Causes, indicators and impacts of climate change: understanding the public discourse in Goat based agro-pastoral livelihood zone, Ethiopia

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ABSTRACT

This study assessed the perceived causes, indicators and impacts of climate change by disaggregating farmers in to adaptor and non-adaptor groups in Goat based agro-pastoral livelihood zone of Ethiopia. The collected quantitative and qualitative data were analysed in descriptive statistics, linear regression, anomaly index, Likert rating scale and conceptual narrations. The findings demonstrated that an increasing temperature and a decreasing rainfall trends were perceived by farmers across the study decades. Higher deforestation rate, rash natural resource exploitation, poor soil and water management rehearses and alarming population growth in descending order were identified as climate change causes. Livestock and crop yield decline, livestock/human diseases epidemics and death, as well as recurrent conflicts due to grazing land were its associated impacts. The status and nature of climate change causes, indicators and impacts were however significantly diverse within similar awareness groups. To mitigate its adverse impacts, the farmers were thus applied livestock, crop and non-agriculture related adaptation strategies. Shortage of finance and eligible household labor combined with the absence of climate related information, training and extension services were hindered farmers to take any measure to the climate change. Therefore, to encourage the farmers’ responsiveness, the finding underlines the importance of supplying applicable as well as legitimate natural resource exploitation system, followed by access to climate related information, awareness rising trainings, credit and input delivery services at local and community level.

1. Introduction

Climate change projections indicated that the severe negative impacts of climate change would harm progressively many poor countries in the world due to their weak adaptive capacity (Ajuang et al., 2016). Among Sub-Saharan African countries, Ethiopia is vulnerable to climate change impacts as it lacks access to adaptive capacity improving components like information sources, capital and technology (EPCC, 2015). Due to the recurrent decline in crop yields, loss of livelihood assets and opportunities, the impacts of climate change are extremely sensible at rural smallholder farmers’ context (Thornton et al., 2014). In Ethiopia, the pastoral and agro-pastoral communities that cover 12% of the population keep livestock in drought prone arid and semi-arid regions. Decline in livestock population and productivity in these regions is thus linked to the recurrent climate change (Berhe et al., 2017). In spite of the challenges, farming in these areas has continued for a years as well as the farmers used their indigenous knowledge to endure their livelihoods (Charles et al., 2014).

Identifying the perceived causes, indicators and impacts of climate change as well as preparing possible adaptation choices as part of national program is hence vital for the country (Tazeze et al., 2012).

Since a significant number of literature has stretched our climate change understanding (Amdu et al., 2012; Belayneh et al., 2012; Adem, 2017; Alam et al., 2017), this study is not the initial interest of climate change in Ethiopia context. However, they were generally studied climate change and related issues employing econometric models. Yet, the other studies were assessed the climate change perception using diverse approaches at macro level (Tagel and Van der Veen, 2015; Asrat and Simane, 2018). The studies conducted so far were so far were stressed on the general climate change patterns, perception and adaptation choices devoid of separating in to varied agro-ecological zones, districts and households (Brockhaus et al., 2012). Experience has shown that climate change perception and adaptation outcomes that were identified at national level do not certainly translate into practice as perception and adaptation are naturally location and sector specific (Berhe et al., 2017).

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In this regard, localized studies on climate change perception and adaptation are imperative as farmers are dissimilar in their culture, experience and identity from the national society (Berrang-Ford et al., 2015). On the other hand, econometric models are less participatory and commonly researcher focused to explain facts which are merely objective and statistical. Due to the complex nature of climate change and its associated risks, inclusive and wider qualitative investigation was noticeable to deal with the causes, indicators and impacts. The prior studies on climate change perception and adaptation were commenced using cross-sectional data; that in return hinders the farmers’ thought through time. Policies which were outlined at national and/or regional circumstances are generally ignored the local situations (Asare-Nuamah and Botchway, 2019). The limitations argued above hence provided room for community level study. Therefore, the current study is planned (i) to examine the consistency between farmers’ perception and the actual measured climate trends, (ii) to assesses the farmers’ perceived climate change causes, indicators and impacts, (iii) to identify the farmers’ lived climate change adaptation strategies in the arid-tropical regions of Northeastern Ethiopia.

2. Theory and literature review

In the recent decades, climate change impacts are becoming an important global threat. To relieve these adverse impacts thus adaptation intervention and meteorological disaster readiness is required (IPCC, 2018). The triumph of adaptation largely depends on the genuine climate change understanding and how the vulnerable farmers perceived the changes (Ayanlade et al., 2017). Farmers in this region faced challenges to access reliable and accurate climate information, in turn increases their vulnerability to the impact of climate change (Chepkoech et al., 2018). Indeed, including Ethiopia, a considerable body of climate change literature is available in East Africa; they were discussing mainly farm-level perceptions and adaptation (Amdu et al., 2012; Alam et al., 2017; Hirons et al., 2018). Very few were focused to compare perceptions with the different period climate records (Akerlof et al., 2013), across regions (De Longueville et al., 2020) and within the societal groups (Feleke et al., 2016). Similarly, local farmers are excluded in policy formulation and implementation, plus their practices and local knowledge were not mainstreamed into the national policies (Gemechu et al., 2015).

