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Perceptions and Determinants of Climate Change Awareness among Farmers across Agro-Ecological Zones in Jabitehinan District, Northwestern Ethiopia

Addisu Bitew BIRHANIE[1, 2*], Daniel Ayalew MENGISTU[1, 3]

[1]Department of Geography and Environmental Studies, Bahir Dar University, P.O. Box 79, Bahir Dar, Ethiopia

[2]Department of Geography and Environmental Studies, Debre Markos University, P.O. Box 269, Debre Markos, Ethiopia

[3]Geospatial Data and Technology Centre, Bahir Dar University, P.O. Box 79, Bahir Dar, Ethiopia

*Corresponding Author Email Address: addisubitew21@gmail.com (Ethiopia)

Abstract: Farmers' perceptions of climate change strongly influence local adaptation decisions and responses to climate risks. This study examined farmers' perceptions of climate variability and the determinants of climate change awareness across agro-ecological zones in Jabitehinan District, Northwestern Ethiopia. Data were collected through household surveys, key informant interviews, and focus group discussions, using a two-stage sampling technique to select 361 respondents. Descriptive statistics, one-way ANOVA, and binary logistic regression were applied. Results showed that 33.5% of farmers attributed climate variability to natural factors, 28.8% to human activities, and 49.8% to religious causes. Most respondents perceived declining rainfall over the past four decades, with delayed onset and early cessation, increasing irregularity, and shifts in planting seasons. Perceptions varied significantly across agro-ecological zones, with higher reporting of rainfall and temperature changes in semi-arid areas compared to temperate highlands and sub-humid zones. Gender, education, access to irrigation, training, climate information, indigenous knowledge, and extension services significantly influenced perceptions, while age, farming experience, income, and off-farm activities did not. The findings highlight the critical role of socio-demographic and institutional factors in shaping climate awareness, emphasizing the need to strengthen education, training, and extension services to support effective adaptation strategies.

Keywords: Climate variability; Agro-ecological zones; Local understanding; Key drivers

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1. Introduction

According to the Intergovernmental Panel (IPCC, 2006) climate change is defined as a change in the state of the climate that can be identified by alterations in the mean and/or variability of its properties and that persists for an extended period, typically decades or longer. Perception is viewed as a crucial factor influencing climate action. It is included to enhance the legitimacy of climate policies and the generation of knowledge regarding climate change (Hügel et al., 2020). Incorporating perceptions of climate change can also enhance public and scientific communication about the phenomenon (Mendoza-Poudereux et al., 2021).

According to Maddison (2007), perceiving change and then deciding whether or not to adopt a particular measure is a process in climate change adaptation. Whenever there arises an opportunity, farmers tend to adopt new varieties of measures or technologies in response to the perceived changes of weather conditions. The supports from extension workers, information gained and technologies available to them highly influence their adaptation and response capacity. Farmers usually use water conservation techniques whenever the rainfall patterns are changed, and amounts of rain are reduced. They tend to plant different crop varieties and use short term crops with adjustment of planting dates. These adjustments are done when they perceive reduction in rainfall and changes in the onset and offset of rainy seasons.

The study by Fosu-Mensah et al. (2012) showed that farmers are well aware of climate change, but few seem to actively take steps toward adjusting their farming activities. According to Deressa et al. (2011), majority of farmers were able to recognize that temperatures have increased and there has been a reduction in the volume of rainfall, still few farmers lack the perception of change in climatic condition of their area to take steps to adjust their farming activities. The degree of farmer's perception on climate change also depends on its impact on farmer's livelihood, their social, institutional and economic background. It differs and depends mainly on level of education, livelihood activity, location and age.

Understanding farmers' awareness of climate change is essential for interpreting local adaptation responses and designing effective climate-resilient strategies. Farmers' views on key climatic attributes particularly long-term changes in temperature, rainfall patterns, and seasonal variability provide valuable insights into how climate signals are experienced and interpreted at the local level. Such awareness reflects not only direct exposure to climatic events but also accumulated experience, indigenous knowledge, and access to climate-related information.

In this context, farmers' reported experiences of climate change are often examined in relation to observed climatic trends to assess the extent to which local understanding aligns with empirical evidence. Long-term temperature and rainfall patterns offer an important reference for evaluating whether farmers' awareness corresponds with documented climatic changes. Assessing the consistency between observed trends and farmers' interpretations helps to clarify the reliability of local knowledge and its relevance for adaptation planning. Moreover, identifying the range of adaptation measures adopted by smallholder farmers highlights how awareness of climate variability translates into practical responses at the household level, thereby informing policy and extension interventions aimed at strengthening climate change adaptation.

According to the belief of majority of participants in the focus group discussion, today's climate change and its consequences are the results of umbrage of God. They also respond that there is a high level of deforestation and old aged trees are being cut for the purpose of timber. According to their saying, the local government is the primary responsible body for this evil practice. Each year, new seedlings will be planted, but because of poor follow up and management, almost all seedlings ceased to survive. Another practice that aggravates climate change is the production of charcoal by cutting trees in the area.

The general objective of this study was to determine the level of smallholder farmers' awareness of climate variability and analyze the key socio-demographic and institutional factors influencing climate change awareness across different agro-ecological zones in Jabitehinan District, northwestern Ethiopia. The specific objectives were to: (i) To determine the level and patterns of farmers' awareness of long-term changes in rainfall and temperature over the past four decades; (ii) analyze farmers' awareness of long-term changes in rainfall and temperature patterns over the past four decades; (iii) compare farmers' climate change awareness across temperate highland, sub-humid, and semi-arid agro-ecological zones; (iv) To analyze differences in farmers' awareness of rainfall and temperature variability across agro-ecological zones; and (v) identify the socio-demographic factors influencing farmers' climate change awareness.

2. Materials and Methods

2.1 Study area Description

The study was carried out in three agro-ecological zones Semi-arid, Sub-humid and Temperate-highland agro ecological zones, in Amhara Regional State, Jabitehinan woreda, North West of Ethiopia. Jabitehnan woreda is found in the Amhara National regional state, West Gojjam zone. It is located between 10^0 30′0″ N-10^0 50′ 0″ N and latitude and 37^0 4′ 0″ E-37^0 32′ 0″ E longitude Figure 1.

Jabitehinan stands out as one of the 15 woredas within the West Gojjam administrative zone. Positioned 374 kilometers Northwest of Addis Ababa and 171.7 kilometers southwest of Bahir Dar, the Regional State capital, this woreda encompasses a total area of 117,020 hectares. Presently, it is organized into 37 rural Kebele administrations and hosts 3 towns Finote Selam, Mankusa, and Jiga being the principal ones. According to the woreda BoARD (2023) the human population of Jabitehinan is 270,147. Among them, 253,348 reside in rural areas, while the remaining 16,799 inhabit urban areas. Meteorological data obtained from the Ethiopian National Meteorology Agency (1981-2022) of the nearest station Finoteselam were extracted, analyzed and presented. The long-term mean annual rainfall of the study area was 1250mm. The research area's lowest temperature was 23.5^{0}C, its highest temperature was 34.8^{0}C, and its yearly average was 33.8^{0}C (Dereje et al., 2022). The primary crops cultivated in the area include maize, teff, and wheat (BoARD, 2023). Topographically, Jabitehinan is categorized into plain land (65%), terrain (15%), valley (15%), and unclassified land (5%). The altitude ranges from 1300 to 2300 meters above sea level. In terms of soil types, the predominant ones in the woreda are black (15%), red (60%), and brown (25%). Considering soil fertility, it is classified as 27% fertile, 71% moderately fertile, and 2% degraded land (BoARD, 2023).

