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Research Article
Understanding Farmers' Perception on Climate Change and Adaptation Strategies in Karetha Watershed, Omo-gibe Basin, Ethiopia

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Abstract

Background and Objective: The change in amount and characteristics of rainfall and increase in temperature influence agricultural activities in Ethiopia. Various techniques and efforts have been practiced to adapt the problems of climate variability. This study aimed to assess farmers' perception on climate change and their adaptation efforts in Karetha watershed. **Materials and Methods:** A multi-stage sampling procedure was applied in Karetha watershed. The watershed was categorized into low, middle and high elevation areas. From each category, three rural kebeles namely Subo Tulama, Ela Bacho and Gessa Chare were selected respectively. A total of 125 households were selected randomly. The collected data were analyzed by using descriptive statistics in SPPS (version 20) software. **Results:** In the three considered agro-ecological areas, all respondents perceived a higher temperature when compared with the situation in the past. Fluctuation in rainfall also perceived as an evidence of climate change by 94% of respondents in the highland areas. Eighty-seven and 85% of respondents in lowland (Subo Tulama) and middle area (Ela Bacho) respectively perceived decline of rainfall. As responded by majority of interviewees in the considered agro-ecological areas, deforestation was major driver of the climate change. In response to the perceived climate change, majority of farmers tried to adapt the threat by practicing soil and water conservation, tree planting, livestock management, planting tolerant and fast growing crop variety, changing crop sowing time and selling assets. **Conclusion:** The study showed that farmers judged prevalence of climate change based on perceived alteration on temperature and rainfall and exerted effort to abate the resulting consequences on their ecosystem and economic wellbeing.

Key words: Dawuro, deforestation, soil conservation, tree planting, watershed

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Globally, the prevailing climate change has been influencing socio-economic, political and physical processes[1]. The reports warned that various conventional managements of industries and land, among others are predicted to further increase the global temperature and create uncertain rainfall characteristics. Increase in average temperature, change in sea level, fluctuation in rainfall intensity and pattern have been commonly reported for different parts of the globe. Accordingly, the climate change related problems have been negatively influencing development efforts and food security of Sub-Saharan Africa and most developing countries by unpredictable incidence of drought and flood[2].

Emerging scientific reports and evidences showed the changing trends of weather. The study predicted that warming temperature and irregularity of rainfall for Ethiopia[3]. Increasing temperature and declining precipitation was reported for Southern Pastoralist areas of Ethiopia[4]. These reports indicated that the negative effects resulting from the climate change could mainly influence agricultural activities[5,6-8].

Because of its historical and recurrent drought, Ethiopia has been thought as a highly vulnerable country to the climate change[3]. Certainly, the subsistence agriculture of the country, which is dominantly rain-fed, becomes vulnerable to the climate change[3]. The unpredictable rainfall characteristics and timing and increasing temperature become a challenge that determined crop sowing and harvesting time and the production as well. The survival and growth of tree/fruit seedlings has been impaired by the problems. The consequences of climate variability such as incidence of drought, decline in forage, decline in water supply and prevalence of diseases influence livestock production of the country. As a result, livestock production and management in Ethiopia is influenced by climate variability. Due to increased variability in climatic characteristics, even natural pasture lands degrade to the extent that it can influence the production of livestock[4]. The influence of climate change on water availability and biodiversity especially on forage quality and quantity can negatively affect livestock production[7,9]. The climate change also influences the types of livestock that farmers tends to keep, for instance, more pack animals retained to serve for off-farm activities in northern Ethiopia[7]. The change in climate characteristics can also aggravate further deforestation and degradation as rural poor exploit the remaining forest and wood land as a means of overcoming the problem[10].

In response to the observed and perceived climate change, farmers in a given agro-ecological and socio-economic activities might implement various site specific adaptation mechanisms. In different parts of Ethiopia, farmers practice approaches that help to adapt climate change. For instance, crop selection, adjustment in cropping time, diversifying food and income sources, changing number and types of livestock retained, planting trees and searching for off-farm opportunities were reported[7].

Various climate change adaptation strategies can have direct and indirect as well as temporal and persisting benefits. For instance, trees in forest/woodland and agricultural lands have several ecosystem services including, among others, shade, improve micro-climate, reduce soil erosion and land slide, regulate water flow and improve soil health. These benefits of trees on various land uses have been reported for different parts of the world[11-13]. The soil and water conservation practices can contribute to the climate change adaptation through maintaining or increasing agricultural productivity.

Practically, the consequences of climate change and its adaptation practices are site specific due to variations in agro-climatic, socio-economic and physical characteristics. The Karetha watershed of Omo-Gibe basin is characterized by undulating topographies with a range of agro-ecological zones and degrading landscapes. In this watershed, the perceived climate change and its adaptation efforts were not studied empirically. Thus, this study aimed to analyze perception of farmers on climate changes and their adaptation strategies in different agro-ecological areas.

