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Original Research Article

Vulnerability of Smallholder Farmers to Climate Variability and Adaptation Practices in Southern Part of Ethiopia: The Case of South Ari District

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Abstract

Within the changing environment local community tried their best to reduce climate extremes vulnerability by implementing different adaptive practices. Hence, the aim of this study was to examine the vulnerability of smallholder farmers to climate variability namely, flood and drought in South Ari *district*. To gather reliable data, five *kebeles* were selected from the *district* using simple random sampling technique. 363 household heads were selected using a systematic sampling method from the five selected *kebeles*. Besides, primary data was collected from focused group discussions, key informants, and field observations. The linear trend analysis showed an increasing trend of rainfall and temperature in the study site. Integrated vulnerability analysis approach result showed that the three *Weyina dega* sub-agro ecology zones of the *district* are vulnerable to climate variability in different ways. Farmland enclosure with trees and growing two different crops on the same plot of farmland at the same season are the new adaptive practices implemented by the local community to reduce soil erosion. The chi-square test result shows that age, level of education, income diversity, number of contacts with developmental agents and access to climate information have a significant relation with the adaptation practices implementation in the study site.

Keywords: Adaptive practices, rainfall, smallholder farmers, temperature, vulnerability.

1. INTRODUCTION

Climate variability is an emerging serious global environmental problem affecting many sectors in the world (Getachew, 2014) and it continues to cause great environmental, social, and economic threats to mankind with its multiple effects (Mikias, 2014). It undoubtedly influences the sustainable development of biodiversity, water, land, and oceans as well as in relation to many sectorial activities especially the agricultural sector (IPCC, 2007). According to IPCC (2014) influences from climate variability impact related extremes such as droughts and floods reveal substantial vulnerability and exposure of ecosystems and human systems.

Environmental problems particularly drought and flood are exacerbating poverty in most developing countries. It is estimated that it will delay economic growth, make poverty reduction more difficult, further it erodes food security and extend existing poverty traps (IPCC, 2014; Abebe, 2007). According to Di Falco C *et al.*, (2011) rural areas are likely to face major impacts on food security, infrastructure and agricultural incomes and these impacts will excessively affect the wellbeing of poor people in rural areas like farmers with limited access to land, modern agricultural inputs, infrastructure, and education.

To tackle climate extremes vulnerability many adaptive practices can be implemented at low cost when compared to the estimated risk (Adger, 2007). So that, developing skills on designing and implementing short-term, medium-term, and long-term sustainable adaptation strategies into today's risk and vulnerability assessment based on current environmental problems is necessary to strengthen response capacities and preparedness, to reduce risks (IFRC, 2009). Furthermore, in countries where most of the poor people depend on agricultural income, it is mandatory to develop sustainable adaptation strategies focusing on increasing agricultural productivity to minimize the vulnerability to climate stress and shocks (IPCC, 2014).

Adaptation practices are critical and most efficient way to reduce the adverse impact of climate on the environment and on human livelihood (IPCC, 2007). Several studies have been confirmed that developing and implementing appropriate adaptation strategies increases food productivity. This can be achieved through the smallholder farmers themselves taking adaptive actions or by governments implementing policies aimed at promoting sustainable adaptation measures (Aung et al., 2015). Hence, this study has the following objectives: [1] to analyze the past 33 years climatic data in the site; [2] to assess the current vulnerability of smallholder farmers to climate variability in the site, and [3] to describe adaptive practices implementing by smallholder farmers in the study site.

The study site is located at the southern part of Ethiopia in South Omo zone in the Southern Nation Nationalities and Peoples Region. Geographically, it lies between 5º 67' north to 6º19' North latitude and 36º 30' east to 36º 73' East longitude. It belongs to *Weyina dega* traditional agro-ecology zone. The *Weyina dega* traditional agro-ecology zone is classified into three sub - agro-ecology zones i.e., cool & wet sub-*Weyina dega* traditional agro-ecology zone, warm & moist sub-*Weyina dega* traditional agro-ecology zone and hot & dry sub-*Weyina dega* traditional agro-ecology zones (Alemayehu, 2003). However, there is no clear boundary among the three sub agro-ecological zones approximately 13 *kebeles*, 27 *kebeles* and 6 *kebeles* are belonging to cool & wet, warm & moist, and hot & dry sub-*Weyina dega* traditional agro-ecology zones respectively (South Ari District Finance Office, 2017). Its elevation is between 1,500masl and 2,300masl altitude above sea level.

