200092, P. R. China.

Corresponding author, email: fangping2000@tongji.edu.cn