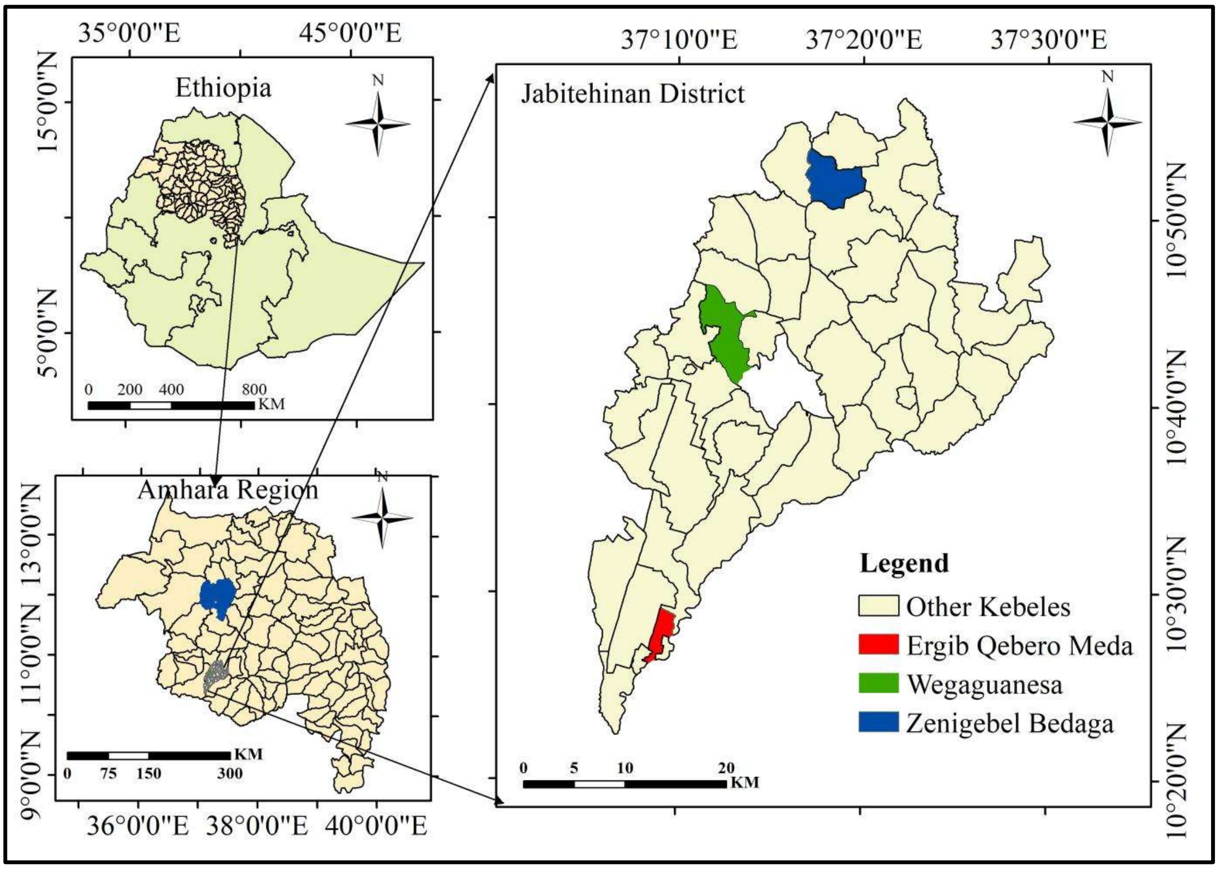

Figure 1. The study area

2.2 Data source and Sampling design

A sample of 361 smallholder households was taken from Jabitehinan district smallholder farmers Table 1. To select the respondents, a two-stage sampling approach was employed. First, three Kebeles were selected in the district purposively based on agro-ecological zones and the intensity of the impact of the climate change and variability. Second, using systematic sampling method, households were selected from each of the three Kebeles; Zengebal Bedega, Woga Guanesa; and Ergib Kebromeda proportionally. The lists of the households were collected from the kebeles administrator's and development agent officials of each Kebeles first. In systematic sampling method, by using random numbers to pick up the unit with which to start, an element of randomness was introduced. This sampling procedure is useful when sampling frame is available in the form of a list. In such a design, the selection process starts by picking some random point in the list and then every nth element is selected until the desired number is secured (Kothari, 2004; Nyariki, 2009).

Table 1. sample household data from the three agroecological zones

No	Name of Kebeles	Agro-climatic Zone	House Hold size	Sample size
1	Zengebal Bedega	Temperate-highland	1160	116
2	Woga Guanesa	Sub-tropical	1530	153
3	Ergib Kebromeda	Semi-arid	920	92
			3,610	361

Key informants and focus group discussion (FGD) participants were selected from Kebeles based on their knowledge and experience of locally observed climate variability and related community perspectives. Individuals with valuable insights into climate-related changes and local conditions were purposefully identified to provide informed viewpoints. Six key informant interviewees, including experts at both regional and district levels, were purposively selected based on their professional experience and educational background to provide detailed information on climate variability and community awareness.

Participants recruited for the focus group discussion (FGDs) included male and female household heads, local community leaders, and development agents to ensure diverse perspectives. A total of four FGD groups were conducted. Each group comprised six participants and focused on discussing issues related to climate change and variability, particularly to address the study objective concerning community awareness and local understanding of climate change.

Descriptive statistic and LiKert scale measurement were used to characterize farmer's perception on changes in long-term temperature, rainfall and other aspects. To analyze smallholder farmers perception to change in climate, further comparison were made correspondence with climate data recorded in Finote Selam Sub-station for 41 years for the period (1981-2022) by fitting a linear trend of annual means of temperature and rainfall. Making this trend in annual average temperature and rainfall a base for comparison, the perception of farmers were analyzed whether it was in line with or opposite to the linear trend fitted from Finote Selam Meteorological data. This was done by asking household heads questions about their opinion on the direction of climate change and using a five level LiKert scale measurement on some attributes of climate change. Percentages were used to analyze the proportion of respondent in each level. Farmers who strongly agree and who simply agree were considered perceived the change while others not. Chi-square Equation (1) was employed to evaluate the importance of variation on evaluated variables between agro ecology (semi-arid, sub-tropical and temperate highland) at p-value < 0.05.

The **Chi-square (χ^2) formula** depends on the type of test being done, but the general formula is:

$$\chi^2 = \sum \frac{(O_i - E_i)^2}{E_i} \tag{1}$$

Where:

- O_i = Observed frequency (actual data)
- E_i = Expected frequency (based on hypothesis or model)
- The summation (Σ) is over all categories or cells.

The word-based approach was utilised to extract themes from the FGD participants' responses and open-ended inquiries, which were subsequently coded for a straightforward count analysis ranking. Logistic regression model Equation (2) was employed to analyze determinants of farmers' perception of climate change and variability.

Binary Logit Model Formula

$$P(Y=1|X) = \pi(X) = \frac{e^{\beta_0+\beta_1X_1+\beta_2X_2+\cdots+\beta_{11}X_{11}}}{1+e^{\beta_0+\beta_1X_1+\beta_2X_2+\cdots+\beta_{11}X_{11}}} \tag{2}$$

: log-odds form is:

$$\ln\left(\frac{\pi(X)}{1-\pi(X)}\right) = \beta_0 + \beta_1X_1 + \beta_2X_2 + \cdots + \beta_{11}X_{11}$$

A one-way ANOVA Equation (3), followed by Tukey's Post-Hoc test was performed to compare farmer's perception on climate change across the three agro-ecological zones. Statistical significance was set at the $p < 0.05$ level, with distinct letters assigned to the means indicating significant differences.

ANOVA Formula Components

- **Total variation**

$$SST = \sum_{i=1}^{k} \sum_{j=1}^{n_i} (Y_{ij} - \bar{Y}_{..})^2 \tag{3}$$

- **Between-group variation**

$$SSB = \sum_{i=1}^{k} n_i (\bar{Y}_{i.} - \bar{Y}_{..})^2$$

- **Within-group variation**

$$SSW = \sum_{i=1}^{k} \sum_{j=1}^{n_i} (Y_{ij} - \bar{Y}_{i.})^2$$

3. Results

3.1 Farmer's perception on climate variability by different agro-climatic zone

Despite changes occurring in the environment, the concepts of climate and climate variability are understood but perceived differently by different people at varied levels in the community. The majority of the respondents interviewed in the selected study area Temperate-highland, Sub-humid and Semi-arid agro ecological zone demonstrated high degrees of knowledge, awareness and understanding of the concept of climate, climate variability and the likely causes of climate change on their local environments.

The majority of the participants had the information of climate variability as the Temperate-highland agro-ecology (13.8%), Sub-humid zone (17.1%), and Semi-arid agro-ecology (19.1%), of respondents were said that there was knowledge about climate variability, where as 12.4%, 14.9%, 22.4% not have information about climate variability respectively (Figure 2). Out of 361 respondents, only 189 respondents (equivalent to 52.3%), were aware of the factors responsible for climate variability where they associated the causes of the changing climate. In the temperate highland agro-ecological zone, 25.7% of respondents demonstrated an understanding of the causes contributing to climate variability. In the sub-tropical zone, this proportion increased to 29.0%. The highest level of awareness was observed in the semi-arid agro-ecological zone, where 45.1% of respondents reported an understanding of the factors driving climate variability. Overall, the results indicate that farmers' awareness of climate variability was substantially higher in the semi-arid zone compared to the temperate highland and sub-tropical zones Figure 2.

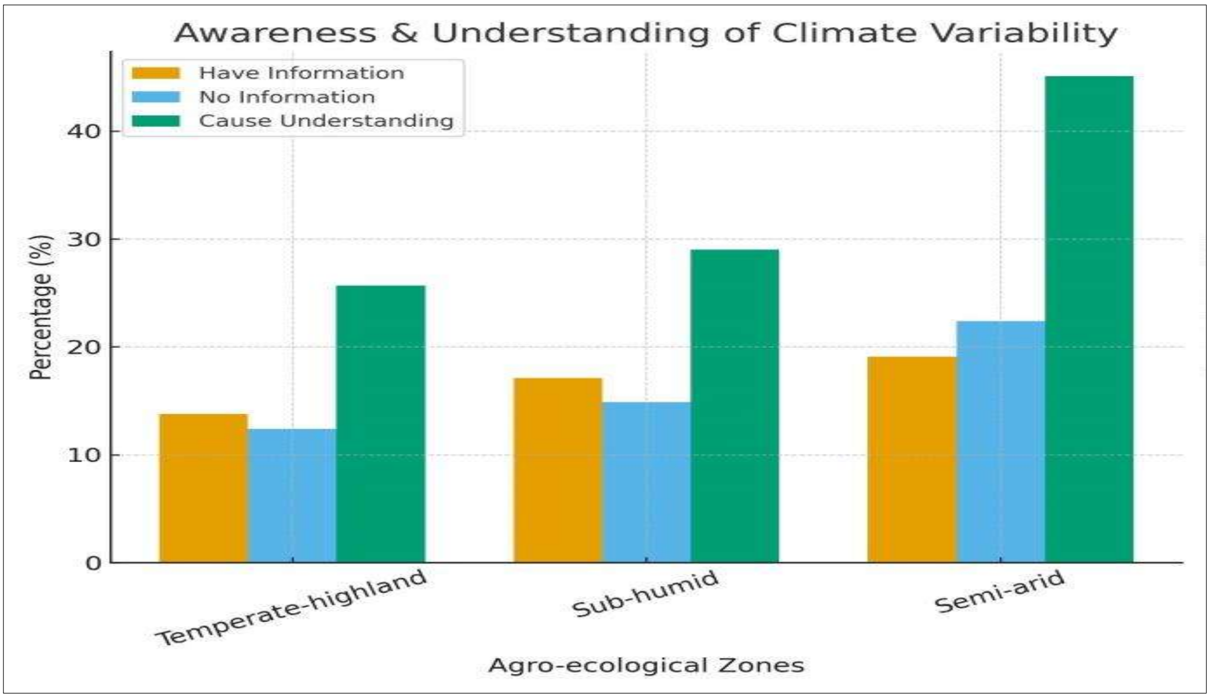

Figure 2. Farmers' perception of climate change causes across the three agroecological zones

The study revealed that farmers perceived multiple indicators of climate variability, particularly those related to changes in rainfall patterns. These indicators included a decline in rainfall over the past four decades; late onset and early cessation of the rainy season; rainfall at the beginning of the rainy season; rainfall during the planting and growing periods; timely cessation of rainfall; rainfall during the harvesting period; off-seasonal rainfall; changes in planting time to adjust to rainfall onset; and increased rainfall irregularity. Farmers' perceptions of these rainfall-related indicators varied across the three agro-ecological zones.