MATERIALS AND METHODS

Study site: This study was conducted near Gibe III hydro-electric dam, about 500 km from Addis Ababa at Southwest direction. The Gibe III hydro-electric dam, the construction of which was completed in 2016, is one of Mega projects in Omo-Gibe river basin that nearly doubled the previous electric supply of the country. The basin has high annual runoff volume and Omo is the only perennial fresh water source for Lake Turkana in between Ethiopia and Kenya. The study area is drained by Karetha river watershed, which flows to Omo river. The area is at right side of Gibe III hydro-electric dam. The Karetha river watershed (98.4 km^2) covers areas of the high, middle and lowland elevation in Loma woreda, Dawuro zone. Its geographic location is 6°53' to 7°03' N latitude and 37°14' to 37°21' E longitude. The elevation ranges from 783-2515 m.a.s.l. The watershed is

characterized with undulating topography and the slope of the land surface ranges nearly flat land to more than 60%. The mean minimum and maximum temperature of the upper part (high elevation) of the area is 12.2 and 21.9°C, respectively. In the lower elevation area, the average temperature of 22.6-25.5°C was recorded[14]. The average annual rainfall of the watershed ranges from 1400-1740 mm where comparatively less rainfall is in the lowland area. The study area is characterized by the two rain-fed cropping seasons, which can be categorized as short (February-May) and long (June-September) cropping seasons, based on amount of rainfall.

The major economic activity of the Karetha watershed is mixed agriculture where both crop cultivation and livestock production are dominantly practiced. It is the smallholder subsistence agriculture. The agricultural activity of the area is susceptible to climate change since it remains as rain-fed. In the middle and lowland areas, maize (*Zea mays* L.), sweet potato (*Ipomoea batatas* (L.) Lam.), sorghum (*Sorghum bicolor* (L.) Moench), teff (*Eragrostis tef* Zucc.), haricot bean (*Phaseolus vulgaris* L.), groundnut (*Arachis hypogaea)* and cassava *(Manihot esculenta* Crantz) were commonly cultivated. Enset *(Ensete ventricosum* Welw.*)* is a perennial staple plant widely cultivated at homesteads in the upper and middle parts of the watershed. This plant tolerates drought condition and thus importantly contributes for climate change adaptation. In the upper parts of the watershed (highland) area, sorghum (*Sorghum bicolor* (L.) Moench), barely (*Hordeum vulgare* L.) and bean (*Vicia faba* L.*)* are commonly cultivated. In lowland area, there is a small woodland area. The common tree species in the area includes eucalyptus species, *Cordia africana*, *Syzgium guineense*, *Melia azedarach*, *Grevillea robust,* ficus speices and *Cobretum molle.*

Methodology

Sampling and data collection: In this study, a multi-stage sampling procedure was applied. The Karetha watershed covering a range of agro-ecological conditions was selected purposively to accommodate the lowland, middle and high elevation areas in a watershed. In this watershed, three rural kebeles namely Subo Tulama, Ela Bacho and Gessa Chare were selected by respectively representing the lowland (kola), midland (weyna dega) and upland (dega) agro-ecological conditions. The elevations of the three kebeles range from below 1000-1500, 1500-1900 and 1900-2515 m.a.s.l, respectively. The consideration of different agro-ecological categories is relevant because vulnerability, perception and adaptation strategies to climate change may vary in these agro-ecological conditions. In each kebele, 10% of households (HHs) were selected randomly using lottery system. The lists of all household heads were obtained from the agriculture and natural resource development office of the respective kebele. Accordingly, 46, 47 and 32 HHs was selected from SuboTulama, Ela Bacho and Gessa Chare kebele respectively. The heads of household were allowed to willingly respond on the structured questionnaire. The structured questionnaire focusing on socio-economic issues, perceived change on climatic characteristics, farmers' evidences on climate change, perceived causes of climate change, observed effects of climate change, farmers' efforts in adapting climate change, farmers' capacity to adapt climate change and challenges to adapt the change.

Data analysis: The collected quantitative and qualitative data were analyzed by using descriptive statistics especially frequency, mean and percentage in SPPS (version 20) software[15].

RESULT AND DISCUSSION

Socio-economic characteristics of the Hhs: The average age of the respondents in three kebeles was close to 40 years (Table 1). This indicated the labor force of heads of HHs to undertake various agricultural activities including the management options that can enhance adaptations to the climate change. In addition, the high family size of the three kebeles (even higher in Gessa Chare and Ela Bacho kebele) on one hand indicates availability of labor force to work on labor-intensive adaptation mechanisms. On the other hand, a large family size demands more basic commodity to sustain life and livelihood and may become problem especially in a face of challenging climate to obtain appropriate and sufficient agricultural products. The problem is more prevalent when most of the household members cannot engage in productive activities.

