



# Climate change, variability, and adaptation in Ethiopia. An analysis from the farmers' perception

## Cambio climático, variabilidad y adaptación en Etiopía. Un análisis desde la percepción de los agricultores

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### Article Data

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### Abstract

Given that the climate has changed historically and will likely change again in the future, it is necessary to comprehend how farmers view climatic variability and change as well as how they will adapt going forward. To lessen the problems related to climate change and variability in Ethiopia, this review paper sought to evaluate and examine farmers' perceptions of these issues, as well as their effects on farming livelihoods. This review study states that although few studies have examined this subject locally, climate change and variability have a substantial impact on agricultural production, livelihood of smallholder farmers, biodiversity loss, and environmental degradation, particularly in low-income countries where agriculture is heavily dependent on rainfall. A wide range of psychological concepts, including knowledge, attitudes, beliefs, and concerns about whether and how the climate is changing, are all part of the complex process of experiencing climate change. Thus, to lessen the issue of climate change and variability in Ethiopia, a variety of site-specific adaptation strategies that incorporate modern science and traditional roots are needed.

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### Resumen

Dado que el clima ha cambiado históricamente y es probable que vuelva a cambiar en el futuro, es necesario comprender cómo ven los agricultores la variabilidad y el cambio climático, así como la forma en que se adaptarán en el futuro. Para reducir los problemas relacionados con el cambio climático y la variabilidad en Etiopía, este artículo de revisión buscó evaluar y examinar las percepciones de los agricultores sobre estos temas, así como sus efectos sobre los medios de vida agrícolas. Este estudio de revisión afirma que, aunque pocos estudios han examinado este tema a nivel local, el cambio climático y la variabilidad tienen un impacto sustancial en la producción agrícola, los medios de vida de los pequeños agricultores, la pérdida de biodiversidad y la degradación ambiental, en particular en los países de bajos ingresos donde la agricultura depende en gran medida de las lluvias. Una amplia gama de conceptos psicológicos, incluidos los conocimientos, las actitudes, las creencias y las preocupaciones sobre si el clima está cambiando y cómo lo está haciendo, son parte del complejo proceso de experimentar el cambio climático. Por lo tanto, para reducir el problema del cambio climático y la variabilidad en Etiopía, se necesita una variedad de estrategias de adaptación específicas para cada sitio que incorporen la ciencia moderna y las raíces tradicionales.

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## Introduction

Climate change (CC) has emerged as one of the biggest environmental challenges to many emerging nations<sup>1-3</sup>. It is anticipated that its effects on farmland degradation will jeopardize the gross domestic product (GDP) and food security of households<sup>4</sup>, contend that the occurrence of catastrophic climatic events and unpredictable rainfall patterns causes an increase in the frequency and intensity of droughts and floods. Rural and urban inhabitants' livelihoods and infrastructure (such as housing, transportation, and agriculture) are directly impacted by this degradation of water quantity and quality<sup>5,6</sup>.

According to more scientific data, the earth's climate is changing quickly due to rising greenhouse gas emissions (GHE)<sup>7,8</sup>. Humans and their socioeconomic activities, health, means of subsistence, and food security are all impacted by the worldwide problem of CC<sup>7,8</sup>. Developing nations and areas are more susceptible to the effects of CC than industrialized<sup>9</sup>. Because of their high reliance on rain-fed agriculture, low technological advancements, and compounding challenges of poverty, rural farmers in sub-Saharan African (SSA) countries are therefore likely to be more vulnerable to CC than farmers in other regions<sup>10,11</sup>. Due to its location in the tropics and other topographic extremes, as well as the low adaptive capacity of its people and resources, Ethiopia is extremely vulnerable to the detrimental effects of CC<sup>12,13</sup>. Ethiopia is experiencing CC and unpredictability due to unpredictable rainfall, frequent droughts, reduced surface water sources, soil erosion, floods, water-logging, and varying diurnal temperatures<sup>14</sup>. The delayed start and early end of the rainy season cause the growing season to be shorter as a result<sup>15-18</sup>. Farmers' ability to adapt will determine how much these and other types of climate shocks affect them<sup>19</sup>. Smallholder farmers that implement adaptation strategies may be able to mitigate negative