On the other hand, despite individual experiences are fluctuate across space and time in Ethiopia, some studies have extensively examined the climate change impacts and adaptation strategies (Arragaw and Woldemalak, 2017; Adu et al., 2018). In fact, most studies on climate perceptions use either climate variability or a combination without attempting to separate in to causes, indicators and impacts. However, separating climate change perceptions may poses substantial analytical challenges, as the perceptions of extremes may dominate the perceptions of long-term trends (Kassie et al., 2014).

Understanding the farmers’ climate change perception, hence aids the policy makers to have a profound knowledge on the localized policy design and implementation. Specifically, comparing the farmers’ perception with actual meteorological records is vital to develop a policy framework for sustainable climate change adaptation (Daniel et al., 2014). Therefore, understanding the local perceptions causes, indicators and impacts of climate change would help to describe whether farmers adapt to the long term changes or simply to the current observations. It is also helpful to design sustainable intervention options for future location specific climate variability and related impacts.

3. Research methodology

3.1. The study location

Despite repeated changes in climate change impacts, its magnitude varies across ecosystems in Ethiopia. Northeast Ethiopia, which comprises semi-arid to arid agro ecology, is highly variable to the impacts of climate change (Mihiretu et al., 2020). The recurrent shocks and stresses in the region are gradually weakened the communities’ resilience capacity to climate change (Halima et al., 2012). Drought, which has an irresistible effect, is the persistent features of the variable climate and weather extremes in the region (Mihiretu et al., 2019b). Despite drought is one of the most distressing natural disasters in the arid-tropical areas, the socioeconomic impacts are severe in districts having an annual precipitation of less than 500 mm (Asrat and Simane, 2018). In addition, emphasis to climate change is given to sedentary agriculture but the attention to marginalized agro-pastoral livelihood systems is scanty.

Using purposive random sampling technique, Abergelle district was nominated to exemplify the arid agro-pastoral livelihood zone in Amhara region. The district is situated 765 km away from the Ethiopian capital city Addis Abeba. Abergele is found at 13°20'N latitude and 38°58'E longitude having an altitude of 1150–2500 m above sea level (Abeje et al., 2016). The annual rainfall of the district is between 300-496 mm while its minimum and maximum temperatures in average were 21 and 41 °C, respectively (Tatek et al., 2016). In the study decades, the district has faced brutal natural resources decline, agricultural yield reduction and water shortage (Mihiretu et al., 2021). Moreover, 80% of arable land in the district is prone to severe drought and soil erosion, hence causing periodic displacement for about 0.1 million people in the study decades (CSA, 2017).

Drought incidences were frequent in the region for the last three decades, but it has happened in few years interval at Abergele. The higher livestock depopulations of 2002, 2007, 2011, 2013 and 2015 in the district were associated with climate change impacts (AWOA, 2016). In the district, crop production is restricted to some areas with modest soil fertility and moisture. Nearly 88.2% of farmers in the district dominantly engaged in goat rearing which accounts 73.4% of the districts livestock (Abeje et al., 2016). On top of the spatial and temporal variations in temperature and rainfall, subsistence farming, high poverty, low income and resources as well as greater dependency ratio makes the district enormously vulnerable to climate change (Tatek et al., 2016). Even though the higher vulnerability and climate change impacts, no sufficient study outputs are there in the district for policy makers to devise location specific intervention.

3.2. Design, sampling technique and data collection

In this study, a mixed research approach was used to address the intended objectives. To select the appropriate sample size and study units, a multi-stage sampling technique was employed. First, Abergele district was selected purposively to represent the predisposed district for climate risks and irregularities in arid agro-pastoral areas of Northeastern Ethiopia. Secondly, applying simple random sampling technique, 4 sections from the 15 sections of the district were identified. Using the district’s population census (3974) as sample frame, 5% error tolerance and systematic random sampling was used to pick respondents from the fresh household lists in each section. Based on their interest and prominence to the subject matter, participants for Focus Group Discussions (FGDs) and Key Informant Interviews (KIs) were selected in purposive random sampling technique.

The study adopted a mixed research to permit the collection of quantitative and qualitative data to find information rich cases and capture various perspectives (Creswell and Plano Clark, 2014). Both primary and secondary data sources were employed to collect the required data. The first were collected using in-depth interview schedule

\[ n = \frac{N \cdot e^2}{N' \cdot (N-N')} \]

where: \( n \) = sample size, \( N \) = total study population, \( e \) = error term or the level of precision.
to cognize climate change from the participants’ natural setting (Mihiretu et al., 2020). It has also the virtue of strength and value when researchers’ seek to realize the lived experiences (Nyantakyi-Frimpong and Bezner-Kerr, 2015). The household survey was conducted at village-level from December to June 2017, employing five enumerators. Semi-structured interview schedule was prepared and pre-tested to examine the questionnaire before actual data collection to check its consistency, logical flow as well as the links among questions. This helped in refining questions that were found to be complex, less relevant, and to verify the rationality and reliability of contents. The questionnaire thus comprised three broader parts: (i) basic information about the household, (ii) perceptions on climate variability and their likely disasters (i.e. causes, indicators, impacts) and (iii) information on climate change adaptation measures and their barriers.