In Gessa Chare, Ela Bacho and Subo Tulama kebeles, all of the HHs was engaged in agricultural activities from which they obtain their major incomes. A higher proportion of them were responded that they majorly obtain income from sale of crops and livestock and their products. On average, the number of cattle appears small, which is about 6-7 in all kebeles, while sheep and goat are 1-3. On other hand, compared to the average family members, the farmland area is also lower even though it is greater than the national average for the Ethiopian highlands, which is about 1 ha[16]. This partially showed that the traditional subsistence agriculture generates less income to the farmers. The less diverse income may increase susceptibility of the household to climate change and subsequent shock. Since these economic activities are directly threatened by the weather phenomena, adaptation to the

Table 1: Socio-economic characteristics of the households in Gessa Chare and Ela Bacho and Subo Tulama kebeles, Karetha watershed, Omo-Gibe basin, Southwestern Ethiopia

Basic socio-economic characteristics of respondents	Kebeles		
	Gessa Chare (n = 32)	Ela Bacho (n = 47)	Subo Tulama (n = 46)
Age (year), average	38.3	42.8	42.2
Education level (%)			
Illiterate	28.1	27.7	32.6
Grade 1-4	31.3	25.5	28.3
Grade 5--8	18.8	23.4	34.8
Grade 9 and above	21.9	23.4	4.4
Mean family members	8.9	8.8	5.9
Mean farmland area (ha)	2.9	2.4	1.9
Mean livestock population			
Cattle	6.7	5.7	5.7
Goat	3.2	3.0	2.8
Sheep	1.5	1.8	1.0
Income source (%)			
Crop	100.0	100.0	97.8
Animals and its products	90.6	55.3	100.0
Fruit and forest products	6.3	6.4	30.4
Honey	3.1	8.5	8.7
Off-farm	3.1	10.6	0.0

Table 2: Perception in climate change in Gessa Chare, Ela Bacho and Subo Tulama kebeles, Karetha watershed, Omo-Gibe basin, Southwestern Ethiopia

Perception on climate change		Kebeles		
		Gessa Chare n = 32 (%)	Ela Bacho n = 47 (%)	Subo Tulama n = 46 (%)
Observed climate change?	Yes	100.0	100.0	100.0
	No	0.0	0.0	0.0
What is climate change for you?	Flood or intense rain	87.5	27.7	2.2
	Drought	43.8	46.8	97.8
	Unusual change of nature	37.5	27.7	4.4
	Irregular temperature	3.1	31.9	37.0
	High temperature	56.3	53.2	69.6
	Low rainfall	93.8	63.8	65.2
Causes of climate change	Nature or bad given	37.5	17.0	28.3
	Man made	100.0	78.7	73.9
	Do not know	0.0	4.3	2.2
Perceived temperature change	Increase	100.0	100.0	100.0
	Decrease	0.0	0.0	0.0
Perceived rainfall change	No change	0.0	0.0	0.0
	Decrease	34.4	85.1	87.0
	Increase	3.1	6.4	2.2
	Fluctuate	93.8	27.7	10.9

climate change appears critically important. The climate smart management may enhance produces for the observed large family size[16].

Unfortunately, nearly one third of the respondents in all kebeles was illiterate or cannot read and write (Table 1). The lower proportion of respondents attained formal education at secondary level and the lowest proportion was observed in Subo Tulama kebele, which is comparatively far away from the woreda center. The lower formal education level could affect the ease to communication and adoption and adaptation of the technologies relevant to address challenge of the climate change.

Farmers' perception on climate change: All farmers in Gessa Chare, Ela Bacho and Subo Tulama kebeles unanimously perceived the prevalence of climate change in their areas (Table 2). Their major evidences were change of rainfall trends and intensity and also perceived increase in temperature. Accordingly, majority of the respondents in all kebeles perceived that high temperature and low and erratic rainfall as their evidences. Other study in Ethiopia also showed similar perception and evidences. For instance, a report indicated that farmers in East Hararghe, Ethiopia, perceived the climate change based on their experiences on temperature and rainfall characteristics[17]. Other reports also explained the

perceived effects of climate variability such as a decrease in water discharge, soil loss and dry conditions[10].

As responded by farmers, the perceived effects of the fluctuating rainfall and increasing temperature ultimately affect the agricultural production. This results in poor survival of seedlings, prevalence of disease on plant and animal, shift in crop sowing and harvesting times, change in plant performances, reduced forage supply for livestock and reduced availability of water. These effects of climate change can directly influence performance of agricultural economy on which all the respondents depend to sustain their life. Other studies showed that climate change enforced farmers to change sowing time and types of crop in northern Ethiopia[8]. This adaptation experience practiced in the Sub-Saharan Africa in general[2].