In the temperate highland agro-ecological zone, the proportions of farmers reporting these indicators ranged from 21.8% to 30.1%. In the sub-humid agro-ecological zone, the corresponding values ranged from 27.7% to 34.6%. The highest levels of awareness were observed in the semi-arid agro-ecological zone, where reported proportions ranged from 40.4% to 47.0% Figure 3. Overall, farmers in the semi-arid zone exhibited a greater awareness of climate variability compared to those in the temperate highland and sub-humid zones. The differences in perceptions of climate change and variability among the three agro-ecological zones were statistically significant ($\chi^2 = 46.8$, $p < 0.001$).

One of the participants during focus group discussions in the Temperate-highland agro-ecological zones reported that "for a successful harvest, planting should now be done with the immediate onset of the rain. The participant explained further that with variable rainfall concentrated within a short period of time, planting early when the soil is still wet helps crops to survive and to tolerate drought conditions until further rains arrive." However, this was reported to be successful only if drought tolerant hybrid seeds are planted. Another participant from the Semi-arid agro-ecological zones reported that, "traditionally, the spring season rain was an alert for the starting point of the rainy season and the majority of the growing farmers would start field preparation to ready for planting at that time, while a few would sow their seeds to exploit early rains and benefit from the earlier harvest. However, nowadays farmers have abandoned such traditional practices, and instead the first rains are now used for crop sowing rather than farm preparation."

Similarly, changes in weather conditions have led to farmers abandoning early planting strategies when they used to scatter seeds on the ground a month earlier before the beginning of the rain. This was done in June in the Temperate-highland agro ecological zones and in some cases was supported by cool weather conditions, while in the sub-humid agro-ecological zones; it was supported by traditional irrigation in areas with local rivers for their crops until the rainy season begun. In the semi-arid, seed planting was done during the time of farm preparations and some would begin germinating just with the presence of morning dew and survived until the first rain began.

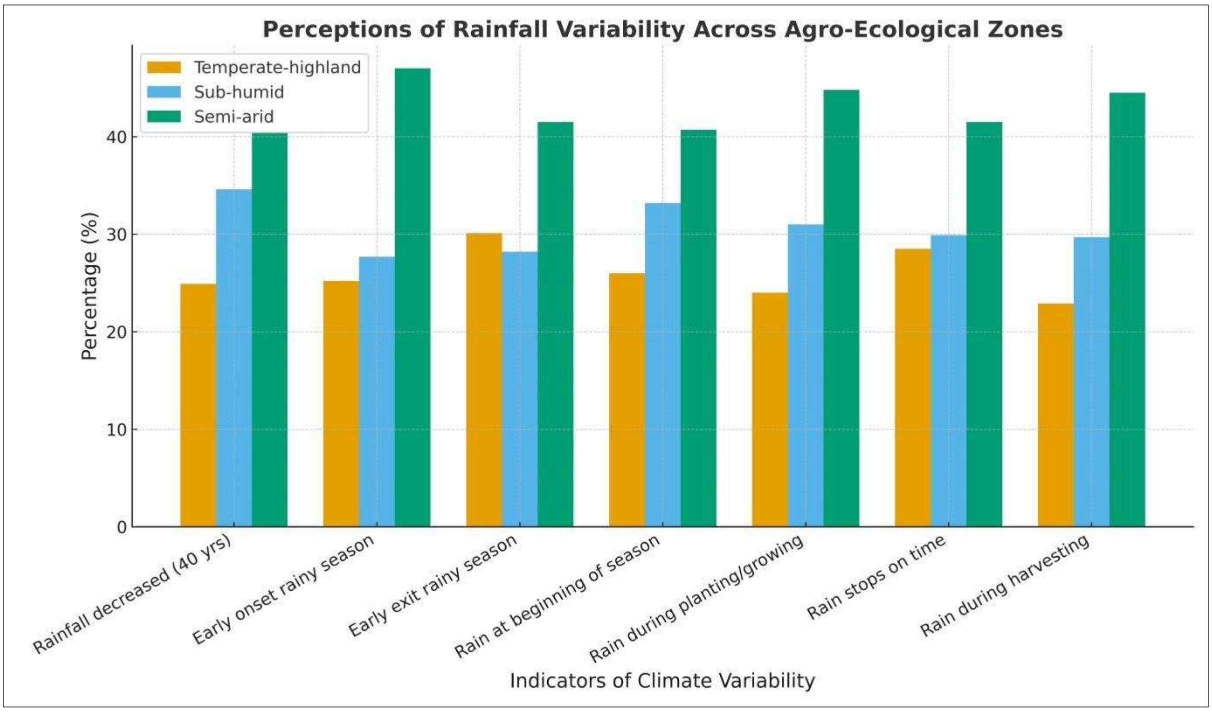

Figure 3. Farmers' perception of rainfall related indicators across the three agroecological zones

Farmers' perceptions of temperature-related indicators, including the increase in daily temperatures, rising temperatures over the past four decades, and the lengthening of months with high daytime temperatures, varied across the three agro-ecological zones.

In the temperate highland agro-ecological zone, 21.6% of respondents perceived an increase in daily temperatures, 18.0% observed a rise in temperatures over the last four decades, and 29.0% reported experiencing longer months with high daytime temperatures. In the sub-tropical zone, 28.5%, 32.9%, and 26.8% of respondents reported the respective indicators. In the semi-arid zone, perception was notably higher, with 49.8% of respondents recognizing an increase in daily temperatures, 49.5% noting rising temperatures over the last four decades, and 44.3% reporting longer periods of high daytime temperatures Figure 4.

Overall, farmers in the semi-arid zone demonstrated the greatest awareness of temperature variability, likely because lowland areas are naturally hotter, making even marginal increases in temperature more noticeable. Perceptions of temperature-related indicators differed significantly among the three agro-ecological zones ($\chi^2 = 22.8$, $p < 0.001$). This result has similar finding with the study by Dereje et al. (2022) Perception and adaptation to climate change by farmers in the Nile basin of Ethiopia.

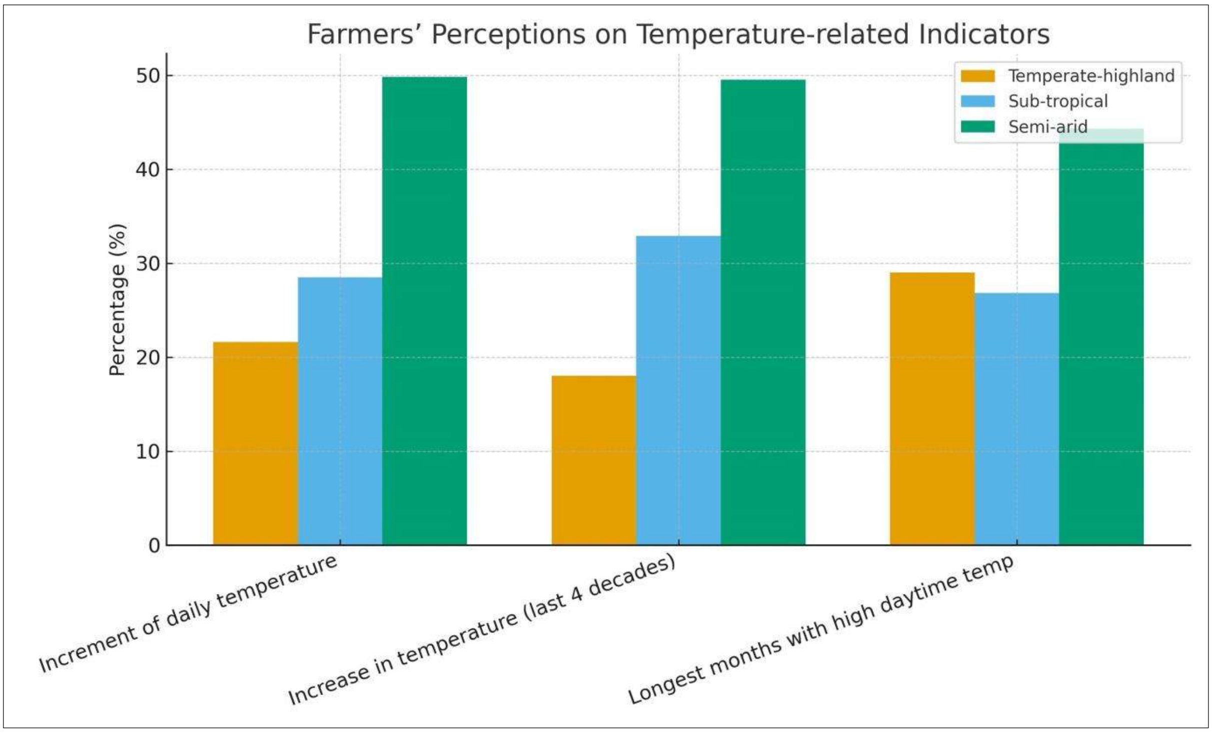

Figure 4. Farmers' perception of temperature related indicators across the three agroecological zones

Many respondents shared the views that in recent years they have noticed an increase in the intensity of sunshine which influences the surface temperature in their localities, in the three agro-ecological zones. Daily temperatures are perceived to have increased, which also leads to an increase in the evening to midnight temperatures. Respondent from the Semi-arid agro-ecological zone was quoted that: "nowadays, days and nights are very hot that I even do not use a bed sheet or blanket to cover myself during the nighttime due to the highest temperature, might be use early morning." Other respondents from Sub-tropical and Temperate-highland agro-ecological zones reported that "nowadays the solar intensity has increased to the extent that at 9-10 am local time the sun is strong and 'stings' like that of the afternoon and midday."