2. MATERIAL AND METHOD

A mixed research approach was employed to collect, analyze, and interpret data. A quantitative approach was used to collect, analyze, and interpret data that was collected from samples using a sample survey method. On the other hand, a qualitative approach was used to capture and analyze data from informants by using interview and FGDs. Photos, which support both the quantitative and qualitative data, were captured during self-observations. To address the specific objectives of this study, data was collected using household sample surveys, interviews, focus group discussion, field observations and document reviews.

Probability sampling was used to select household head representatives from the five selected *kebeles* of the study site. Selecting representatives for this study from the site proportional to each sub *Weyina dega* traditional agro-ecology zone employed two-stage sampling techniques. Firstly, using simple random sampling techniques four kebeles were selected for the study (one *kebele* from the cool & wet sub- *Weyina dega* traditional agro-ecology zone, three *kebeles* from the warm & moist sub- *Weyina dega* traditional agro-ecology zone and one *kebele* the hot & dry sub- *Weyina dega* agro-ecology zone). Secondly, systematic sampling technique was applied to the sample frame of each selected *kebele* to select representative household heads from each traditional agro-ecology zone. The number of sample household heads was distributed to each *kebele* using the probability proportional to size (PPS) method to ensure equal representation. Systematic sampling methods were applied by computing k (sampling interval). Then, randomly a number (1-9) was drawn to pick-up the unit with which to start the sample inclusion and then every kth element were selected until the desired number was secured. Purposive sampling was employed to select key informants. The sample size of the study was estimated based on C.R. Kothari, (2004) formula, a commonly used formula in different social research.

2.1 Construction of Vulnerability Indices

Current vulnerability of the study site was assessed using integrated vulnerability analysis approach. This approach was employed to develop indices for socio - economic and biophysical indicators. The indicators were classified into adaptive capacity, exposure, and sensitivity. As indicated in many research papers the use of indices is challenged by many doubts; these are the choices of the right indicators, sign (directions) of relationships with vulnerability and weights attached to each index. The choice of indices was carried out based on a reviewed literature. The sign of vulnerability indicators was adopted from the procedure followed by Temesgen *et al.*, (2008), who assigned positive value to adaptive capacity, a negative value to sensitivity and exposure and then calculate the vulnerability indicators value. Thus, vulnerability is calculated as the net effect of adaptive capacity, sensitivity, and exposure.

$$Vulnerability = (Adaptive\ capacity) - (Sensitivity\ + Exposure) \ldots\ldots 1$$

In this relationship the higher value of indicators, the lesser vulnerability and vice versa. Factor scores, a numerical value that indicates a variable relative standing on a latent factor, of each vulnerability indicator were obtained by running principal component analysis on the raw data (percentage of adaptive capacity, sensitivity, and exposure of each variable in the three sub- *Weyina dega* traditional agro ecology zones). Since there are no well-defined weights assigned to the vulnerability indices principal component analysis method, which used for indices with no well - defined weight, was employed to standardize the vulnerability indices across all traditional sub- *Weyina dega* traditional agro ecology zones. To obtain the standardized vulnerability indices of each vulnerability indicators of the three sub- *Weyina* *dega* traditional agro ecology zones the following procedures were employed.

First, principal component analysis was run on the raw data (percentage of each vulnerability indicators) to obtain mean and standard deviation of each indicator. Then, each raw data subtracted by its mean and divided by its standard deviation to standardize the value of each indicator. For example, if a* is original data of each variable of all agro ecology zone, b* is the mean of each variable across all agro ecology zone and c* is its standard deviation, the standardized value of each variable is obtained by: -

$$\frac{a* - b*}{c*} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

The next step is constructing indices for each sub- *Weyina dega* traditional agro ecology zone. Accordingly, each adaptive capacity indicator factor scores multiplied by its correspondent standardized value of indicator and then added together. Similarly, each sensitivity and exposure indicator factor scores multiplied by its correspondent standardized value of indicator and then added together. Finally, the value of sensitivity and exposure of each traditional sub-*Weyina dega* traditional agro ecology zone subtracted from adaptive capacity value of its correspondent sub-*Weyina dega* traditional agro ecology zone. For example, if "e" is the factor score of land holding capacity variable in warm & moist sub-*Weyina dega* traditional agro- ecology zone, and "f" is its standardized value, "g" is factor score of livestock and "h" is its standardized value, and "w" is factor score of rain fall (exposure) and "x" is its standardized value, and "y" is factor score of livelihood dependency (sensitivity) and "z" is its standardized value, all in the same agro ecology zone, vulnerability indices of the sub-*Weyina dega* traditional agro ecology zone is calculated as;