Majority of the respondents in the Gessa Chare kebele indicated that incidences of flood and intense rainfall as indicators for climate change. Whereas a higher proportion (97.8%) of the Subo Tulama kebele residents perceived incidences of recurrent drought as an evidence. The people in highland area such as Gessa Chare where the rainfall is high were perceived flood and intense rainfall and again a less rainfall and high temperature as evidences for climate change. The change in the amount and trend of rainfall perceived to result on water discharge extremes, incidences of flood, land slide and deviation in crop sowing time. In highland area, drought might not severely influence agricultural production and productivity but the heavy rainfall could damage a lot, because in highland area the comparatively increasing temperature may not be challenge but instead promotes growth of the existing and new plant species that are beneficial. For instance, in upper highland, farmers emphasized that growth of maize is enhanced with current climate condition compared with last two decades practice and experience. Accordingly, the upper highland area is less vulnerable to drought but suffer from flood and thus the farmers' perception again appears logical.

The perceived evidences on the climate change appeared slightly different from one kebele to the other because in lowland area recurrent drought results comparatively sever shock on farming activities. In general, the respondents in the middle and lowland areas perceived increase in temperature and decrease in rainfall whereas the highland respondents' perceived increase in temperature and fluctuation in rainfall. Accordingly, a higher proportion of the respondents in the Sub Tulama kebele, which is categorized as kola agro-climatic zone, perceived drought as a major problem. Thus, in this lowland area, the incidence of drought is importantly affects farmers' economic activities and livelihood. In lowland area, the perceived change in climate has resulted in low discharge of springs, poor survival of planted seedlings, decrease in forage supply and deviation in crop sowing and harvesting times. Other studies also indicated that climate variability enforced farmers to change their crop sowing time and change in type of crops in northern Ethiopia[8], Central Rift Valley area of Ethiopia[6] and in Uganda[5].

About 38% of respondents in the Gessa Chare and 17% in Ela Bacho kebele perceived climate change as a natural phenomenon (Table 2). In this regard, they perceived that certain group of people that they locally label "Gate" in Dawuro language can allow or defer rainfall in their area. This cultural perception and belief does not concur with global hydrological cycle, which is driven by solar energy, gravity and regional conditions. On the other hand, majority of the respondents in all kebeles perceived the climate change as manmade. The frequently perceived anthropogenic cause was excessive deforestation resulting from increasing population and expansion of agricultural land. This response agrees with the findings for East Hararghe[17] where farmers mentioned deforestation as a major cause of climate change in their area. For the smallholder farmers that depend on the traditional agriculture, expanding the agricultural land with the aim of sustaining livelihood of the increasing household members may result in cultivation of marginal lands and succession of any accessible forest and woodland. Since they have limited income options to depend on, deforestation and cultivation of the marginal land cannot be avoided easily. It has been indicated that agricultural expansion as important cause of deforestation in Ethiopia. Other concurring result for western Ethiopia underlined poverty as important cause of deforestation[18].

Climate change impacts and adaptation strategies: Respondents of all kebeles perceived from medium to very severe impacts of climate change. When they compared with the perceived weather conditions of the previous two decades, the recent years' rainfall and temperature changes have been affecting their agricultural activities at the rate of medium to severe. The respondents' in Gessa Chare Kebele perceived irregular rainfall and increase in temperature as evidences of climate change (Table 2), which supposed to influence their agricultural activity severely. The temperature increase in highland area can partly have positive effect to increase agro-biodiversity and productivity. For instance, maize has been introduced to the upper part of this highland area in recent years, which is favored by the increasing temperature. The irregularity in rainfall might pose uncertainty on crop growing schedule especially in sowing and harvesting periods and supposed to negatively influence management of

Table 3: Perceived impacts and adaptation practices to climate change in Gessa Chare, Ela Bacho and Subo Tulama kebeles, Karetha watershed, Omo-Gibe basin, Southwestern Ethiopia

		Kebeles		
Climate change impact farmers' adaptation strategies		Gessa Chare n = 32 (%)	Ela Bacho n = 47 (%)	Subo Tulama n = 46 (%)
Perceived severity of climate change	very sever	37.5	19.2	2.2
	Severe	62.5	55.3	28.3
	Medium	0.0	23.4	69.6
	Less	0.0	0.0	0.0
	None	0.0	0.0	0.0
Applied adaptation strategies	Yes	100.0	100.0	97.8
	No	0.0	0.0	2.2
Applied adaptation measures by	Implementing SWC	93.8	91.5	93.5
	Planting tree/fruit tree	84.4	83.0	78.3
	Livestock management	43.8	38.3	39.1
Other cope up mechanisms	Selling asset (eg livestock	93.8	66.0	93.5
	Look for government aid	21.9	2.1	26.1
	Off-farm employment	0.0	14.9	13.0
	Reduction of consumption	0.0	31.9	2.2
	Use credit service	0.0	31.9	8.7
	Diversify food source	3.1	25.5	0.0
Who to solve climate problem	God	53.1	40.4	50.0
	Government	50.0	55.3	65.2
	NGO	15.6	0.0	23.9
	Farmers	96.9	8.5	63.0
Have capacity to solve	Yes	40.6	12.8	13.0
climate change problem	No	59.4	80.9	80.4
Heard government plan on climate	Yes	96.9	91.5	97.8
	No	3.1	8.5	2.2