The respondent from Temperate-highland agro-ecological zone said that "Nowadays there is no difference between Semi-arid and Temperate-highland agro-ecological zones based on temperatures, we know all experience almost the same degrees of heat and sunshine." However, most of the respondents during focus group discussions and household interviews in the Temperate-highland agro-ecological zone perceived that temperatures have increased almost two times than in the past four decades. Similar observations have been made different parts of Ethiopia (Gadédjisso-Tossou, 2015; Adeoti et al., 2016; Tesfaye et al., 2016).

Farmers' perceptions of climate variability and its impacts on agriculture, including crop pests and diseases, crop failure, coolness, and drought, differed across the three agro-ecological zones. In the temperate highland zone, 21.3% of respondents reported that crop pests and diseases have increased and become more problematic than in earlier times. In the sub-tropical zone, 28.2% of respondents observed an increase in pest and disease problems, while in the semi-arid zone, the proportion was much higher at 50.4% (Figure 5). About 20.2% of farmers in the temperate highland zone reported experiencing crop failure over the past four decades. In the sub-tropical zone, 32.9% of respondents reported crop failure, whereas in the semi-arid zone, nearly half of the respondents (47.3%) reported crop failure during this period. In the temperate highland zone, 45.1% of respondents reported experiencing cooler conditions than in earlier times. In the sub-tropical zone, 31.0% of farmers noted the same, and in the semi-arid zone, 45.9% of respondents reported experiencing coolness over the past decades. Drought was reported as increasingly frequent by 28.5% of respondents in the temperate highland zone. In the subtropical zone, 31.0% of farmers perceived more frequent droughts, while in the semi-arid zones; the proportion was 45.1% Figure 5.

Overall, farmers in the semi-arid zone reported the highest awareness of these climate variability indicators compared to the temperate highland and sub-tropical zones. Statistical analysis confirmed that differences in perceptions of these four indicators among the three agro-ecological zones were highly significant ($\chi^2 = 49.3$, $p < 0.001$).

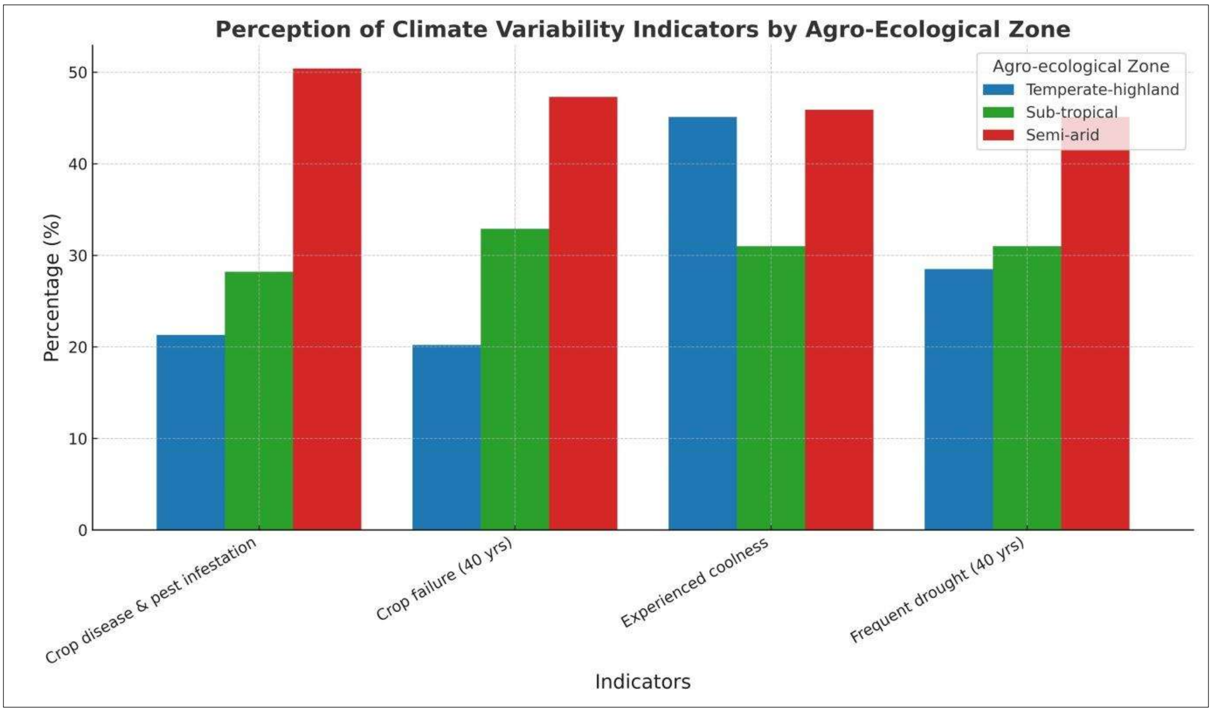

Figure 5. Farmers perception of crop disease related indicators across the three agroecological zones

Farmers' perceptions of climate variability related to livestock, human health, invasive species, and livelihood changes varied across the three agro-ecological zones. In the temperate highland zone, 28.5% of respondents reported that heat-related livestock diseases have become more frequent. In the sub-tropical zone, 28.8% of farmers observed similar increases, while in the semi-arid zone, 29.7% of respondents reported a higher incidence of heat-induced livestock diseases Figure 6. About 24.3% of farmers in the temperate highland zone perceived an increase in heat-related human illnesses. In the sub-tropical zone, 27.4% of respondents reported this phenomenon, and 28.4% of farmers in the semi-arid zone noted an increase in heat-induced human diseases. Farmers in the temperate highland zone reported 22.9% occurrence of new or invasive plant species. In the sub-tropical zone, 28.5% of respondents observed this trend, while in the semi-arid zone, 29.6% of farmers reported the emergence of new plant species or invasive weeds. In the temperate highland zone, 30.7% of respondents noted that some sources of livelihood have been affected by changing climate conditions. In the sub-tropical zone, 25.7% of farmers reported livelihood changes, while in the semi-arid zone, 26.9% of respondents observed similar shifts in livelihood strategies.

Overall, the semi-arid zone showed relatively higher awareness of these indicators compared to the temperate highland and sub-tropical zones. The differences in farmers' perceptions of heat-related livestock and human diseases, emergence of invasive species, and livelihood changes across the three agro-ecological zones were significant ($\chi^2 = 11.9$, $p = 0.011$).

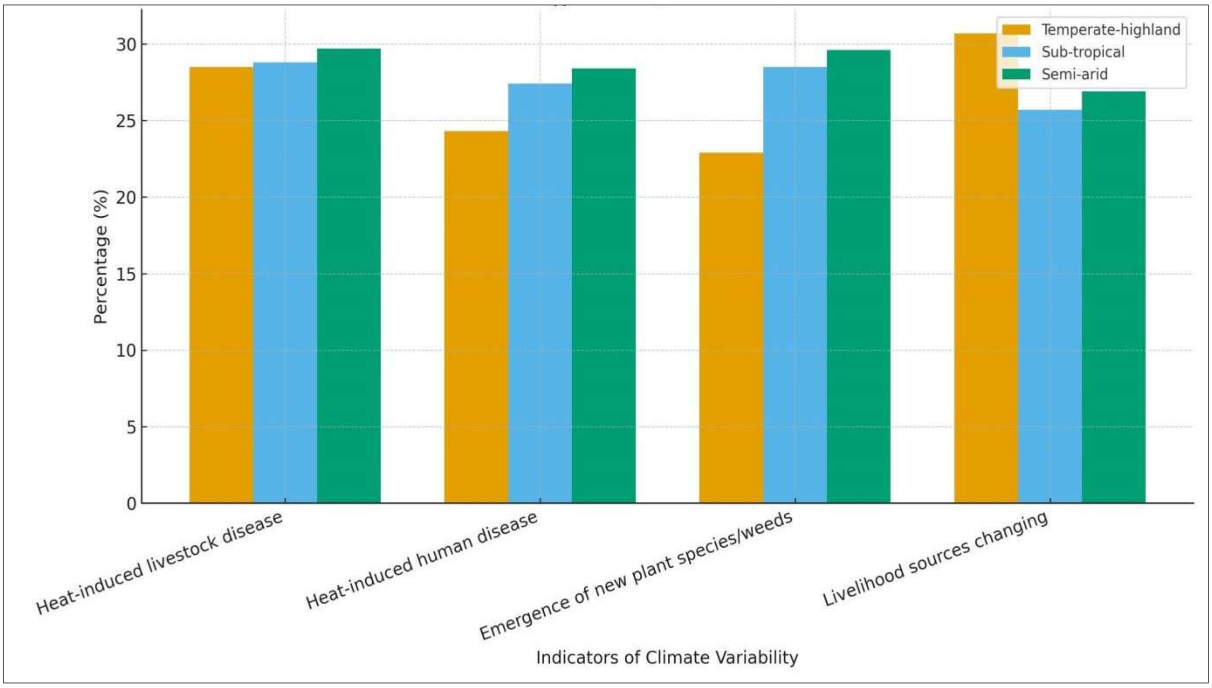

Figure 6. Farmers' perception of health-related indicators across the three agroecological zones