The Likert scale questions on climate change perception were developed and forwarded for sample farmers. The collected data includes perception of climate change, the perceived causes, indicators and impacts of climate change as well as the farmers’ lived adaptation options, which are vital for endorsing fit-for-purpose strategies to climate change adaptation. To understand the retrospective information regarding climate change trends, in-depth perception data were collected using FGDs and KILs. Both are accurate instruments for gathering impartial and non-exaggerated qualitative data from discussants since members would act as check for one another (Abrha and Simhadri, 2015). A total of 8 FGDs were conducted containing 8–10 participants per group for ease management, smooth interaction, rich details and equal opportunity to share insights (Mihiretu et al., 2021). To have the wider views of different social segments, the discussants were picked purposively to represent diverse gender, education and wealth status. In addition, 16 KILs were conducted involving well-versed community members and attentive experts at different levels to get deep and diverse climate information. The discussion was held in local language and recorded to translate into English. To compare and verify the farmers’ perception with the actual meteorological trends thereby to come up with thoughtful recommendation outputs, 30 years (1987–2016) temperature and rainfall records was collected from Kombolcha station of the Ethiopian National Meteorological Authority (ENMA).

3.3. Data analysis

The collected quantitative data were analyzed using descriptive statistics (viz., frequency, percentage and mean), but the qualitative data were assessed through context analysis. The meteorological records of rainfall and temperature changes across time were analyzed in Excel. Inferential statistics ($\chi^2$) was hired to compare the statistical differences among respondents in perception levels. Linear regression model was also employed to verify the farmers’ perception with actual of meteorological trends. Applying just a regression of time and temperature/rainfall is not sufficient to prove the farmers’ perception. Because of the model incompetence to show the level of significance, magnitude as well as the expected errors associated with variables in the regression. Employing some relevant temperature and rainfall trend analysis techniques would be hence imperative (Gebre et al., 2013). In this regard, annual rainfall anomaly index was used to examine the trend, as well as to analyse the frequency and intensity of dry and rainy years by using Eq. (1).

$$Z = \frac{X_i - \bar{Y}_i}{S} \quad (1)$$

where, $Z$ is standard rainfall anomaly; $X_i$ is annual rainfall of a particular year; $\bar{Y}_i$ is the long term average annual rainfall for the period of observation, whereas $S$ is the standard deviation for annual rainfall observation period. The category of rainfall anomaly index intensity was: $>4$ (extremely humid), $2-4$ (very humid), $0-2$ (humid), $2-0$ (dry), $4-2$ (very dry), $<-4$ (extremely dry) (Hare, 2003).

In addition, the coefficient of variation (CV) was used to analyse the variability and defined as the degree in which the rainfall volume is varying across time, and calculated by Eq. (2).

$$CV = \frac{\sigma}{\mu} \times 100 \quad (2)$$

where, ‘$\sigma$’ is the standard deviation and ‘$\mu$’ is average precipitation. The variability trend is classified as lower (CV $\leq$ 20), moderate (20 < CV $\leq$ 30) and higher (CV $\geq$ 30) (Hare, 2003).

Among nonparametric tests, the Mann-Kendall’s trend test was used to detect the trends in annual rainfall and temperature using formula (3). The test assumes that the meteorological data set is arbitrarily ordered but helps to test the hypothesis of no climatic trend by using rainfall and temperature as proxies (Chepkoech et al., 2018).

$$S = \frac{N^2-1}{8} \sum_{j=1}^{N} \text{sign} (X_i - X_j) \quad (3)$$

where, ‘$N$’ is the number of data points; ‘$X_i$’ is greater than ‘$X_j$’ then the score is ‘$+1$’, ‘$X_i$’ is smaller than ‘$X_j$’ then the score is ‘$-1$’.

The test infers an increasing trend when ‘$S$’ is higher and positive, but a decreasing trend when ‘$S$’ is lower and negative.

In the study, farmers were also inquired to evaluate the climate change causes, indicators and impacts using five point Likert item questions having a scale of 1, 2, 3, 4 and 5, for the responses of strongly disagree, disagree, neutral, agree and strongly agree, respectively. This scaling method assumes that each statement measures some aspect of a distinct variable then to appropriately apply the summation. The perceptions measured in Likert scale were summed and averaged for statistical analysis simplicity (Mihiretu, 2019). Nonetheless, before combining the scores, Cronbach’s $\alpha$ was tested for internal consistency within statements since in the absence it is impossible to have reliability among scores. The higher $\alpha$ coefficient (0.74) indicated a good internal consistency within item statements and permits a composite construction since the acceptable $\alpha$ value is stated to be between 0.7-0.9 (Likert, 1932). To understand how climate change perception was varied among farmers of similar awareness groups, the analysis was done by disaggregating respondents in to adaptor and non-adaptor groups. The data collected from FGDs and KILs were interpreted and narrated to complement results from the quantitative data (Gebremedhin et al., 2018).