the agricultural activities. The majority of respondents in Ela Bacho and Subo Tulama perceived the decrease in rainfall and increase in temperature that can affect their agricultural activity at medium to very severe level. In these middle and lowland kebeles, both cases can negatively influence the productivity of livestock and crops. Other related studies also reported that smallholder farmers in Ethiopia perceived the climate change and its impacts[10].

Institutional perspective in climate change adaptation: A small proportion of respondents expect the need for government support to cope up challenge. However, majority of the respondents, which is bout 94, 66 and 94% respectively in Gessa Chare, Ela Bacho and Subo Tulama kebeles, attempt to cope up the perceived climate change by selling household assets such as cattle (Table 3). In the Karetha watershed, the major asset that the farmers can sell is livestock, which is difficult in these kebeles where the average number of livestock is small (Table 1). This practice may increase further vulnerability of the society for climate change as selling assets can highly influence capital base of people and increase vicious cycle of poverty and vulnerability.

About one third of respondents in Ela Bacho kebele tried to cope up the climate change problem by reducing household consumption and using credit services, but none of the respondents in the Gessa Chare Kebele use this strategy and a very few proportions of the respondents in Subo Tulama kebele pursue this option. The strategy of adapting climate change by reducing household consumption can result subsequent problems. For instance, reducing the level of household consumption especially quantity and variety of food items could affect human health and their productivity, which in turn influence food security. The credit services can have both positive and negative and positive aspects in adapting climate change. Accesses to the credit services and investing on the ascertained business may positively contribute to adaptation to the climate change. In this regard, the credit service could fill temporal gap but worthy approach when the investment can bring profit. Otherwise it is an uncertain approach to climate change adaptation especially for rural poor depending on the subsistence agriculture.

None of the respondent in Gessa Chare kebele pursues off-farm employment as coping up mechanism to the climate change but about 15 and 13% of respondents in the Ela Bacho and Subo Tulama kebeles respectively had opportunity for off-farm options (Table 3). The off-farm income opportunity could increase capital base of farmers to ensure economic resilience on climate change. Lack of off-farm opportunity worsens the vulnerability of farmers to climate change problems, because off-farm activities can bring money that can supplement the farmers income in the period when there is resource gaps and thus reduce the possibility of selling assets.

On the other hand, a high proportion of farmers in the Gessa Chare and Subo Tulama kebele perceived the God, government and farmers to solve the climate change problem, but in Ela Bacho kebele a majority of respondents give responsibility to the God and government. Thus, in all kebeles, majority of them perceive that they do not have capacity to solve the problem and more than 91% of the respondents had heard the government plan on climate change. Practically, proper implementations of the fitting and sustainable adaptation mechanisms require wise approach in terms of community participation and scientific standard. In this perspective, the perception of community is appropriate in that government should provide packages of scientifically acknowledged technologies that can assist the effort of community in adapting climate change. For instance, customizing crop varieties that can tolerate the changing climate and give higher yield can be an option. Furthermore, introducing productive and drought-tolerant livestock breeds and adapting plant species that can diversify fruit, wood and forage demand can play important role in this typical rural area. The farmers indicated that they are striving to overcome the situation and the sought government support should be compatible with farmer's needs.

Crop and land management for climate change adaptation: In Gessa Chare, Ela Bacho and Subo Tulama kebeles, the respondents explained that they were trying to adapt the climate change problems by practicing different adaptation strategies to overcome the perceived climate change problems. More than 91% of the respondents in Gessa Chare, Ela Bacho and Subo Tulama kebeles practiced the soil and water conservation measures such as building stone bunds, soil bunds and *Fanya juu* terraces to adapt the climate change. Those soil and water conservation measures can reduce the surface runoff and soil loss, enhance infiltration and soil moisture. This adaptation mechanism have multiple advantages resulting from retaining plant nutrients, improving soil moisture and reducing flood risk. Studies also showed that terracing is considered as a means to adapt climate change in East Hararghe, Ethiopia[17]. The soil and water conservation measures were also practiced to adapt climate change in northern part of Ethiopia[8] and Central Rift Valley area[6]. Similarly in Uganda, farmers practice the soil and water conservation measures to adapt the climate change[5].