consequences and capitalize on positive changes in climate variables<sup>20</sup>. Ethiopian farmers, both generally and in the research field specifically, take into account a variety of strategies for mitigating and/or adapting to CC. Diversifying the sources of household income, conserving water and soil, diversifying crops, modifying planting dates, destocking, seasonal migration, crop rotation, and using climate information services to make well-informed decisions are among the most popular adaptation strategies<sup>21</sup>. However, several demographic, socioeconomic, and institutional factors, including access to information about markets and climate, education, age, gender, and farming experience, as well as availability to extension and credit services, off-farm and on-farm employment opportunities, water storage facilities, and farm size, all affect farmers' ability to adapt<sup>22-24</sup>. Designing appropriate policies to support efficient and location-specific adaptation strategies in the agricultural sector requires an understanding of the extent of CC, how smallholder farmers perceive these changes, and the factors influencing their adaptation decisions<sup>25</sup>.

A later mapping on powerlessness and destitution in Africa put Ethiopia as one of the most defenseless nations to climate alter with and the slightest capacity to reply<sup>26</sup>. Undoubtedly, Ethiopia has experienced at slightest five major national droughts since 1980, at the side handfuls of neighborhood dry seasons. Cycles of dry spells make destitution traps for numerous family units, always foiling endeavors to construct up resources and increment wages.

Despite its vast coverage in Ethiopia, the reviews concerning Farmer perception and adaptation to CC and variability are new areas of research or not yet reviewed and a lot of information is not yet documented. Additionally, the Current knowledge of farmers about CC and adaptation is insufficient for

reliable prediction of CC and adaptations; it also is insufficient for rigorous evaluation of planned adaptation options, measures, and policies of governments. This implies there is a huge information gap in Ethiopia. Therefore, this review paper was conducted to fill the gaps by reviewing Farmer perception, the impacts of CC and variability, and its adaptation mechanism in Ethiopia.

## Development

### *Definition and concept of global CC and adaptation.*

The main environmental concern of the present and the future will be global CC. In addition to the natural climate variability seen over comparable periods, the United Nations Framework Convention on Climate Change (UNFCCC)<sup>27</sup> defines CC as a change in the composition of the global atmosphere that is ascribed, either directly or indirectly, to human activities. The evidence of CC has grown over the last several decades, showing that it has already occurred, is occurring, and will continue to occur, bringing with it regional effects on people's means of subsistence<sup>28</sup>. The Intergovernmental Panel on Climate Change (IPCC) concluded that there is already climate variability occurring globally, with a variety of implications for both the environment and human society. The sustainable development of biodiversity, water, forests, land, and oceans, as well as numerous sectorial activities, would undoubtedly be impacted by climate variability<sup>29</sup>. The susceptibility and ability to adapt varies across nations, areas, economic sectors, and social groupings on a spatiotemporal basis<sup>30</sup>.

*Environmental impact of CC and variability.* The frequency and severity of extreme weather occurrences (heat waves, torrential rainstorms, high winds, droughts, floods, etc.) will rise due to CC. Droughts that have returned frequently have oc-

curred recently and are still happening in several areas of the nation right now. Many people still remember the catastrophic drought in 1984-1985, which is still regarded as one of Ethiopia's most serious drought disasters. Droughts have been getting bigger throughout time and space. In the past, Ethiopian famines and food shortages have been directly caused by droughts. Frequent droughts have caused property destruction, human mortality, and cattle migration<sup>31</sup>.