4. Results and discussion

4.1. Socioeconomic profile of sample households

As depicted in Table 1, the farmers average age was 45.4(±9.83) and 13.8% of them were female-headed. Three-fourth of sample farmers never been to school, the average schooling for literate respondents was 1.8(±2.06) in completed years. The average family size of the household was 3.9(±1.44), which was lower than the national (4.9) as well as the regional (4.5) averages (EDHS, 2016). The farmers had 18.5(±9.61) years of practical experience in agriculture and nearly all of them are dependent on livestock-based livelihood. The average livestock holding per household was 13.5(±6.89) in Tropical Livestock Unit (TLU). The average land holding of the households was 1.4(±0.89) in hectare, which was higher than the national (1.14) and regional (1.21) averages in Ethiopia (CSA, 2017). Annual average income of the households was in ETB 24,000(±8458.9) or 1043.5 USD, which was by far higher than the national average per capita income reported to be 784USD in the same year. Among the respondents, 53.1% were accessed climate related information from different sources (Table 1). One-third (34.2%) of them were accessed trainings related to climate change. Despite all respondents had contact with extension agents in the community, 55.4% of them never been to school, the average schooling for literate respondents was 1.8(±2.06) in completed years. The average family size of the household was 3.9(±1.44), which was lower than the national (4.9) as well as the regional (4.5) averages (EDHS, 2016). The farmers had 18.5(±9.61) years of practical experience in agriculture and nearly all of them are dependent on livestock-based livelihood. The average livestock holding per household was 13.5(±6.89) in Tropical Livestock Unit (TLU). The average land holding of the households was 1.4(±0.89) in hectare, which was higher than the national (1.14) and regional (1.21) averages in Ethiopia (CSA, 2017). Annual average income of the households was in ETB 24,000(±8458.9) or 1043.5 USD, which was by far higher than the national average per capita income reported to be 784USD in the same year. Among the respondents, 53.1% were accessed climate related information from different sources (Table 1). One-third (34.2%) of them were accessed trainings related to climate change. Despite all respondents had contact with extension agents in the community, 55.4% of them

In this study, the adaptor groups are farmers whose awareness level of climate change was consistent with the trends of meteorological records, but vice versa for the non-adaptor groups.
them were ensured that below 6 contacts per year, which is lower than the national average (≤6 in a year) (MoA, 2014).

4.2. Climate change as perceived by farmers: a disaggregated overview

To assess the farmers’ overall climate change perception, a question aimed to identify whether they perceived or not was forwarded. In view of that, 86.5% of them were claimed changes in climate but the rest were denied changes across the study decades (Table 2). The finding is in line with Belayneh et al. (2012) study from Doba district of Eastern Ethiopia, who discovered that most of the respondents have noticed climate change. Farmers’ climate change perception further studied by disaggregating respondents in to different age groups, sex category and education status. Because a study by Goebbert et al. (2012) indicated that farmers’ climate change perception is likely to be influenced by different demographic variables. Out of total respondents (86.5%) who perceived climate change, 62.6% and 77.8% were male-headed and illiterate household heads, respectively. The $\chi^2$ result in Table 2 shows that significant difference among 5.8%, 74.2% and 6.5% respondents who were in young, adult and elder age groups ($p < 0.05$). Respondents, found in the adult age were better perceived climate change compared to those who were in young and elder age clusters. This is may be because as age increases, the farmers would become extra likely to access and acquire knowledge from different sources.

4.2.1. The historical trend of annual average temperature

The farmers who reported changes in climate were again asked about the patterns in annual temperature and rainfall, thus 76.8%, 7.1% and

| Table 1. Description of the respondent farmers’ household characteristics, n = 260. |
|-----------------------------|----------------|-------------------------|-----------------------------|
| Categories                  | Variables          | Indicators             | Estimates              |
| Demographic features        | Sex of the household head (%) | M                      | 86.2                      |
|                             |                      | F                      | 13.8                      |
|                             | Age of the household head (years) | $\mu$                  | 45.4                      |
|                             |                      | Std.                   | 9.83                      |
|                             | Educational status the household head (%) | Literate                | 75.1                      |
|                             |                      | Illiterate             | 24.9                      |
|                             | The household head’s level of education (grades) | $\mu$                  | 1.8                       |
|                             |                      | Std.                   | 2.06                      |
|                             | farming experience of the household head (years) | $\mu$                  | 18.5                      |
|                             |                      | Std.                   | 9.61                      |
|                             | Family size of the household (number) | $\mu$                  | 3.9                       |
|                             |                      | Std.                   | 1.44                      |
| Socioeconomic characteristics | Land size owned by the household (ha) | $\mu$                  | 1.4                       |
|                             |                      | Std.                   | 0.89                      |
|                             | Annual income of the household (ETB) | $\mu$                  | 24000.0                   |
|                             |                      | Std.                   | 2458.9                    |
|                             | Total livestock owned by the household in TLU | $\mu$                  | 13.5                      |
|                             |                      | Std.                   | 6.89                      |
| Institutional services/characteristics | The household head’s access to climate information (%) | Yes                  | 53.1                      |
|                             |                      | No                     | 46.9                      |
|                             | The household head’s frequency of contact with extension agents (%) | <6                     | 55.4                      |
|                             |                      | $\geq$6                | 44.6                      |
|                             | The household head’s access to training (%) | Yes                  | 34.2                      |
|                             |                      | No                     | 65.8                      |

Note; M: Male, F: Female, $\mu$: Mean; Std.: Standard deviation, TLU: Tropical Livestock Unit. In the survey month, 1 USD = 23 ETB (Ethiopian Birr).