From the Semi-arid agro-ecological zone focus group discussions participants revealed that "there has been an increase in the population of pests, crop diseases and insects, compared to the past 40 years." They also associate the increase "with the declining amount of rainfall, as higher rainfall was believed to cause more deaths of the pest and insect populations, while moderate rainfall and warm conditions encouraged the survival and proliferation of insects." Also, the limited availability of varieties of grasses for insects to feed on confined them to agricultural crops only. In addition, reliable rainfall speeds up the growth of crops making them less vulnerable to pest damage. One of the participants in the focus group discussions in Sub-humid agro-ecological zone reported that due to an increase in droughts and continued crop failures in the Semi-arid zones, many pests and insects have migrated to the Sub-humid zones." Temperate-highland agro ecology zone farm observations and guided transect walks revealed that many of the crops in the highlands had been attacked by insects (grasshopper) and crop diseases (Akenchira for maize).

Focus group discussions and interviews revealed that in the past drought incidences occurred, but they were rare and their occurrence took a sequential series over time to the extent that farmers were able to predict when another incidence of drought would occur. The drought incidences in the past four decades were reported to occur about every 7-10 years where the drought name represents the coping strategy opted for during that particular drought. However, the study revealed that, the majority of the participants perceived that in recent years, drought conditions have become more frequent and intense especially since the 1990s. Discussions with the three agro-ecological zone participants suggested that drought conditions in recent years occur almost in every season, or in consecutive years which result in increased crop failures and food shortages at the household level, especially in the Semi-arid agro-ecological zones highly venerable.

Drying of local ponds and springs, fluctuations in river and stream flow, wetland drying, and flooding over the past four decades were identified by respondents as key indicators of climate variability Figure 7. In the temperate highland zone, 22.9%, 21.0%, 22.7%, and 30.4% of respondents, respectively, strongly agreed with these indicators. In the sub-humid zone, the corresponding values were 31.0%, 31.0%, 31.0%, and 31.5%, while in the semi-arid zone they were 45.9%, 45.1%, 46.2%, and 37.3%. A chi-square test showed that perceptions of these indicators differed significantly among the three agro-ecological zones ($\chi^2 = 44.1$, $p < 0.001$).

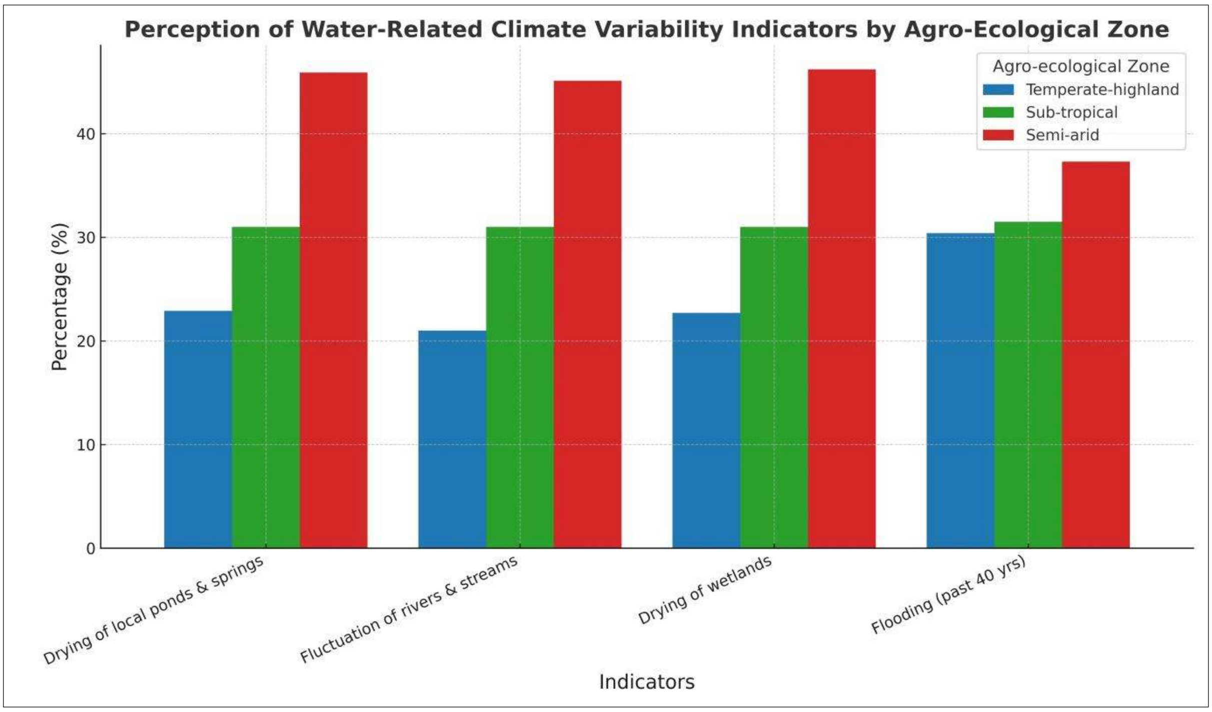

Figure 7. Farmers' perception of water related indicators across the three agroecological zones

Focus group participants from Semi-arid agro-ecological zones perceptions most of the participants suggested that "the area has experienced a steadily decline in the amount of water in the local rivers and streams over the past forty years. They attribute this to rises in temperature and declines in rainfall, and increased rainfall variability. Some of the perennial rivers and streams have become seasonal, and others have dried out altogether." In the Sub-tropical zone, participants reported that "most of the rivers flowing from the Temperate-highland agro-ecological zone have become seasonal, as they now only flow during and shortly after the rainy season. From observations, most rivers and streams in the Temperate-highland agro-ecological zones had low volumes of water and some had dried, while in the Sub-humid and Semi-arid agro-ecological zones many river channels had dried Figure 8." The photo was taken in the month of March 2023 which is in between the winter (dry season) and summer (large rainy season). This finding is supported by several studies which suggest that climate change will affect the future discharge and flow of many rivers and streams (Orindi et al., 2005; Nyong et al., 2007; Collier et al., 2008).

Figure 8. The dried river channel during the month of March taken during field time

Deforestation has become more severe in recent years as communities attempt to compensate for income losses caused by climate-related challenges. In addition, migration to urban areas has increased due to the declining capacity of agriculture to sustain rural livelihoods. These trends were perceived as indicators of climate variability Figure 9.

In the temperate highland agro-ecological zone, 26.5% and 43.7% of respondents strongly agreed that deforestation and livelihood changes, respectively, have intensified. In the sub-humid zone, the corresponding figures were 29.3% and 27.9%, while in the semi-arid zone they were 43.7% and 28.2%. The community is migrating to cities due to inability of agriculture to support their livelihood, deforestation is becoming severe than earlier times to compensate the income loss by due to climate related problems as an indicator of climate variability between the three agro-ecological zones was significant ($\chi2$ = 33.9 with P < 0.000).

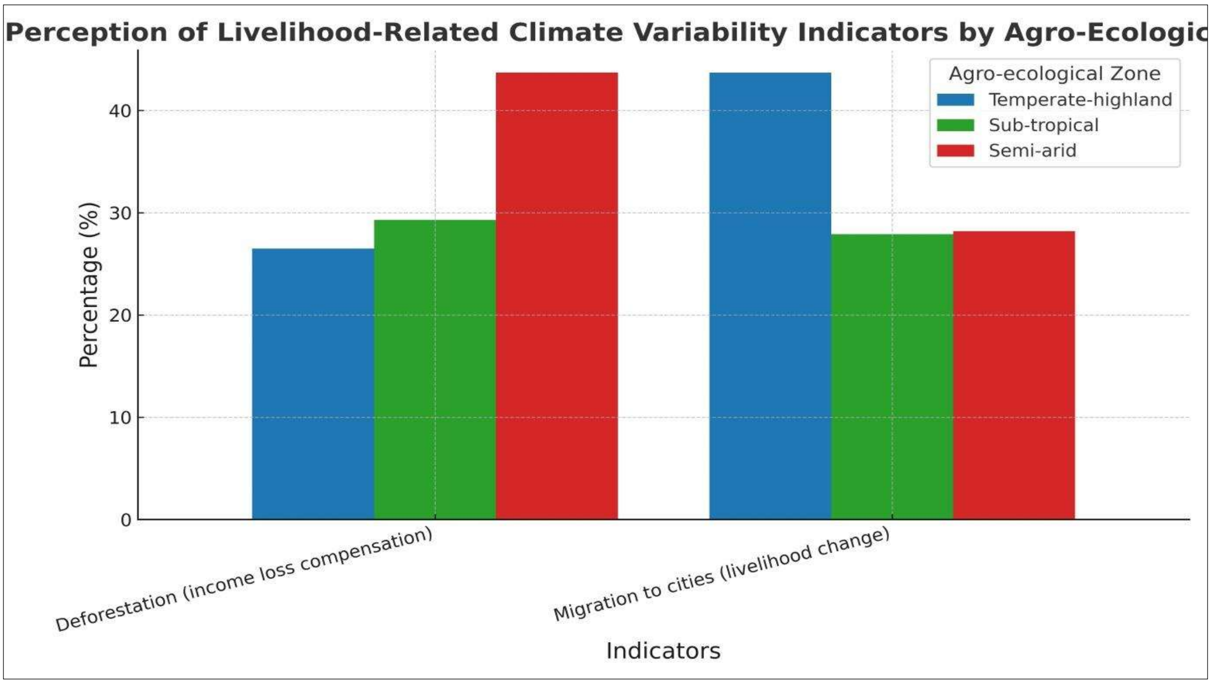

Figure 9. Farmers' perception of livelihood related indicators across the three agroecological zones