$$[(e * f) + (g * h)] - [(w * x) + (y * z)] \ldots\ldots.\ldots 3$$

The same procedure was applied to obtain the vulnerability indices value of the rest sub- *Weyina dega* traditional agro ecology zones.

Null Hypothesis: H (0); independent variables (household headship background) have no significant impact on the implementation of climate adaptive practices. Standard is the alpha level, usually set at α = 0.05, or 5% error, and is determined to accept or reject the hypothesis. Accordingly, if the chi-square test p-value is less than or equal to alpha ($p<0.05$), then the null hypothesis is rejected. If the chi-square test p-value is greater than alpha ($p>0.05$) the alternative hypothesis is rejected (Mburu, 2015).

3. RESULTS

3.1 Climate Data Trend

The amount of rainfall recorded by the weather station showed an increasing trend with a rate of 3.7mm per decade. Coefficient of variation result indicated January month has high rainfall variability and April has low. In terms of seasons winter is the driest and spring is the wettest. Autumn and spring rainfall shows an increasing trend by 13.1mm and 5.6mm per decade respectively with low rainfall variability.

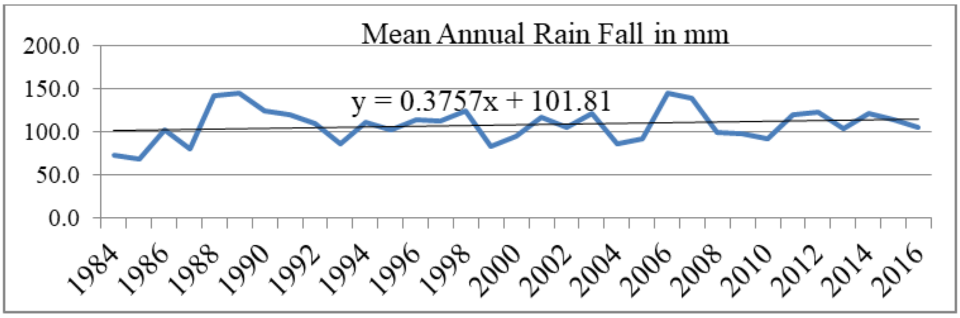

Figure 1: Mean Annual Rainfall Trend for Jinka Station (1984 - 2016)
Source: Own construction, computed from NMA, 2017 climate data

The mean annual maximum and minimum temperature of the study site is 27.43 °C and 16.2°C respectively. Both maximum and minimum temperatures showed an increasing trend by 0.45°C and 0.39°C per decade respectively. The mean annual temperature over the past 33 years of the station was 21.8 °C, showed an increasing trend by 0.4 °C per decade. The lowest and highest mean annual temperature in the study site were recorded in 1986 and 2015 respectively. The lowest and the highest mean annual temperature coefficient of variation was observed in 1994 and 2015 respectively. March and July months are the hottest and coldest months of the years respectively. Autumn and spring seasons showed a relatively high mean annual temperature variation more than in winter and summer seasons in the site. Annual average temperature is above the total mean of the weather station from 2000 onwards.

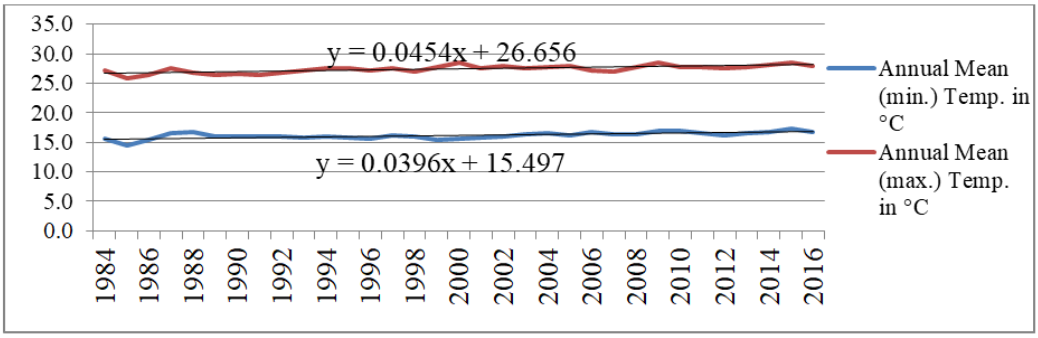

Figure 2: Max. And Min. Mean Annual Temperature Trend for Jinka Station (1984 -2016)
Source: Own construction, computed from NMA, 2017 climate data