| Table 2. Farmers’ climate change perception by disaggregating in to different change indicator, n = 260. |
|-----------------------------|----------------|------------------------|
| Categories                  | Total perception (%) | Disaggregated perception levels (%) |
|                             | Age clusters | Level of education | Sex category |
|                             | Young | Adults | Elders | $\chi^2$ | Literate | Illiterate | $\chi^2$ | Male | Female | $\chi^2$ |
| Changes in climate          | 86.5  | 5.8    | 74.2   | 6.5       | 0.021** | 23.9       | 62.6     | 0.100 | 77.8   | 8.7      | 0.102    |
| Temperature                 | Increased | 76.8  | 4.9    | 66.1   | 5.8       | 0.001*** | 17.9      | 58.9    | 0.204 | 69.2   | 7.6      | 0.163    |
|                             | Decreased | 7.1   | 2.3    | 24.2   | 2.4       | 1.023     | 2.2       | 4.9     | 0.101 | 3.3     | 3.8      | 0.112    |
|                             | No change  | 16.1  | 5.2    | 4.9    | 6.0       | 0.102     | 7.2       | 8.9     | 0.112 | 8.7     | 7.4      | 0.443    |
| Rainfall amount             | Increased | 2.2   | 1.3    | 0.9    | 0.0       | 0.101     | 0.9       | 1.3     | 0.422 | 2.2     | 0.0      | 0.932    |
|                             | Decreased | 83.5  | 5.8    | 72.8   | 4.9       | 0.023**   | 20.5      | 63.0    | 0.120 | 74.6   | 8.9      | 0.203    |
|                             | No change  | 14.3  | 5.0    | 4.1    | 5.2       | 0.231     | 5.8       | 8.5     | 0.210 | 8.1     | 6.2      | 0.312    |
| Rainfall variability        | Yes       | 61.7  | 5.9    | 50.6   | 5.2       | 0.016**   | 43.9      | 17.8    | 0.027** | 54.2    | 6.5      | 0.110    |
|                             | No        | 7.5   | 2.0    | 2.5    | 3.0       | 0.140     | 3.6       | 3.9     | 0.100 | 3.7     | 3.8      | 0.432    |
|                             | Don’t know | 30.8  | 10.2   | 8.6    | 12.0      | 0.901     | 16.7      | 14.1    | 0.103 | 17.6    | 13.2     | 0.342    |

Note: ***, **, significance levels at 1 and 5% probability, respectively; n = sample size.
The age clusters were: young (<35); adult (36–64); elder (≥65).
16.1% of them were perceived an increasing, decreasing and constant trend of temperature, respectively in the study years. On disaggregated level, 76.8% revealed that temperature is rising since the last three decades, of which 58.9% and 69.2% were illiterate and male-headed (Table 2). The $\chi^2$ result displayed a statistically significant difference among age groups; hence, 66.1% of farmers found in adult age were perceived an increasing temperature ($p \leq 0.01$). This infers that dissimilarity in temperature perception among age groups was not a chance factor, rather it may be due to young and elder farmers are less likely to recall the long-term climate trend and have less exposure to climate information. This is in agreement with Tazeze et al. (2012) study in the arid lowlands of Babille district of eastern Ethiopia, indicated that older farmers are averse to retrieve climate trends through time and even less prospective to be exposed for diverse climate information sources. The three decades annual temperature records were regressed to verify the farmers’ perception with the trends of meteorological data. The regression output thus exhibited an increasing trend as indicated by the trend line equation ($y = 0.1096x + 39.187$). The positive slope coefficient demonstrates an increasing trend in annual temperature by approximate value of 0.2 °C (Figure 1). This result is therefore nearer to the global warming rate projected to be 0.6 °C in the 21st century. Nonetheless, due to related variables errors in linear regression to show the level of significance and magnitude, using regression output purely may not be ample to verify farmer's perception. Temperature annual anomaly index and the Mann-Kendall’s trend test were thus employed to analyze the frequency, intensity and trends of temperature in the district across time. The highest average annual temperature of the decades was recorded in 2008, 1995, 2010, 2014, 2003 and 2011, however the lowest was in 1996, 2004, 1999, 2006, 2013 and 1994 in ascending order. The annual temperature was ranged between 32.5 - 47.5 °C with an average of 40.9 °C (Table 3). The long range anomalies of the annual temperature displayed inter-annual variability and the trend after 2005 was greater than the long-term average (Figure 2). The anomaly index discovered an increasing trend in annual temperature hence the finding was consistent with MK test which demonstrated a non-significant increasing trend in annual average temperature (Table 3). Therefore, the empirical result from Thornton et al. (2014) study in tropical regions in the world confirmed an increasing trend in annual average temperature.

4.2.2. The historical trend of annual mean rainfall

Among total respondents, 83.5%, 14.3% and 2.2% in descending order perceived a decreasing, constant and increasing rainfall patterns in the study years. The decreasing rainfall trend was evaluated further by farmers of different age, sex and education levels. Among the respondents (83.5%), 72.8%, 63% and 74.6% were adult in age, illiterate in educational status and male in sex, respectively. The $\chi^2$ test discovered that those at different age group were statistically different in their perception to rainfall trends ($p \leq 0.05$). In support of a decreasing rainfall trend, the respondents also stated that rainfall variability, recurrent drought and lower precipitation were witnessed in the study district. The minimum and maximum ever recorded annual rainfalls were 200.8mm and 608.9mm, respectively with annual average of 427.7 ± 81.4mm (Table 3). The trend in annual mean rainfall was decreasing roughly by 11.7mm as presented in the equation ($y = -11.655x + 588.09$). As indicated in Figure 3, the negative slope implied a decreasing trend in annual rainfall within the last 30 years. The rainfall anomaly index (RAI) and MK test showed the annual rainfall distribution of the district, and the drought and rainy year variability was witnessed by RAI means (Figure 4). The positive RAI values represent rainy years, whereas the dry years were labeled by negative values with different degrees of intensity. The RAI value was ranged from humid to dry and very dry periods, thus portrayed a decreasing rainfall trend in the district. The Mann-Kendall’s trend test also displayed significantly a decreasing trend of annual rainfall (Table 3). Therefore, the respondents’ perception on decreasing rainfall trend was in agreement with actual rainfall trends. However, an empirical study by Gemechu et al. (2015) in Ethiopian rift valley contrarily discovered an increasing trend in annual rainfall for most alike study years (1984–2013).