Key informant participants in the study area reported "to have witnessed an increased occurrence of deforestation in almost every year for the past forty years. The deforestation incidences were said to have consumed significant parts of the forest reserves devastated those areas which had never previously been cleared since the forest grew. The decline in the thickness of the forest reserves caused by increased drought, luck of forage for their cattle and reduced the rate of surface cover, hence exposing land and water catchments to the direct sun rays which increase the rate of evaporation and evapotranspiration." Furthermore, from oral history interviews with the old age Key informant participant, "it seems that water catchment sources had dried because of the removal of the surface cover forests and disturbances from human activities." For instance, the participant reported that "traditionally it is believed that forests considered as the house of their animals and birds, however due to lack of income from their crops due to climate variability the community used forests for charcoal production as a source of income."

3.2 Descriptive Analysis of Farmers' Perception across Agroecological Zones

The analysis of farmers' perception scores across the three agro-ecological zones showed considerable variation Table 2. Farmers in the semi-arid zone reported the highest mean perception score of 3.80 (SD = 0.63, n = 153), indicating a relatively stronger awareness and recognition of climate change. In comparison, respondents from the sub-humid zone had a mean perception score of 3.10 (SD = 0.71, n

= 116), reflecting moderate awareness. Farmers in the temperate highland zone recorded the lowest mean perception score of 2.90 (SD = 0.77, n = 92), suggesting comparatively lower awareness.

Overall, across all 361 respondents, the mean perception score was 3.30 (SD = 0.74), indicating a moderate level of climate change awareness in the study area. These results suggest that farmers' perceptions of climate variability differ by agro-ecological zone, with the semi-arid zone farmers being the most perceptive, followed by those in the sub-humid and temperate highland zones. This variation may reflect differences in exposure to climatic events, livelihood activities, access to climate information, and institutional support Table 2.

Table 2. Descriptive analysis of farmers' perception across agroecological zones

Zone	N	Mean	Std. Deviation
Semi-arid	153	3.80	0.63
Sub-humid	116	3.10	0.71
Temperate highland	92	2.90	0.77
Total	361	3.30	0.74

3.3 Analysis of Variance (ANOVA) for Farmers' Perception on Climate Change among Agro-Ecological Zones

There were significant differences in mean awareness levels among the agro-ecological zones, demonstrating that zone-specific conditions have a significant effect on farmers' awareness Table 3.

Table 3. Analysis of variance (ANOVA) for farmer's perception on climate change among different agro-ecological zones

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	60.49	2	30.25	61.7	.000
Within Groups	175.3	358	0.49		
Total	235.8	360			

* = significant at 0.05 level

There were significant differences in farmers' perceptions of climate change across the three agro-ecological zones. Temperate-highland vs. Sub-humid, Farmers in the Sub-humid zone reported significantly higher perceptions of climate change than those in the Temperate-highland zone (Mean Difference = -0.70, $p < 0.000$) Table 4. Semi-arid vs. Temperate-highland, the mean perception score of farmers in the Semi-arid zone was slightly higher than that of farmers in the Temperate-highland zone (Mean Difference = 0.20), but the difference was not statistically significant ($p = 0.071$) Table 4.

Sub-humid vs. Semi-arid, Farmers in the Sub-humid zone reported significantly higher perceptions compared to those in the Semi-arid zone (Mean Difference = 0.90, $p < 0.000$) Table 4.

Table 4. Post-Hoc Pairwise Comparison of farmer's perception on climate change among the three agro-ecological zones

(I) Zone	(J) Zone	Mean Difference (I–J)	Sig.
Temperate highland	Sub-humid	-0.70*	.000
Semi-arid	Temperate highland	0.20	.071
Sub-humid	Semi-arid	0.90*	.000

* = significant at 0.05 level

3.4 Results of the Binary Logit Model

In this section, a binary logistic regression model was employed to identify the determinant factors of farmers' perception of climate change. The Hosmer–Lemeshow test of model coefficients produced a Chi-square value of 0.000 with 6 degrees of freedom, which is insignificant at $p>0.05$. This indicates that the predicted and observed frequencies closely match, meaning there is no significant difference between them. Therefore, the estimates of the model fit the data at an acceptable level.

Table 5; Logistic regression result for perception of farmers in different agroecological zones

Predictor	B (Coeff.)	Exp(B) = Odds Ratio	Sig. (p-value)
Age	0.012	1.012	0.210
Gender (1=Male 2=Female)	0.420	1.52	0.048*
Education (1=can't read write 2= can read and write)	0.085	1.09	0.030*
Farming experience (years)	0.020	1.02	0.120
Access to irrigation (1=user 2=non-user)	0.590	1.80	0.010*
Training (1acces to training 2=not get training)	1.120	3.07	0.000*
Formal weather forecasts (1=Access to information 2= Not access to information)	0.750	2.12	0.002*
Indigenous early warning (1=Practiced 2=Not practiced)	0.430	1.54	0.040*
Annual income (per 10,000 Birr)	0.065	1.07	0.070
Extension contacts (1=has contact 2= not contacted)	0.090	1.09	0.015*
Off-farm activities (1=participate off farm 2= not participate off farm activities)	-0.180	0.84	0.300
Constant	-2.400	—	0.000*

* = significant at 0.05 level

The binary logistic regression results revealed that gender, education, irrigation, training, access to forecasts, indigenous warning systems, and extension contacts significantly influenced farmers' perception of climate change, while age, farming experience, annual income, and off-farm activities showed no significant effect Table 5.

Among the socio-demographic variables, gender has a statistically significant effect on farmers' perception of climate change (p = 0.048). The odds ratio (Exp (B) = 1.52) indicates that male farmers are about 1.5 times more likely to perceive climate change than female farmers. Similarly, education level was significant (p = 0.030), with an odds ratio of 1.09, implying that farmers who can read and write are more likely to perceive climate change than those who cannot.

In contrast, age (p = 0.210) and farming experience (p = 0.120) do not show statistically significant effects, suggesting that perception of climate change is not strongly influenced by farmers' age or length of farming experience in the study area.

Institutional and information-related factors play a crucial role in shaping farmers' perceptions. Access to irrigation was significant (p = 0.010), with farmers who use irrigation being 1.8 times more likely to perceive climate change than non-users. Training emerges as one of the strongest predictors (p = 0.000), with an odds ratio of 3.07, indicating that farmers who have access to training are more than three times more likely to perceive climate change compared to those who did not receive training.

Similarly, access to formal weather forecasts significantly influences perception (p = 0.002). Farmers with access to weather information are 2.12 times more likely to perceive climate change than those without access. The practice of indigenous early warning systems also shows a significant effect (p = 0.040), increasing the odds of climate change perception by about 1.5 times.

Economic and livelihood variables show mixed results. Annual income has a positive but statistically insignificant effect (p = 0.070), suggesting that higher income may slightly increase awareness, though the effect is not strong at the 5% significance level. Extension contact significantly affects perception (p = 0.015), with farmers who have contact with extension agents being 1.09 times more likely to perceive climate change, highlighting the importance of advisory services. Conversely, off-farm activities do not significantly influence perception (p = 0.300).

The constant term was significant (p = 0.000), indicating that the model is well-specified and that the included predictors jointly explain farmers' perception of climate change.

Overall, the logistic regression results demonstrate that institutional support, access to information, training, and education are the most influential determinants of farmers' perception of climate change, while demographic factors such as age and farming experience play a lesser role. These findings underscore the importance of strengthening climate-related training, extension services, and information dissemination to enhance farmers' awareness and adaptive capacity across different agro-ecological zones.

4. Discussions

Studying how people in developing countries perceive the risks of climate change is essential because these nations require adaptable strategies to respond effectively to shifting environmental conditions. Farmers observed that average temperatures had risen and rainfall levels had decreased due to changes in the timing of the rains (Sraku-Lartey et al., 2020). Similar findings have been reported in numerous studies conducted by scholars worldwide, which align closely with the results presented in this work (Asekun-Olarinmoye et al., 2014; Akanbi et al., 2021; Arıkan et al., 2021). The results indicate that a substantial proportion of farmers were aware of the factors contributing to climate variability. Awareness of the causes of climate change varied across agro-ecological zones, with farmers in the semi-arid zone demonstrating the highest level of understanding, followed by those in the sub-tropical and temperate highland zones, this result in line with the study done by (Biswas et al., 2021; Ebrahim et al., 2022; Khatri et al., 2023).