3.2 Current Vulnerability to Climate Variability

Over the past decades, the study site was known for producing surplus crops in the area. But the district last five years report revealed that agricultural crop production is decreasing in quantity. For instance, maize and "*Teff",* the most stable food crops in the study site, products decreased by 47,230 and 3,063 tons respectively from 2011 to 2015. In addition, the district Women and Children Affairs' Office report indicated that the number of children migrating from rural *kebeles*/villages to urban areas in the district is increasing towards the recent years. These problems may be triggered by the presence of climate variability namely, flood and drought which affects crop production in the study site. Data collected from the district Disaster Prevention, Preparedness and Food Security Office indicated that farmers in the study site are becoming more vulnerable to climate variability in recent years. The office report indicated crops growing on 1.5 km2 were damaged by extreme cold in the site during autumn season of 2016. The damage resulted in a loss of 1,044 ton of crop harvest in the district and 850 household heads became vulnerable to food insecurity. Similarly, in 2016 spring season crops grown on 5 km2 were damaged by flooding. As a result, 484 household heads became vulnerable to food insecurity and 575 children suffered from malnutrition. The report also indicated that 38.7 km2 rangeland was damaged by extreme weather events (cold and drought) in the years 2015 and 2016.

Vulnerability can further be classified into social, economic, and environmental in the context of an agricultural-based community. Social, economic, and environmental variables for this study were selected based on literature associated with the reality in the study area. Moreover, indices are constructed based on Temesgen *et al*., (2008).

3.2.1 Principal Component Analysis (PCA) Result

As observed from the factor scores, the first PCA was positively associated with most indicators identified under adaptive capacity, and negatively associated with all the indicators categorized under exposure and sensitivity. Thus, for the construction of vulnerability indices, nine indices of adaptive capacity indicators, which are positively associated with the first PCA, from 18 indicators and three indicators of sensitivity and exposure, which are negatively associated with PCA, remain open for discussion. Higher values of the vulnerability index show less vulnerability in the area and vice versa because adaptive capacity is positively loading, and exposure and sensitivity indices are negatively loading to PCA.

Table 1: Principal Component Analysis

Vulnerability Indicators	**Factor Score**
Male headed households	0.962
literate household heads	-0.274
Married household heads	-0.797
Population dependency	0.845
Farming Experience of household heads	-0.672
Age of household heads	-0.946
Livestock ownership	1
Ownership of crops produced	-1
Farmland size	0.977
Off-farm income	-0.397
Soil and water conservation	0.994
Income level	0.048
Land under irrigation	0.404
Access to Credit	-0.761
Access to market	-0.565
Access to road	-0.331
Access to agricultural technologies	0.954
Access to early warning information	0.907
Livelihood dependency	-0.388
Rainfall	-0.149
Temperature	-0.149

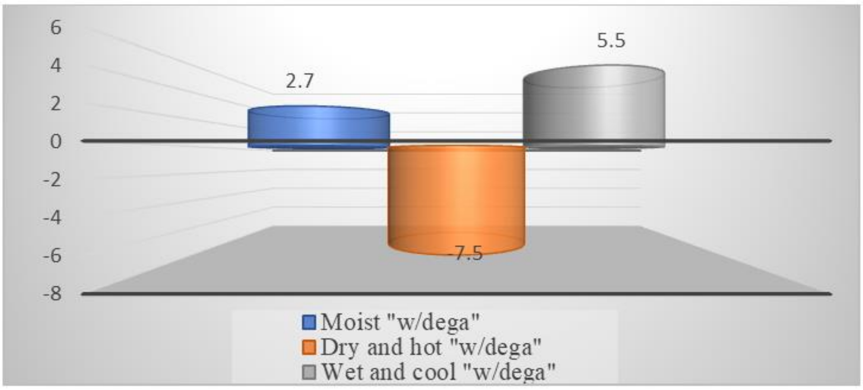

Figure 3: Vulnerability Indices of the Study Site
Source: Computed from PCA result, 2017