### *Impact of CC and variability on biodiversity loss.*

Numerous species in Ethiopia are susceptible to the effects of CC. Several forest tree species have demonstrated poor or hindered regeneration as a result of environmental changes brought about by CC and human activities. CC has caused dieback of *Olea europaea* subsp. *cuspidata* and *Juniperus procera* in the Desa'a woodland in Northern Ethiopia<sup>32</sup>. The most vulnerable species are usually those with tiny populations, restricted habitat requirements, and/or limited geographic options (such as those confined to Afro alpine habitats, including Ethiopian wolves, giant lobelia, and *Walia ibis*). *Parthenium hysterophorus* and *Prosopis juliflora* are two invasive alien species that are becoming more common and a threat to the nation's biodiversity due to environmental degradation and CC<sup>33,34</sup>. Additionally, changes in the distribution of species and ecosystems will result from CC. According to a climate model for Southwest Ethiopia, range-gap shifts and contractions, lowland biotic attrition the net loss of species richness in the tropical lowlands due to altitudinal range shifts in the absence of new species arriving and extinction due to anticipated warming at the end of this century will all have a significant negative impact on the region's biodiversity<sup>35</sup>. The model also projected that species that are endemic or endangered and have limited elevation ranges will be disproportionately affected by warming-related range contraction and extinction.

*Socio-economic impacts of climate change and variability.* Increased soil erosion from heavy rains, more unpredictable rainfall in terms of both amount and distribution, altered crop sowing and harvesting dates due to delayed commencement and early end of rainfall, modifications to agricultural systems, and a rise in pest and disease incidence are all consequences of CC. Crop productivity is impacted, resulting in subpar harvests and/or total crop failures for both cash and staple commodities like coffee, wheat, and maize. Food security and crop productivity are likely to suffer as a result<sup>36</sup>.

Due to a lack of water and pastures, which are used as animal feed, CC also has an impact on the production of livestock. Pests and diseases that afflict crops and livestock are becoming more widespread, expanding into previously uninhabitable areas due to low temperatures. For example, higher elevation places are becoming more and more of a niche for cereal stemborers<sup>37</sup>.

*Vulnerability to climate change and variability in Ethiopia.* Due to its relatively low level of industrialization, Ethiopia has very low carbon emissions, but it will be among the nation's most severely affected by CC. Ethiopia has the lowest ability to adapt to the effects of CC of any nation in the world<sup>33,38-41</sup>. Ethiopia is also one of the most vulnerable to these effects. According to studies<sup>37,42-47</sup>, smallholder farmers in Ethiopia are typically extremely vulnerable to the effects of climate variability and change. Due to its geographic location, the country's fast-growing population, its reliance on natural resources and agriculture for sustenance, widespread poverty, and its limited resources (financial, institutional, technological, human, and infrastructural), Ethiopia is particularly vulnerable to the effects of CC. Because agro ecologies, cultures, production methods, and livelihood choices vary greatly, there are regional variations in both sensitivities to the impacts of CC and communities' ability to adapt. Ethiopia generally possesses a limited

ability to adjust to the effects of CC. This suggests that decreasing vulnerability to the effects of CC requires increasing adaptive capacity.

*Farmer's perception of climate change and variability in Ethiopia.* The complicated process of perceiving CC includes a variety of psychological concepts, including information, attitudes, beliefs, and concerns regarding whether and how the CC<sup>48</sup>. Among other factors, an individual's qualities, experiences, information received, and the cultural and geographical setting in which they live all impact and shape their perception<sup>48,49</sup>. As a result, assessing public opinion of CC and attempting to identify its causes are difficult tasks.

Studies revealed, Ribot<sup>50</sup> stated that smallholder farmers were asked about the trends they had noticed in the primary climate indicators, specifically rainfall, temperature, and drought over the previous 20 years, rather than being asked directly about their perceptions of CC. The study's findings supported observations of changes in rainfall problems and rainy times over the previous 20 years. Specifically, about 49.41 % of respondents thought rainfall had decreased, 4.71 % thought it had increased, 18.53 % did not notice the trend, and 27.35 % thought rainfall had stayed the same. In addition, they found that there was a difficulty with rainfall beginning (51.18 %), ceasing (71.18 %), ending before the perceived time (61.18 %), and falling after the believed time (42.06 %). Because crop growing is heavily dependent on rainfall, smallholder farmers have faced challenges due to the unpredictable nature of rainfall. Therefore, rainfall features influence pre-production, pre-harvest, and post-harvest production activities, which in turn influence overall farm-level productivity.