4.2.3. The historical pattern in annual rainfall distribution

In the study, among farmers who perceived the climate change, 61.6% were witnessed recurrent rainfall variability across years, but 7.5% and 30.8% of them were with ‘no variability’ and ‘I don’t know’ responses, respectively (Table 2). More specifically, rainfall variability was better perceived by male, adult and literate farmers in descending order. The $\chi^2$ test discovered that respondents who were adult and literate perceived the rainfall variability at a significant level as they are likely to realize the variation using academic knowledge that they are blessed with ($p < 0.05$). This is covenant with Tagel and Van der Veen (2013) study in Highlands of Ethiopia, who specified that education advances the farmers’ climate change perception as it helps to recall and forecast situations.

The RAI also witnessed that the trend below the long-term average becomes noticeable since 1995 (Figure 4). The positive and negative RAI values characterize the rainy and dry years, respectively with different degrees of intensity. The frequency exhibited 17 years of positive RAI (i.e. humid) and 13 years of negative RAI (dry to very dry). The periods endured longest with droughts were from 1999 to 2001. Among the study years, 2007 was the highest with a negative RAI value (-2.16) and classified under the very dry year. Table 3 portrayed a significant decline in rainfall trend with CV of 20.1% ($p \leq 0.05$). This result confirmed continuous rainfall variability but the lower CV clinched that relatively less inter annual rainfall variability in the district. The rainfall variability thus can affect crop production since the area is largely reliant on the risky rain-fed production system.

In this perspective, the respondents’ perception of rainfall variability was in agreement with the results of analyzed meteorological data though they found tough to describe the magnitude. This result agrees with Viste et al. (2013) and Arragaw and Woldema (2017) who described a recurrent rainfall variability in most tropical and sub-tropical regions of Ethiopia. Ajuang et al. (2016) also found that a strong inter annual variability of precipitation over the preceded four decades in the upper Nyakach division of Kenya in equatorial Eastern Africa. To understand how perception was differed within similar awareness group, respondents’ opinion on the causes, indicators and impacts of climate change were assessed through classifying in to two groups. Based on Table 2, among the perceived respondents, 76.8%, 83.5% and 61.7% were respectively witnessed an increasing temperature, decreasing rainfall and variability consistent with the trends of meteorological records, hence this group was defined as climate change adopters. However, from the perceived respondents, 7.1%, 2.2% and 7.5% were respectively observed a decreasing temperature, increasing rainfall and no variability, on top of ‘no change’ (30.4%) and ‘I don’t know’ (30.8%) responses, this group was on the other hand defined as a non-adaptor group.
To understand variances in the perceived climate change causes, indicators and impacts within similar awareness groups, the respondents were divided into two groups (1 = whose awareness was close to the recorded meteorological trends and 2 = otherwise). For simplified statistical analysis, hence, 76.8%, 83.5% and 61.7% of respondents who observed increasing temperature, decreasing rainfall and variability trends were averaged (74%) as adopter group. Those whose awareness was not closed to the meteorological trends, but witnessed a decreasing temperature (7.1%), increasing rainfall (2.2%) and no rainfall variability (7.5%), on top of 'no change' (30.4%) and 'I don’t know' (30.8%) responses were averaged (26%) as non-adopter group. Furthermore, strongly agree and strongly disagree responses were merged to agree and disagree, respectively in Likert scale as respondents in each category were small in number.

4.3.1. Climate change causes

As portrayed in Table 4, respondents who were classified as adopter were perceived a high rate of deforestation, increased natural resource depletion, poor soil and water management experience and fastest population growth as climate change causes in their descending order. On the other hand, fastest population growth, increased natural resource depletion, poor soil and water management experience and higher rate of deforestation in ascending order were important causes of climate change identified by non-adopter farmers group. Therefore, it’s apt to infer that the farmers were mindful as climate change is not a supernatural fine for humankind, rather it is an anthropogenic negligent stemmed from irresponsive natural resource utilization as well as humble remedial practices. The \( \chi^2 \) test also indicated that except high rate of deforestation and poor soil and water management experience, there was significant variation among adopter and non-adopter farmers in their perception levels to the climate change causes \( (p \leq 0.05) \). The farmers’ perception on the climate change causes was hence in agreement with the study by Mihiretu et al. (2020) in the arid lowlands of eastern Ethiopia, who exactly identified increased deforestation, rapid population growth and insufficient natural resource management as common climate change causes. The FGDs participants’ opinion on climate change causes is summarized as follows:

“The most important climate change causes in the study district were mainly human made. Deforestation, natural resource degradation and the growing population were hence among the others” (Summarized from FGDs).