The respondents in all kebeles undertook crop management practices such as growing drought tolerant species/variety, cultivate fast growing species/variety and changing sowing time (Table 4). Growing plant species that can tolerate the changing climatic condition is an option to adapt the climate change problems. Majority of the respondents in the Gessa Chare kebele have grown plant species that can tolerate the climate change. For instance, the enset (*Enset ventricosum*) plant is commonly referred as a drought tolerant, which is grown in Gessa Chare and Ela Bacho kebeles. Studies showed that enset tolerates the drought conditions and remains important food and fodder plant in the Ethiopia[19]. Similar to the other parts of southern and southwestern Ethiopia, growing enset can help in adapting the climate change problems in the study area.

In the Ela Bacho and Subo Tulama kebeles, sweet potato (*Ipomoea batatas* (L.) Lam.) and cassava (*Manihot esculenta* Crantz) were considered to tolerate climate change especially dry condition. The farmers in these areas customized to grow these plants since several years and practically this is not new experience for these farmers. As a result, a small proportion of farmers in these areas assume that they planted as a new tolerant species as they have been customized the practices. The experiences of growing tolerant crops help to have options during worse climatic period. Cassava (*Manihot esculenta* Crantz) is a drought tolerant staple plant grown in different part of tropics and in West Africa it has been promoted for its ability to adapt climate change and improve food security[20]. The farmers' experience of growing this plant is worthy with respect to its drought tolerating ability to adapt climate change as drought has been perceived as a major climate change problem that the farmers perceived in middle and lowland areas of Karetha watershed.

In addition, the majority (more than 51%) of respondents in all kebeles shifted the crop sowing time and also cultivate fast growing crops (Table 4). A higher proportion of respondents (75%, Table 4) in Gessa Chare kebele experienced to cultivate fast growing plant such as haricot bean. The respondents in Ela Bacho (31.9%) and Subo Tulama (50%) kebeles also undertook similar practices. The haricot bean (*Phaseolus vulgaris*), which is commonly recommended by agronomists, mature in few months and thus in the study area farmers learned to grow and scaled up it in recent years. The haricot bean (*Haseolus vulgaris* L.) is preferred in Ethiopia in general for its early maturity[21]. As perceived by the farmers, this characteristic of haricot bean is importantly required for adapting climate change in order to fill food gaps especially when there is a delay in commencing of rainfall. Another fast growing crop identified by the farmers mainly in the Gessa Chare kebele is a locally improved maize variety that labeled as BH660. This maize variety was released by a research institute and fits to elevation range of 1600-2400 meter above sea level[22]. Thus, this maize variety is highly promoted by the farmers in upper agro-ecological location of the study area. The sweet potato (*Ipomoea batatas* (L.) Lam.) is also perceived

Table 4: Crop management practice for coping climate change in Gessa Chare, Ela Bacho and Subo Tulama kebeles, Karetha watershed, Omo-Gibe basin, Southwestern Ethiopia

	Kebeles		
How do you manage crop?	Gessa Chare n = 32 (%)	Ela Bacho n = 47 (%)	Subo-Tulama n = 46 (%)
Applying chemical fertilizer	68.8	89.4	69.6
Changing sowing time	87.5	51.1	54.4
Selecting crop type and variety	84.4	40.4	82.6
Sowing in line	0.0	4.26	0.0
Growing tolerant species	71.2	12.8	17.4
Planting fast growing crop	75.0	31.9	50.0

as the fast growing plant cultivated in the Ela Bacho and Subo Tulama kebeles. This fast growing crop can give yield and rescue the farmers and thus help in adapting climate change in areas where the rainfall commences lately or ceases early than usual. The concurring study in northern part of Ethiopia also showed that farmers tended to introduce the fast growing crops to overcome the problem of erratic, delaying and early ceasing rainfall problems[7]. The fast growing crop types become immediate solution to fill the food gaps that can occur due to climate change especially when rainfall delays. Diversifying the crop production is also reported as important adaptation option in Central Rift Valley areas of Ethiopia[6] and in Maruf kebele, Blue Nile basin of Ethiopia[10].

In all kebeles, majority of the respondents (more than 69%) use chemical/inorganic fertilizer for adapting the climate change by increasing crop yield (Table 4). Inorganic fertilizers have been highly promoted by the government to increase crop yield per hectare. The inorganic fertilizer can compensate the lost or missing plant nutrients and thus improve crop yield. The climate change adaptation by farmers may include the increased use of agricultural inputs and attempts to grow drought tolerant crop types in southeastern Ethiopia.

The decline in quality and availability of forage in response to the climate change can possibly influence livestock production negatively. As livestock have been severely affected by the climate change, designing the adaptation strategy to sustain their production is highly important for farmers[23]. Heat stress severely affects animal production, especially reduces milk productivity and production of lactating dairy cows[9]. Thus, the shading benefit of trees can supplement livestock production. Accordingly, planting the multi-purpose trees that can provide shade and forage during feed scarce period can be an option. About 40% of the respondents in all kebeles undertake special management for livestock including growing multi-purpose trees and keeping livestock in house during peak temperature time and supplying supplementary forages in response to the climate change.