Smallholder farmers in Central Ethiopia have been observing and perceiving changes in temperature over the past 20 years. Approximately 71.98 % of respondents reported that the temperature had increased, 4.42 % that it had decreased, 27.35 % that

it had remained the same, and 18.53 % that they had not noticed any changes. Drought was also regarded as a significant climatic indicator variable in the study, and while roughly 69.41 % of respondents agreed that droughts occurred frequently, 43.24 % and 6.18 % of respondents thought that the frequency of drought occurrence had decreased and remained constant, respectively. 17.65 % of the population remained unclear regarding temperature changes<sup>51</sup>.

*CC adaptation in Ethiopia.* The term "adaptation to CC" describes modifications made to the environmental, social, and economic systems in response to the effects of CC, both real and predicted. The ability to adapt reduces susceptibility to CC. A policy for adapting to CC must be flexible enough to accommodate a wide range of environmental, social, economic, cultural, and political conditions. Given that adaptation to CC is inherently and unavoidably local, it must be localized<sup>50,52</sup>. Adaptation must therefore be a national priority and necessitate devoted local activity<sup>53</sup>. Diverse, site-specific adaptation strategies that draw on traditional origins while also utilizing contemporary science are required<sup>54</sup>. Integrating scientific understanding with indigenous knowledge and customs is necessary for CC adaptation. Furthermore, adjusting to CC must be an ongoing effort.

Communities in Ethiopia possess valuable indigenous knowledge, abilities, and technologies that are critical for addressing dangerous environmental situations, such as CC and variability. To deal with and overcome the effects of climate variability and change, they actually use a variety of short- and long-term mitigation and adaptation techniques. Planning for CC prevention and adaptation should therefore begin with promoting the application of indigenous knowledge and regional coping mechanisms<sup>41,55</sup>.

Communities' capacity to adjust to the effects of climate variability and change is, however, limited by

a variety of causes and obstacles. It is advised to lessen exposure and sensitivity while also boosting adaptive ability and fortifying the adaptation processes by expanding on current methods<sup>44</sup>. Communities now need specialized support (human, financial, technical, technological, institutional, and infrastructural) from the government and other relevant stakeholders (scientists, development partners, NGOs, international donors, etc.) due to their limited capacity for adaptation and the urgent effects of CC.

*Determinants of adaptive capacity.* The dynamic social, economic, technological, biophysical, and political environment that varies with time, place, and sector is the backdrop in which adaptation to CC and its dangers occurs. Systems' ability to adapt is determined by this intricate combination of factors. While the number of researchers studying adaptive capacity in the context of CC is quite small, in the areas of risks, resource management, and sustainable development, there is a good understanding of the factors that affect societies' ability to adjust to climate stimuli. The primary characteristics of communities or regions that appear to determine their potential for adaptation may be identified from this literature, and they are as follows: economic wealth, technology, information and skills, infrastructure, institutions, and equity<sup>56</sup>.

*Ethiopia's coping strategies to CC and variability.* Ethiopia has demonstrated efforts to mitigate CC through conservation and legislative measures. Ethiopia has ratified several important international environmental treaties and conventions, including the Paris Agreement, the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC), the United Nations Convention on Biological Diversity (CBD), and UNCCD. Ethiopia has also created and carried out a variety of national initiatives and programs about CC, in addition to actively participating in international climate negotiations. Ethiopia is acting to address CC by im-

plementing the two categories of responses: adaptation and mitigation. In light of this, Ethiopia created its Nationally Appropriate Mitigation Action (NAMA) and National Adaptation Programme of Action (NAPA), which it submitted to the UNFCCC in 2007 and 2010, respectively.

*Ethiopia created a CRGE strategy in 2011 to promote socioeconomic development and fight CC.* The four pillars of the CRGE strategy are as follows: i) Enhancing agricultural and livestock production methods to increase food security and farmer income while lowering GHE, ii) Preserving and restoring forests for their ecosystem services and economic value, especially as carbon stocks; iii) Increasing the amount of electricity generated from renewable energy sources for local and regional markets; iv) Transitioning to more energy-efficient and modern transportation, industrial, and building technologies.