4.3.2. Climate change indicators

The combined Likert scale revealed that shortage of rainfall, an increased temperature, erratic rainfall, recurrent drought and short rainy season in descending order were agreed indicators of climate change by the adaptor group. Nevertheless, for non-adopter respondents the perceived climate change indicators were frequent drought, higher temperature, erratic rainfall, shortage of rainfall and short rainy season in descending order \( (\chi^2 \text{test}) \). Most respondents in the adaptor group were provided an account that rainfall was showed a downward trend while temperature was increasing across the study decades, hence the district is getting heater as compared to the preceded decades. Perception on climate change indicators was in agreement with Daniel et al. (2014) study in the upper Blue Nile basin which reported extreme heat and temperature, less precipitation and variability to be among others. The \( \chi^2 \) test also revealed that except to frequent drought and short rainy season, there were statistically significant variations between climate change indicator and non-adopter respondent groups \( (p \leq 0.05) \). The study also discovered that the drought frequency in the district used to be in 5/6 years interval, but these days it occurs within 3/4 years interval. This result is in line with Mihiretu et al. (2019a) study in Abergelle district, as
Farmers' perception on climate change causes combined from the Likert scale.

| Climate change causes                      | Groups   | Scaled responses (%) | Scale mean | Difference among groups |
|-------------------------------------------|----------|----------------------|------------|-------------------------|
|                                           |          | D        | N        | A        |              | x ^ 2     | P-value |
| Fast population growth                    | Adaptor  | 12.0     | 15.4     | 72.6     | 3.16       | 2.639     | 0.003*** |
|                                           | Non-adaptor | 31.8 | 30.5     | 37.7     | 2.41       |           |         |
| Higher rate of deforestation              | Adaptor  | 14.2     | 4.8      | 81.0     | 4.28       | 1.468     | 0.121   |
|                                           | Non-adaptor | 15.5 | 6.2      | 78.3     | 4.14       |           |         |
| Increased natural resource depletion      | Adaptor  | 6.2      | 13.8     | 80.0     | 3.94       | 4.628     | 0.023** |
|                                           | Non-adaptor | 24.4 | 31.2     | 44.4     | 2.32       |           |         |
| Poor soil and water management            | Adaptor  | 11.3     | 14.4     | 74.3     | 3.64       | 3.352     | 0.113   |
|                                           | Non-adaptor | 10.4 | 13.6     | 76.0     | 3.52       |           |         |

Note: ***, ** levels of significance at 1 and 5%, respectively, D: Disagree, N: Neutral A: Agree.

Farmers' perception on climate change indicators from Likert scale responses.

| Climate change indicators          | Groups   | Scaled responses (%) | Scale mean | Difference between groups |
|-----------------------------------|----------|----------------------|------------|--------------------------|
|                                   |          | D        | N        | A        | x ^ 2     | P-value |
| Frequent drought                  | Adaptor  | 10.4     | 12.2     | 78.4     | 3.84       | 0.638     | 0.140   |
|                                   | Non-adaptor | 11.8 | 14.5     | 73.7     | 3.68       |           |         |
| Erratic rainfall distribution     | Adaptor  | 8.5      | 10.6     | 80.9     | 4.24       | 2.826     | 0.001*** |
|                                   | Non-adaptor | 15.4 | 16.3     | 68.3     | 2.86       |           |         |
| Shortage of rainfall              | Adaptor  | 0.00     | 7.5      | 92.5     | 3.42       | 1.264     | 0.022** |
|                                   | Non-adaptor | 14.5 | 21.2     | 64.3     | 2.24       |           |         |
| Higher temperature                | Adaptor  | 2.5      | 12.3     | 85.2     | 4.04       | 2.052     | 0.001*** |
|                                   | Non-adaptor | 10.4 | 18.2     | 71.4     | 2.58       |           |         |
| Short rainy season                | Adaptor  | 16.2     | 20.6     | 63.2     | 3.45       | 0.208     | 0.241   |
|                                   | Non-adaptor | 14.4 | 24.2     | 61.4     | 3.26       |           |         |

Note: ***, ** levels of significance at 1 and 5%, respectively, D: disagree, N: neutral A: agree.

to them drought has hit the district repeatedly in ten years interval. The FGD participants also testified that:

“Due to water pollution, frequent hunger and the resultant diminutive disease resistance, different human diseases such as malaria, fever and diarrhea were observed in dry seasons. Among social groups, the poor, female headed, older household members and the children were most the exposed groups for the adverse climate change impacts (Summarized from FGDs).