Trees for climate change adaptation: The forest and woodland cover decreased as perceived by all respondents in the Gessa Chare kebele and by about 94% of respondents in Ela Bacho and 98% in Subo Tulama kebeles (Table 5). The perceived causes of decrease in forest and woodland cover includes the increasing demand for agricultural land by increasing human population and increasing demand for fuel wood and construction material. The decreased forest cover implies the decline in supply of forest products such as wood material, non-timber forest products and forage. In addition, the decreased ecosystem services such as micro-climate amelioration, soil and water conservation ability and shade for soil, human, crop and livestock resulting from decreased forest cover could negatively affect the environment. The decreased forest cover, in general, increases susceptibility of the environment to climate change.

About 84, 82 and 78% of the respondents in Gessa Chare, Ela Bacho and Subo Tulama kebeles respectively planted seedlings of various tree/shrub species (Table 3) in response to the perceived climate change. The planted tree/shrub species expected to provide various products including fruits and livestock forages. These products help in adapting the climate change problems through increasing availability and diversity of food and feed options. The soil and water conserving and improving nature of the trees/shrub species can enhance productivity of crop and livestock, which on the other hand increase resilience of the environment. The tree/shrub can ameliorate micro-climate that can promote performance of crop and livestock. Finding of this study agrees with the result for East Hararghe, Ethiopia, where the farmers use planting of trees and forage plants as their major adaptation option[17]. Such adaptation experience exist in Sub-Saharan Africa in general[2]. In southeastern Ethiopia, agro-pastoralist also plant tree to adapt the climate change.

The proportion of respondents that undertake tree/shrub planting appeared to slightly decrease from higher elevation to lower elevation in the Karetha watershed. This could be for three major reasons: 1) in higher elevation area there is limited natural forest or wood land that can be source of various

Table 5: Perceptions on forest cover and tree planting in Gessa Chare, Ela Bacho and Subo Tulama kebeles, Karetha watershed, Omo-Gibe basin, Southwestern Ethiopia

		Kebeles		
Forest cover, tree planting and management		Gessa Chare n = 32 %	Ela Bacho n = 47 %	Subo-Tulama n = 46 %
How the forest covers appear in your area?	Not changed	0.0	2.1	0.0
	Increased	0.0	0.0	0.0
	Decreased	100.0	93.6	97.8
	Increased and then decreased	0.0	0.0	0.0
	Decreased and then increased	0.0	4.3	0.0
Why forest cover decreased?	Agriculture expansion	100.0	91.5	89.1
	Fuel and construction demand	93.8	44.7	80.4
	Population increase	93.8	85.1	71.7
	Poor forest management	9.4	8.5	2.2
For what purpose do you plant trees?	Construction material	78.1	87.2	39.1
	Fuel wood	40.6	34.0	6.5
	Wood material for sell	81.3	19.2	47.8
	Fruit	87.5	38.3	73.9
	Shade	78.1	46.8	60.9
Anticipated roles of tree	Diversify food	75.0	53.2	26.1
to cope climate change	Increase income	84.4	44.7	76.1
	Shade	59.4	38.3	54.4
	Livestock forage	62.5	61.7	43.5
	Conserve soil and water	96.9	70.2	52.2
	Reduce flood damage	50.0	36.2	6.5
	Improve soil fertility and crop production	43.8	53.2	47.8
Retain tree/shrub	Yes	100.0	89.4	93.5
	No	0.0	10.6	6.5
Manage planted/retained tree	Yes	100.0	91.49	67.4
	No	0.0	8.5	30.4
Tree/shrub management practices	Weeding	84.8	8.5	8.7
	Pollarding	81.3	51.1	13.0
	Pruning	53.1	8.5	19.6
	Thinning	78.1	31.9	45.7

wood material compared to the lower elevation area. Thus, farmers are more motivated in this area to plant and possess their own wood material sources; 2) the Gessa town, which can be local market destination for fruits and wood material, is at higher elevation of the study area and thus farmers could be interested to tap this opportunity by planting trees/shrubs; and 3) in the lower elevation area seedling survival could be lower due to warm climatic condition and may discourage farmers interest of planting trees/shrubs.