The study shows respondents responded that among the indicators of climate variability rainfall decreased for the past four decades, early onset and early exit of rainy season, rain at the beginning of the rainy season, rain during the planting and growing season, rain stops on time in the locality, rain during harvesting period, Off-seasonal rainfall, change in planting time/date to adjust to onset of rainfall, and erratic nature of rainfall were perceived by the farmers differently (Nhamo et al., 2020; Akanbi et al., 2021; Dias, 2022; Akano et al., 2023).

Farmers' perceptions of temperature-related indicators, including the increase in daily temperatures, rising temperatures over the past four decades, and the lengthening of months with high daytime temperatures, varied across the three agro-ecological zones (Capstick et al., 2015; Chala et al., 2020; Bourekba, 2021; Cheval et al., 2022; Ebrahim et al., 2022). The meteorological data revealed that the average annual temperature has been increasing steadily over the past 41 years. The results indicate a rising trend in average annual temperature within the study area, suggesting possible implications for increasing climate variability and associated environmental and agricultural impacts. This finding aligns with survey responses, where 91.9% of participants reported a temperature increase, corroborating earlier research findings (Minwuye, 2017). The study findings indicated that farmers residing in the Semi-arid agro-ecological zone area perceived greater climate changes compared to those in the Temperate-highland agro-ecological zones. This observation might be attributed to the recurrent drought occurrences in the region in recent years or to various environmental shifts leading to decreased water availability (Saguye, 2017; Sraku-Lartey et al., 2020; Van Valkengoed et al., 2022).

The findings indicate that communities across all agro-ecological zones perceived an increasing incidence of crop diseases and pest infestations, higher rates of crop failure, declining coolness, and more frequent drought events over the past four decades. These perceptions suggest a clear worsening of climate-related agricultural risks over time.

Overall, the semi-arid zone consistently showed stronger perceptions of climate stress compared to the sub-humid and temperate highland zones, indicating greater vulnerability in drier environments. This pattern aligns with previous studies that report higher sensitivity of semi-arid regions to climate variability and its impacts on agricultural production (Karki et al., 2020; Aidoo et al., 2021; Akanbi et al., 2021; Bourekba, 2021; Ebrahim et al., 2022). Drought conditions in recent years occur almost in every season, or in consecutive years which result in increased crop failures and food shortages at the household level, especially in the Semi-arid agro-ecological zones highly venerable (Dias, 2022). Drying of local ponds and springs, fluctuation of rivers and streams water volume, drying of wet lands, flooding in the past 4 decades as an indicator of climate variability were increased (Karki et al., 2020; Ruiz et al., 2020). Crop disease pest infestation increases and becomes problem than earlier times, experience regarding crop failure over the last 40 years, experienced of coolness, frequent occurrence of drought in the past 4 decades climate variability/change (Elum et al., 2017; Bourekba, 2021; Ebrahim et al., 2022). Heat-induced livestock disease, heat-induced human disease, Emergence of new plant species/invasive species in the form of weed, some sources of livelihoods of the community are changing due to changing climate conditions as an indicator for climate variability (Okonya et al., 2013; Minwuye, 2017; Mkonda et al., 2018; Aidoo et al., 2021; Akanbi et al., 2021).

5. Future work

This study has provided valuable insights into farmers' perceptions of climate variability across agro-ecological zones in Jabitehinan district. However, several areas remain open for further research. Longitudinal Studies, Future research should employ panel or time-series data to better capture how farmers' perceptions evolve over time in relation to changing climate patterns. Integration of Scientific Climate Data, combining farmers' perceptions with meteorological and satellite-based climate data could strengthen the analysis by aligning subjective experiences with objective climate records. Broader Geographic Coverage, Expanding the study to multiple districts or regions in Ethiopia would allow for comparative analysis and generalization of findings across diverse agro-ecological zones. Policy and Adaptation Linkages, Further studies should focus on how farmers' perceptions influence their adaptation practices and decision-making. This would help policymakers design locally appropriate climate adaptation strategies. Socio-cultural Dimensions, Given the significant proportion of respondents attributing climate variability to religious or supernatural factors, more in-depth qualitative research is needed to understand how cultural and belief systems shape climate risk perception. Gender and Youth-focused Studies, since gender was identified as a significant factor influencing perception, future research should explore the differentiated experiences of men, women, and youth in climate variability adaptation. Impact on Livelihoods and Food Security, Further studies can examine the direct link between climate variability perception, actual adaptation measures, and their outcomes on household income, crop yields, and food security. Climate Information Systems, Research on the effectiveness of indigenous early warning systems and formal forecasts, including the integration of ICT-based tools, could provide valuable insights for improving climate communication strategies. By addressing these gaps, future research can contribute to a more comprehensive understanding of climate variability perceptions and support the development of targeted interventions that enhance farmers' resilience to climate change.

6. Conclusion

This study examined farmers' perceptions of climate variability across different agro-ecological zones in Jabitehinan district, Northwest Ethiopia, and highlighted the diverse ways in which local communities experience and interprets changes in climate. The results revealed that perceptions of climate variability were not uniform but varied significantly by agro-ecological zone, with semi-arid households showing the highest awareness of both rainfall and temperature-related changes. A considerable share of respondents attributed climate variability to religious or supernatural causes, while others associated it with natural and human factors, reflecting the interplay between cultural beliefs and scientific understanding.

The findings further demonstrated that perceptions were shaped by socio-demographic and institutional factors such as gender, education, irrigation access, and training, access to forecasts, indigenous early warning systems, and extension contact. These factors proved more influential than age, farming experience, income, or off-farm activities, suggesting that information access and institutional support play a greater role in shaping climate awareness than personal characteristics alone.

Overall, the study underscores the importance of understanding local perceptions as a foundation for designing effective climate adaptation strategies. Policymakers and development practitioners should recognize the heterogeneity of perceptions across agro-ecological zones and integrate both scientific and indigenous knowledge systems when promoting adaptation. Strengthening climate information dissemination, enhancing education and training, and fostering inclusive extension services will be critical in bridging perception gaps and enabling farmers to make informed decisions that enhance resilience to climate variability.

7. Policy Implications

The findings of this study highlight the need for policies that strengthen farmers' adaptive capacity to climate variability by addressing the socio-demographic and institutional factors that shape perception. Since education, irrigation access, training, extension services, and access to both formal forecasts and indigenous early warning systems significantly influenced perception; policies should prioritize expanding rural education and capacity-building programs, investing in small-scale irrigation infrastructure, and improving the accessibility and reliability of climate information. Efforts must also be tailored to local realities, as perceptions varied significantly across agro-ecological zones, implying that uniform policies may be ineffective. The substantial proportion of respondents attributing climate variability to religious or supernatural causes underscores the importance of integrating awareness campaigns that respect cultural beliefs while enhancing scientific literacy. Moreover, gender-sensitive climate policies are essential to ensure equitable access to information and resources, as gender was found to be a key determinant of perception. Overall, policy interventions should aim to bridge knowledge gaps, enhance localized adaptation strategies, and promote inclusive and sustainable approaches that empower farming communities to respond effectively to climate change.

8. Recommendation

Based on the findings of this study, it is recommended that interventions aimed at enhancing farmers' resilience to climate variability should prioritize improving access to accurate and timely climate information through both modern forecasts and indigenous early warning systems. Strengthening education, training, and extension services is essential to build farmers' capacity to interpret climate signals and adopt appropriate adaptation practices. Given the significant influence of gender on perception, climate policies and programs should be designed in a way that is inclusive and sensitive to the needs of both men and women, while also creating space for youth engagement. Efforts should also focus on promoting irrigation and other sustainable water management practices to reduce dependence on increasingly erratic rainfall patterns. Since a considerable proportion of farmers associate climate variability with religious or supernatural causes, awareness-raising campaigns that integrate scientific knowledge with respect for cultural and belief systems are necessary to bridge gaps in understanding. Policymakers and development practitioners should also tailor strategies according to the unique challenges and perceptions within each agro-ecological zone, as differences across zones were found to be statistically significant. In doing so, interventions will be more context-specific and effective in fostering adaptive capacity and ensuring sustainable livelihoods in the face of climate change.

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9. Reference

1. Adeoti, Ai, Coster, As, & Akanni. (2016). Analysis of farmers' vulnerability, perception and adaptation to climate change in Kwara State, Nigeria. International Journal of Climate Research, 1(1), 1–16. https://doi.org/10.18488/journal.112/2016.1.1/112.1.1.16
2. Aidoo, Danley Colecraft, Boateng, Seth Dankyi, Freeman, Comfort Kudadjie, & Anaglo, Jonathan Nicholas (2021). The effect of smallholder maize farmers' perceptions of climate change on their adaptation strategies: the case of two agro-ecological zones in Ghana. Heliyon, 7(11), e08307. https://doi.org/10.1016/j.heliyon.2021.e08307
3. Akanbi, Remilekun T, Davis, Nerhene, & Ndarana, Thando (2021). Climate change and maize production in the Vaal catchment of South Africa: assessment of farmers' awareness, perceptions and adaptation strategies. 82, 191-209
4. Akano, Oreoluwa, Modirwa, Sinah, Oluwasemire, Kolapo, & Oladele, Oladimeji (2023). Awareness and perception of climate change by smallholder farmers in two agroecological zones of Oyo state Southwest Nigeria. Climate Research, 82, 191–209. https://doi.org/10.3354/cr01628
5. Arıkan, Gizem, & Günay, Defne (2021). Public attitudes towards climate change: A cross-country analysis. Environmental Politics, 30(1–2), 158–174. https://doi.org/10.1080/09644016.2020.1814043
6. Asekun-Olarinmoye, Esther O, Bamidele, James O, Odu, Olusola O, Olugbenga-Bello, Adenike I, Abodurin, Olugbenga L, Adebimpe, Wasiu O, Oladele, Edward A, Adeomi, Adeleye A, Adeoye, Oluwatosin A, & Ojofeitimi, Ebenezer (2014). Public perception of climate change and its impact on health and environment in rural southwestern Nigeria. Research and Reports in Tropical Medicine, 5, 1–10. https://doi.org/10.2147/RRTM.S53984
7. Biswas, Bikram, Roy, Sajib Kumar, Ullah, Mohammad Nur, & Mukharjee, Shanjay Kumar (2021). Public perceptions about the impact of climate change on human health: a study of Bangladesh. Aquademia, 5(2), ep21012. https://doi.org/10.21601/aquademia/11445
8. Board. (2023). Farming systems and Production pattern of Jabi Tehinan wereda. (0743-0167).