3.3 Adaptive Practices in the Study Site

Respondents were asked to identify the types of adaptation practices they implemented over the last few years in response to climate variability impacts. Accordingly, soil conservation practice, change in crop variety, mixed farming, temporary/seasonal migration, off-farm activity and planting early maturing crops are the major adaptation practices implemented in the study site by the smallholder farmers. In addition to the familiar adaptive practices the local community made the farmland enclosure by planting tree surrounding the tilled/ploughed land particularly at the steep slope areas to reduce the amount of flood that erode the farmland. They also grow taro or "*godere*" and maize; two different types of crops on the same farmland during the same season to reduce soil erosion because they believe that taro or "*godere"* has a capacity to retain more amount of water that comes in the form of erosion.

To check the use of adaptation practice in the study site, respondents were asked whether they implemented any adaptation practices or not in the last few years to reduce the impact of climate variability. The following table shows their response.

Table 2: Adaptation practices implementing by households in the study site

Adaptation practices implemented by households	**Moist & warm "*Woyina Dega*"**		**Dry & hot "*Woyina Dega*"**		**Wet &cold "*Woyina Dega*"**		**Total**	
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
Soil conservation practice	12	18.5	-	-	8	28.6	20	20.4
Change crop variety	15	23	-	-	-	-	15	15.3
Mixed farming	21	32.3	2	40	10	35.7	33	33.7
Temporary/Seasonal migration	10	15.4	3	60	6	21.4	19	19.4
Off-farm activity	3	4.6	-	-	4	14.3	7	7.1
Planting early maturing crops	4	6.2	-	-	-	-	4	4.1
Total	65	100	5	100	28	100	98	100

Source: Computed from respondents' response, 2017

3.3.1 Chi-Square Test Result

As indicated in different research, the background of individual household heads has potential to affect implementation of adaptation practices. Chi-square test results showed that age, level of education, income diversity and the number of contacts with agricultural developmental agents has a significant relationship with the implementation of adaptation practices in the warm & moist sub-*Weyina dega* traditional agro-ecology zone but no significant relationship with the implementation of adaptation practices in both cool & wet, and hot & dry sub-*Weyina dega* traditional agro-ecology zones. There is a significant relationship between farmland holding capacity, number of livestock, amount of crop harvested, and income generated from agriculture of the household heads and their implementation of adaptation practices in warm & moist, and cool & wet sub- *Weyina dega* traditional agro-ecology zones. Farm income level has a significant impact on the implementation of adaptation practices in both warm & moist, and hot & dry traditional sub- *Weyina dega* traditional agro-ecology zones. Accesses to climate change information is the only variable that has a significant relationship with the implementation of adaptation practices in all sub- *Weyina dega* traditional agro-ecology zones in the study site. Gender and family size have no significant relationship with the implementation of adaptation practices in any sub- *Weyina dega* traditional agro-ecology zones in the study site.

4. DISCUSSION

4.1 Climatic Data Trend

Unlike results of different research conducted on climate change and/or variability in Ethiopia, autumn and spring seasonal rainfall trend of the study site shows an increasing trend by 13.1mm and 5.6mm per decade. Almost all research conducted on climate change and/or variability in Ethiopia concludes that rainfall decreases, and temperature increases towards the recent years. For example, Chris *et al.,* (2012) study result concludes that autumn and spring rains in parts of Ethiopia have declined by 15–20 percent since the mid-1970s and in the future it declines across the western and southern parts of Ethiopia. In contrast to Chris *et al.,* (2012) study the Jinka station climate data revealed that autumn and spring mean annual rainfall increased since 1984 and will increase by 13mm and 5.6mm per decade in the future decades respectively. Autumn and spring seasonal rainfall variability (30% & 18% respectively) of the study site is negatively affecting crop cultivation than other seasonal rain fall variability. It is because the study site is known for cultivation of crops during autumn and spring seasons. The raise of rainfall trend during these seasons toward the recent years occasionally resulted in crop damage and causes food insecurity in the area. On the other hand, the raising trend of autumn and spring season rainfall has positive effect for the hot & dry sub- *Weyina dega* traditional agro ecology zone community in regenerating pasture/grass for the livestock fodder.