Ethiopia plans to use the CRGE strategy to develop a green economy that is climate resilient and has net-zero national GHE by 2030, as well as to attain rapid economic growth and middle-income status by 2025. Due to the planned increase in plant cover, which will remove GHE from the atmosphere, Ethiopia will have zero net GHE. As a result, the nation wants to expand economically while maintaining net-zero GHE and CC resilience.

Ethiopia's CRGE strategy is an excellent illustration of how Africa is beginning to see the need to achieve several development goals at the same time as supporting international efforts to slow down global warming<sup>57</sup>.

Local, national, and international commitment is needed for the CRGE strategy to be implemented. In addition, Ethiopia's Ministry of Environment, Forests, and Climate Change (MoEFCC) established the National Secretariat of Reducing Emissions from Deforestation and Forest Degradation (REDD+) in 2013. Accordingly, to be eligible for results-based payments under the global REDD+

mechanism, which is a component of the Payment for Ecosystem Services (PESs), Ethiopia created its Forest Reference Level (FRL) and submitted it to the UNFCCC in 2016. Finalizing the design of the national REDD+ plan is currently underway. Ethiopia's REDD+ program aims to address the restoration of natural forest regions in Central, Eastern, and Northern Ethiopia as well as the destruction of priority forest areas in the country's southwest and south. To address the effects of CC, a variety of governmental and non-governmental organizations are working on developing and implementing various mitigation and adaptation techniques.

Ethiopia is advocating for the preservation, sustainable use, and management of its forests and other natural resources. Large-scale afforestation, reforestation, and forest management initiatives exist, including Participatory Forest Management (PFM). Up until 2030, it is anticipated that 1 million hectares of degraded woods will be reforested and 2 million hectares of pasturelands will be afforested. Enhancing forest protection, development, and management is necessary because, among other things, forests are essential for mitigating the effects of and adapting to CC.

## Conclusion

A wide range of psychological concepts are involved in the complex process of experiencing CC and variability, including knowledge, attitudes, beliefs, and worries about whether and how the climate is changing and variable. Due to poor rainfall, high rainfall variability, and rising temperatures, smallholder farmers have been using several adaptation strategies to address their low agricultural production. The region's farmers depend on rain-fed agriculture while taking the hazardous weather conditions into account. It was discovered that access to education, farming expertise, and extension services improved

the adaption process. This suggests that raising public knowledge of the possible advantages of adaptation through education should be a key component of policy. This review paper examined farmers' perceptions of the effects of CC and their adaptation strategies, with a particular emphasis on the decisions they made in response to seasonal variations in climate and related factors. Numerous socioeconomic factors influence these decisions, such as household wealth (land area and animal ownership), access to information on short- and long-term CC, and the availability of institutions like credit and health care (human and cattle). To mitigate the effects of CC, the majority of Ethiopian farmers are utilizing crop diversification, better seeds, early maturing crops, and shifting planting dates by rainfall commencement and offset. The following suggestions were sent in response to this review paper to promote adaptation techniques aimed at mitigating the negative effects of CC. To ensure that farmers have up-to-date information about rainfall and temperature patterns, the following recommendations were suggested: i) encourage the use of improved crops and early maturing seeds that can withstand the effects of CC, ii) improve the quality of meteorological data and increase the number and their spatial distribution, iii) facilitate research and extension services to provide adequate extension information services, iv) implement irrigation technology to lessen reliance on rainfed agriculture and ensure food supply, v) encourage mixed agriculture through enhanced crop and livestock production to broaden farmers' sources of income and help them withstand the risks associated with CC.

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### **Conflicts of interest**

The author declares that there is no potential conflict of interest.

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### **Ethical considerations**

I declared that this manuscript is not submitted for possible publication to other journal publishers. In addition to this, I confirmed that this review finding is free of research misconduct.

### **Research limitations**

Due to the absence of baseline data and the fact that the review research relies on only one-time metrological data which do not illustrate the dynamics in the context of the review area. Undoubtedly, a review of research with a longer duration would produce additional data. In addition, the meteorological information obtained from the National Meteorological Agency was incomplete. It is deficient in value for a few months or years.

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