9. Bourekba, Moussa. (2021). Climate change and violent extremism in north Africa. In: CASCADES Research Paper. Barcelona: Barcelona Centre for International Affairs.
10. Capstick, Stuart, Whitmarsh, Lorraine, Poortinga, Wouter, Pidgeon, Nick, & Upham, Paul (2015). International trends in public perceptions of climate change over the past quarter century. Wiley Interdisciplinary Reviews: Climate Change, 6(1), 35–61. https://doi.org/10.1002/wcc.321
11. Chala, Dechassa, Belay, Simane, & Bamlaku, Alamerew (2020). Analysis of farmers perceived and observed climate variability and change in Didessa sub-basin, Blue Nile River, Ethiopia. Environmental Systems Research, 9, 15(2), 149–164. https://doi.org/10.1186/s40068-020-00180-4
12. Cheval, Sorin, Bulai, Ana, Croitoru, Adina-Eliza, Dorondel, Ștefan, Micu, Dana, Mihăilă, Dumitru, Sfîcă, Lucian, & Tișcovschi, Adrian (2022). Climate change perception in Romania. Sustainability, 14(1), 253–272. https://doi.org/10.3390/su14010253
13. Collier, Paul, Conway, Gordon, & Venables, Tony (2008). Climate change and Africa. https://doi.org/10.1093/oxrep/grn019
14. Dereje, Kehali, Soromessa, Teshome, & Eshete, Abeje (2022). Carbon storage of selected church forests in northern Ethiopia: implications for climate change mitigation. 10(1), 25-48
15. Deressa, Temesgen Tadesse, Hassan, Rashid M, & Ringler, Claudia (2011). Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia. The Journal of Agricultural Science, 149(1), 23–31. https://doi.org/10.1017/S0021859610000685
16. Dias, Nunes And. (2022). Perception of climate change effects over time and the contribution of different areas of knowledge to its understanding and mitigation. Climate, 10(1), 7. https://doi.org/10.3390/cli10010007
17. Ebrahim, Ahmed Aliy, Miheretu, Birhan Asmame, & Alemayehu, Arragaw. (2022). Vulnerability of smallholder farmers to climate variability and change across different agro-ecological Zones in Oromo Nationality Administration (ONA), North east Ethiopia. PLOS ONE, 17(6), e0268094. https://doi.org/10.1371/journal.pone.0268094
18. Elum, Zelda A, Modise, David M, & Marr, Ana (2017). Farmer's perception of climate change and responsive strategies in three selected provinces of South Africa. Climate Risk Management, 16, 246–257. https://doi.org/10.1016/j.crm.2016.11.001
19. Fosu-Mensah, Benedicta Y, Vlek, Paul Lg, & Maccarthy, Dilys Sefakor (2012). Farmers' perception and adaptation to climate change: a case study of Sekyedumase district in Ghana. Environment, Development and Sustainability, 14(4), 495–505. https://doi.org/10.1007/s10668-012-9339-7
20. Gadédjisso-Tossou, Agossou (2015). Understanding farmers' perceptions of and adaptations to climate change and variability: The case of the Maritime, Plateau and Savannah Regions of Togo. Agricultural Sciences, 6(12), 1441–1454. https://doi.org/10.4236/as.2015.612140
21. Hügel, Stephan, & Davies, Anna (2020). Public participation, engagement, and climate change adaptation: A review of the research literature. Wiley Interdisciplinary Reviews: Climate Change, 11(4), e645. https://doi.org/10.1002/wcc.645
22. IPCC (2006). IPCC Guidelines for National Greenhouse Gas Inventories Volume 4. Prepared by National Greenhouse Gas Inventories Program, (Eggleston H.S., Buendia L., Miwa K., Ngara T. and

Tanabe, K., eds.), Institute for Global Environmental Strategies (IGES) Publishing, Hayama, Japan. (9251039550).

23. Karki, Sikha, Burton, Paul, & Mackey, Brendan (2020). Climate change adaptation by subsistence and smallholder farmers: Insights from three agro-ecological regions of Nepal. Cogent Social Sciences, 6(1), 1720555. https://doi.org/10.1080/23311886.2020.1720555
24. Khatri, Bishnu Bahadur, & Pasa, Rajan Binayek (2023). People's Perception on Climate Change: The Context of Local and Global Discourse. Asian Journal of Population Sciences, 2(1), 68–79. https://doi.org/10.3126/ajps.v2i1.51091
25. Kothari. (2004). Research methodology: Methods and techniques: New Age International.
26. Maddison. (2007). The perception of and adaptation to climate change in Africa (Vol. 4308): The World Bank. https://doi.org/10.1596/1813-9450-4308
27. Mendoza-Poudereux, Isabel, Dziminska, Malgorzata, Pellegrini, Giuseppe, & Rowland, Jussara (2021). Climate change and public perception. Citizens' proposals for better communication and involvement. Journal of Science Communication, 20(3), A09. https://doi.org/10.22323/2.20030209
28. Minwuye, Bewuketu. (2017). FARMERS'PERCEPTION AND ADAPTATION STRATEGIES TO CLIMATE CHANGE: THE CASE OF WOREILLU DISTRICT OF AMHARA REGION, NORTHEASTERN ETHIOPIA. https://doi.org/10.22004/ag.econ.302090
29. Mkonda, Msafiri Yusuph, He, Xinhua, & Festin, Emma Sandell (2018). Comparing smallholder farmers' perception of climate change with meteorological data: experience from seven agroecological zones of Tanzania. Weather, Climate, and Society, 10(3), 435–452. https://doi.org/10.1175/WCAS-D-17-0036.1
30. Nhamo, Luxon, Ebrahim, Girma Yimer, Mabhaudhi, Tafadzwanashe, Mpandeli, Sylvester, Magombeyi, Manuel, Chitakira, Munyaradzi, Magidi, James, & Sibanda, Mbulisi (2020). An assessment of groundwater use in irrigated agriculture using multi-spectral remote sensing. Physics and Chemistry of the Earth, Parts A/B/C, 115, 102810. https://doi.org/10.1016/j.pce.2019.102810
31. Nyariki, Dickson (2009). Household data collection for socio-economic research in agriculture: approaches and challenges in developing countries. Journal of Social Sciences, 19(2), 91–99. https://doi.org/10.31901/24566756.2009/19.02.02
32. Nyong, Anthony, Adesina, Francis, & Osman Elasha, Balgis (2007). The value of indigenous knowledge in climate change mitigation and adaptation strategies in the African Sahel. Mitigation and Adaptation Strategies for Global Change, 12(5), 787–797. https://doi.org/10.1007/s11027-007-9099-0
33. Okonya, Joshua S, Syndikus, Katja, & Kroschel, Jürgen (2013). Farmers' perception of and coping strategies to climate change: Evidence from six agro-ecological zones of Uganda. Journal of Agricultural Science, 5(8), 252–262. https://doi.org/10.5539/jas.v5n8p252
34. Orindi, et al. (2005). Adapting to climate change in East Africa: a strategic approach: International Institute for Environment and Development London, UK.
35. Ruiz, Itxaso, Faria, Sérgio H, & Neumann, Marc (2020). Climate change perception: Driving forces and their interactions. Environmental Science & Policy, 108, 112–120. https://doi.org/10.1016/j.envsci.2020.03.020

36. Saguye, Tesfaye Samuel (2017). Assessment of Farmers' Perception of Climate Change and Variability and It's Implication for Implementation of Climate-Smart Agricultural Practices: The Case of Geze Gofa District, Southern Ethiopia. Journal of Geography and Natural Disasters, 7(1), 1–15. https://doi.org/10.4172/2167-0587.1000191
37. Sraku-Lartey, Margaret, Buor, Daniel, Adjei, Prince Osei-Wusu, & Foli, Ernest G %J Information Development. (2020). Perceptions and knowledge on climate change in local communities in the Offinso Municipality, Ghana. Information Development, 36(1), 16–35. https://doi.org/10.1177/0266666918811391
38. Tesfaye, Wondimagegn, & Seifu, Lemma (2016). Climate change perception and choice of adaptation strategies: Empirical evidence from smallholder farmers in east Ethiopia. International Journal of Climate Change Strategies and Management, 8(2), 253–270. https://doi.org/10.1108/IJCCSM-01-2014-0017
39. Van Valkengoed, Am, Perlaviciute, Goda, & Steg, Linda (2022). Relationships between climate change perceptions and climate adaptation actions: policy support, information seeking, and behaviour. Climatic Change, 171(1–2), 14. https://doi.org/10.1007/s10584-022-03338-7