Annual and seasonal rain fall variability, especially autumn and spring season variability influences agricultural production and livelihood of the smallholder farmers than summer and winter season's rainfall variability. This idea is supported by Hirut and Kinde, (2015) study result which stated that the livelihood of the southern part of Ethiopian farmers is highly dependent on rain-fed agriculture which is very sensitive to climate variability and change. Agriculture in this region is largely determined by climatic factors. Among this changing in the distribution and amount of rainfall during autumn and spring seasons affects the agricultural system in the area.

Crop production in the district is decreasing towards the recent years, especially from 2011 onwards. The crop yield reduction in the study site is mainly attributed to climate variability, such as flooding, drought and extreme cold. In line with this statement IPCC (2014) stated that as assessment of many studies coverings a wide range of regions and crops shows that negative impacts of climate change or variability on crop yields have been more common than positive impacts. Climate change negatively affects wheat and maize yields in many regions and in the world.

According to Woldeamlak (2009) inter-annual and seasonal variability of rainfall is a major cause for fluctuations of cereal crop production. Rainfall is the common yield-limiting factor as use of chemical fertilizers and other agricultural inputs is limited. This shows that there are high correlations between cereal crop production and rainfall. Similarly, Hummel (2015) as cited in Desalegn *et al.,* (2015) conclude that higher rainfall and temperatures variability reduce crop productivity in low income and agriculture-based economies. Likewise, Mikias (2014) confirmed that climate change and variability particularly rainfall variability has great impact on crop cultivation and livestock rearing.

As the Inter-governmental Panel on Climate Change mid-range (A1B) emission scenario, in Ethiopia the mean annual temperature will increase in the range of 0.9 -1.1 °C by 2030, in the range of 1.7 - 2.1 °C by 2050 and in the range of 2.7-3.4 °C by 2080. There has been a warming trend in the annual minimum temperature over the past 55 years. It has been increasing by about 0.37 °C every ten years (National Meteorology Agency, 2007). Mean annual temperature in Ethiopia has increased by 1.3°C between 1960 and 2006 with an average rate of 0.28°C per decade. The increase in temperature in Ethiopia has been most rapid in July – September, which is a major crop growing season of the country, at a rate of 0.32°C per decade (Sweeney, 2010).

Similarly, the mean annual temperature of the study area shows an increasing trend by 0.4 °C per decade with a coefficient variation of 0.02 in the period between 1984 and 2016. However, the study site temperature trend showed an increasing trend it is not as much as predicted by Chris *et al.,* (2012), 1.0°C. In agreement with Chris *et al.,* (2012) study data collected from south Omo zone finance and economic development revealed that crop production decline from 2011 onwards. The increasing of mean annual temperature of the study site (0.4°C per decade) is below the expected increasing mean annual temperature of the country (1°C) and minimum annual mean temperature increased by 0.39°C per decade is greater than the national minimum annual mean temperature increase, (0.37°C per decade). Similarly, maximum annual mean temperature increased by 0.45°C per decade, which is greater than the national maximum average temperature increase, (0.1°C per decade). So that, the warming effect is strengthening the impacts of droughts and could mainly decrease the amount of crop production in the study site. Based on analysis result of meteorological data it is possible to conclude that increased temperature and rainfall variability with frequent drought create loss of crop yield, livestock productivity, and increase vulnerability of the local small holder farmers and prevalence of human and animal disease not familiar to the area.

4.2 Current Vulnerability of the Study Site to Climate Variability

In consistent with the survey result different researchers conclude that households with male headed, large family size with working potential, high literacy rate, high farming experience and high participation in different social meetings usually have high social power to withstand adverse effects of climate variability (Gutu, *et al.*, 2012). In agreement with Gutu, *et al.*, (2012) study result the survey result shows that farmers in the study site have high social adaptive capacity (90%).