The experience of retaining naturally regenerating woody species is also high in Karetha watershed. The planted and retained trees could help in adapting climate change as it can diversify food sources, increase income, shade, livestock forage, conserve soil and water, reduce flood damage and improve soil fertility and crop production (Table 5). Farmers either retain or manage trees to achieve one or more of these roles. Recognizing the benefits of tree/shrub such as wood materials and fruits, a higher proportion of farmers were planted at private holdings for sell and direct household consumption. In the Gessa Chare and Subo Tulama kebeles, a higher proportion of respondents plant trees for shade. The effort of planting trees for various objectives can compromise the disadvantages resulting from the decreasing natural forest/woodland coverage. It can increase ecosystem services such as shade, soil and water conservation, flood control, soil fertility improvement and nutrient cycling. As a result, it helps in adapting the climate change through improved and diversified agricultural products. Selling of the fruits and wood products can reduce possibility of selling household assets due to climate change disaster and thus increase resilience. The trees' shade relieves human and livestock and maintains their productivity and resilience to climate change. The fruits that can be harvested from the planted trees could be used for household consumption and thus diversify food sources and improve quantity and balanced diet, which in turn improve productivity of human.

Farmers practice various management activities to increase the growth of trees. At early age of seedlings, weeding was carried out to enhance growth by avoiding unwanted plants that competes with the planted seedlings.

Table 6: Farmers tree species preference in Gessa Chare, Ela Bacho and Subo Tulama kebeles, Karetha watershed, Omo-Gibe basin, Southwestern Ethiopia

	Kebeles		
Species	Gessa Chare n = 32 %	Ela Bacho n = 47 %	Subo-Tulama n = 46 %
Mangifera indica	71.9	73.9	55.3
Eucalyptus species	15.6	28.3	55.3
Cordia africana	40.6	52.2	57.5
Persia americana	81.3	26.1	55.3
Citrus aurantium	0.0	26.1	0.0
Cupressus lusitanica	78.1	0.0	17.0
Grevillea robusta	68.8	2.2	27.7
Terminalia brownii	0.0	10.9	0.0

Pollarding was carried out to reduce shading effect on crop and regulate crown size and stimulate flowering. Pruning was practiced to enhance agricultural crop growth by increasing sunlight reaching to the crop and maintain straightness of tree bole.

Based on the observed and anticipated benefits, farmers prefer certain tree/shrub species to others (Table 6). In one or more of the study kebeles, majority of the respondents prefer species such as Mango (*Mangifera indica*), Eucalyptus species, avocado (*Persea americana*) and *Cordia africana* in three kebeles (Table 6). The *Mangifera indica* is a fruit tree highly preferred in three kebeles and more productive in middle and lowland areas, which is important to supplement fruit needs and also becomes income option. The *Persea americana* is also preferred fruit tree in all kebeles, due to its high nutritive value and availability of the market especially in the nearby towns. The *Cordia african* tree is highly preferred especially for its quality lumber and suitability for the agroforestry practices. The widely used and preferable construction wood is obtained from Eucalyptus species and as a result it has high household demand and market option. Thus, farmers prefer tree/shrub species based on their experience. Thus, maximizing the multiple benefits of trees by building on the existing experiences can help for adaptation to the climate change. In the effort of planting different tree species, farmers disclosed that they have limited access to the seedlings or planting material. Some of them use the traditional seedling raising methods in their home garden that produce seedlings with poor survival possibility. The government tree nursery in Gessa Chare kebele has been producing seedlings but might be difficult for all farmers to get sufficient seedlings based on their preferences. Some farmers training centers trying to raise seedlings but cannot demonstrate and provide sufficient seedlings compared to the farmers demand, because, managing tree nursery requires at least good access to water especially in dry season. Thus, if the government can support the farmers need and effort, more seedlings can be planted for better climate adaptation and even for mitigation.

The majority of the respondents retain some tree species that regenerated or grown naturally on their landholdings (Table 5). *Cordia africana*, Ficus species, *Syzgium guineense*, *Croton macrostachyus*, acacia species, *Terminalia brownii* and *Terminalia schimperiana* are commonly retained tree species in the considered kebeles. The major purposes of retaining tree/shrub are for timber, soil fertility improvement, shade of coffee and using for construction material. This practice of tree management can contribute for adapting climate change. Retaining the naturally regenerated trees can ease the establishment and increase the possibility of seedlings survival. Farmers had this experience for longtime especially on cultivated land and home garden, which helps to tap the benefits of the trees.

CONCLUSION

In three agro-ecological areas, the result showed that farmers' perceived prevalence of climate change, which is manifested by the increasing temperature and declining or fluctuating rainfall. The study also identified that farmers in the considered agro-ecological areas exert optimum efforts to adapt the consequences of climate change on their livelihood by implementing available and affordable techniques and technologies. The management and development of agricultural crop, soil, water and tree received a high attention of farmers, which appeared logical for their ecosystem and economic sustainability.

SIGNIFICANCE STATEMENT

This study is imperative as it showed the climate change, its effects and adaptation strategies in the geographically connected agro-ecological areas. It provides a reference level for other studies that intends to cover a range of agro-ecological zones. The practitioners could benefit from it for abating climate change by implementing approved technologies that fit to the understanding and knowledge of farmers in the agro-ecological area.

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