4.3.3. Climate change impacts

Farmers’ associate the climate change impacts with agricultural production decline hence decline in crop yield, diminishing livestock productivity as well as livestock and human diseases outbreaks were identified as top three climate change impacts by adaptor farmers (Table 6). On the other hand, crop yield decline, livestock and human diseases occurrence, livestock production decline, higher livestock death, water reduction and conflict for resource competition in descending order were the major climate change impacts identified by non-adaptor farmers. In line to this finding, Charles et al. (2014) are documented an increased crop failure, higher disease occurrence and forced sale of livestock, migration, dependence on relief, loss of biodiversity and adverse human development effects were impacts of climatic variability in alike agroecology of southern Malawi. The x ^ 2 test discovered that except conflict for resource competition and water reduction, there was no significant difference among groups in perceiving climate change impacts (p ≤ 0.05). The study by Akerlof et al. (2013) in dryland areas stated that due to a decreasing trend in pasture and water availability, the livestock getting weaker and undernourished thus exposed them for diseases in the winter season. According to farmers, as an agro-pastoral, farmers in the district migrate with their livestock for pasture and water in the consequence conflict will arise with the nearby communities. The KIs in district livestock department described the climate change impacts on livestock sector as follows:

“Due to the recurrent climate change stresses, different livestock diseases were noted in the district in the last three decades (viz. drought, sudden and erratic rainfall). For instance, ovine pasteurellosis was an epidemic caused by the long journey for pasture and water, which in turn result in early abortion and even death. Likewise, Anthrax occurs by grazing infected pasture displaced from an infected area through flood. The other economically important and contagious livestock disease was Peste des Petits Ruminants (PPR), which communicate through contacting with several flocks during grazing and watering. In this case, if there is no vaccination, the livestock mortality rate would grow up to 30%. These diseases finally resulted in meat and milk yield reduction, hide and skin loss and lower rate of livestock reproduction. The veterinarian in the district also justified that the preventive health program is challenged by two main problems. First, farmers are reluctant to use vaccines and even come with part of their flock for vaccination. Secondly, compared to the livestock population, there is shortage of medical inputs, health clinics and trained technicians in the district.” (KII-6, Abergelle district)

4.4. Farmers’ practical adaptation strategies to climate change

Despite larger portion of respondents (86.5%) had good climate change perception, only 63.5% of them were applied multiple adaptation strategies (viz., crop, livestock and non-agriculture related) at a time (Figure 5). This result is agreement with Belayneh et al. (2012) study in dryer Doba district of eastern Ethiopia stated that a sole strategy is tight to inverse the climate change impacts, thus a bundle of choices are likely to be effective. As demonstrated in Figure 5, multiple strategies were
used to defend the impacts of climate change. For instance, to improve crop productivity, farmers were planting drought resistant and short season varieties. To reverse the retreating livestock productivity, farmers used the conserved feed sources followed by diversifying livestock types. To mitigate the outbreak of livestock diseases and the subsequent demises, flock depopulation and reproduction season alteration were used as an action by farmers. Because of constraints usually associated to the farmers’ lived poverty experiences, 36.5% of them were not employ any adaptation strategy to react the adverse climate change impacts. The constraints were hence lack of access to climate awareness raising training and extension services, unidentified reasons, shortage of climate information, limited access to credit and funding and absence of eligible household labor in their descending order (Figure 5). Absence of credit and funding services for instance would hamper the farmers from accessing essential resources and technology acquisition, thus would inhibit their climate change adaptation decisions. The largest share of them thus advised to have solid legal arrangement and/or proclamation that will avert rash natural resource exploitation custom, followed by accessing information and capacity building training on climate change and essential technological inputs as well as capital assets and funds to build sustainable and climate friendly livelihood system in the long run.

5. Conclusion

Results of this study demonstrate that the farmers were perceived an increasing trend in annual temperature, while a decreasing trend of annual rainfall in the study decades. Except an increasing trend of temperature, the farmers’ perception on the trend of decreasing rainfall was confirmed by Mann-Kendall’s trend analysis. A higher rate of deforestation, increased natural resource depletion, poor soil and water

management practices and rapid population growth were acknowledged as climate change causes in their descending order. Shortage of rainfall, increased temperature, erratic rainfall, recurrent drought and short rainy season in descending order were approved as indicators of climate change. The adverse impacts of climate change were visible in varying season in descending order were approved as indicators of climate change causes in their descending order. Shortage of rainfall, management practices and rapid population growth were acknowledged as climate change impacts by farmers. The identified causes, indicators and impacts of climate change were therefore significantly different in their importance and magnitude within farmers of similar awareness groups. Farmers who perceived changes were used adaptation measures related to livestock, crop and non-agriculture strategies to endure their livelihood under climate change. Lack of access to climate awareness raising training and extension services, unidentified reasons, shortage of climate information, limited access to credit and funding and absence of eligible household labor in their descending order were constraints that hamper farmers not to take any action in response to climate change. Therefore, on top of household level actions, regional and community specific public policies on effective and sustainable adaptation strategies are required to endure the farmers' livelihood under climate change. In this regard, the finding underlines that the concerned government body should offer legitimate and contextually applicable natural resource exploitation system at community level. Secondly, the concerned stakeholders are required to provide capacity building trainings to advance the farmers' awareness on the potential climate risks as well as adaptation choices of climate change. Farmers’ access to worth schooling and awareness creation campaigns will enhance their climate change perception and the application of ecologically kind adaptation rehearses. Thirdly, it’s also critical to refresh the local experts’ knowledge and skill to avail accurate and refined climate information in the rural community. Fourthly, there is a need to empower the vulnerable groups of the local community through creating chances to access essential resources for climate change adaptation (viz., technological inputs, financial credit and extension services). Finally, to diversify the farmers' indigenous agriculture based livelihood system, the local administrations should device and strengthen other non-agriculture based job and income creating enterprises.

Declarations

Author contribution statement

Ademe Mihiretu: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Eric Ndemo Okoyo: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Tetsaye Lemma Tefera: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

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Data will be made available on request.

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The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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