4.2.1 Principal component analysis

Since most of economic vulnerability indicators such as livestock ownership, farmland size, soil conservation etc., (<60% economic adaptive capacity), are categorized under agriculture sector it is possible to say that this sector (agriculture) is the most vulnerable to climate variability in the study site. In agreement with this idea Kefyalew (2011) study result indicated that agriculture (crop cultivations and livestock rearing), water, health, forests, pastures, and biodiversity are the most vulnerable sectors to climate variability in Ethiopia context. Similarly, National Meteorology Agency (2007) or National Adaptation Program of Action (NAPA) document indicated that the most vulnerable sectors to climate variability and change are agriculture, water, and human health. In addition, NAPA indicated that smallholder rain-fed farmers and pastoralists are found to be the most vulnerable and the arid, semiarid and the dry sub-humid parts of the country are affected most by drought. According to IPCC (2014), rural areas are likely to face major impacts on water availability and supply, food security, infrastructure, and agricultural income. These impacts will excessively affect the wellbeing of the poor in the rural area, like those farmers with limited access to farmland, modern agricultural inputs, and infrastructure. Hence, access of household heads to credit, market, road, agricultural technologies and to climate change early warning information contribute more to climate variability impact resilience of smallholder farmers. As farmers access to these infrastructure increases their vulnerability to climate variability decreases. Access to infrastructure especially access to credit have a great role in promoting the implementation of adaptation options to reduce the negative impact of climate variability. In line with this idea, Yirga (2007) pointed out that availability of credit eases the cash constraints and allows farmers to purchase inputs such as fertilizer, improved crop varieties, improved livestock and irrigation facilities.

Smallholder farmers of the study area are easily susceptible to climate variability impacts because their livelihood depends on natural resources such as farming and forest. The greater the level of dependence of household on natural resources, the greater will be their vulnerability to climate variability. This is due to the fact that the availability of such natural resources depends on climatic variables such as rainfall and temperature, which can be changed from time to time due to climate variability. According to Gutu *et al.*, (2012) households who totally depend on agriculture are the most vulnerable as compared to the partial dependent (medium vulnerable) and who don't depend on agriculture (low vulnerable). Similarly, Desalegn, *et al.*, (2015) study result confirmed that Ethiopian rural farmers are the most vulnerable to the impacts of climate change and variability due to their dependency on rain-fed agriculture, because agriculture is the major source of economic growth in the country. By the same token, Mikias (2014) study result indicated that many researchers confirmed that climate variability in Ethiopia poses risks to poor farmers who have an immediate daily dependence on climate sensitive livelihoods (rain- fed agriculture) and natural resources (i.e., they are the most vulnerable to climate change).

Temesgen *et.al*, (2008) study result also indicated that Ethiopian farmers are exposed to both gradual climate change (mainly temperature and precipitation) and extreme climate change (mainly drought and flood). Very high dependence on rain fed agriculture which is very sensitive to climate variability and change, under-development of water resources, low health service coverage, high population growth rate, low economic development level, low adaptive capacity, inadequate road infrastructure in drought prone areas, weak institutions, lack of awareness, etc. are causes for vulnerability of Ethiopia to climate variability and change. In line with Temesgen *et.al*, (2008) the survey result shows that the three sub- *Weyina dega* traditional agro ecology zones of the study site have less than 60% adaptation capacity and greater than 70% sensitivity.

The principal component analysis result shows that the net effect of adaptation, exposure, and sensitivity is positive for cool & wet, *and* warm & moist sub- *Weyina dega* traditional agro ecology zones and negative for dry & hot sub- *Weyina dega* traditional agro ecology zone. This result indicated that relatively cool & wet sub- *Weyina dega* traditional agro ecology zone is less vulnerable, warm & moist sub- *Weyina dega* traditional agro ecology zone is moderately vulnerable and hot & dry sub- *Weyina dega* traditional agro ecology zone is relatively the most vulnerable site of the three sub- *Weyina dega* traditional agro ecology zones in the district. The lesser vulnerability of the cool & wet sub- *Weyina dega* traditional agro ecology zone is associated with its relatively higher soil conservation practice implementation, high income level, high access to agricultural technologies, and its higher access to early warning information. Hot *&* dry sub- *Weyina dega* traditional agro ecology zone high vulnerability is mainly associated with low soil conservation practices implementation, low access to agricultural technologies, low early warning information and its high population dependency.

4.3 Adaptation Practices in the Study Area

Climate change adaptation is critical and most efficient way for reducing the adverse impact of climate change. According to IPCC (2007) it is important to decrease exposure and vulnerability through implementation of appropriate adaptation practices. Aung *et al.*, (2015) also stated that reducing vulnerability to climate change can be achieved through the smallholder farmers themselves taking adaptive actions or by governments implementing policies aimed at promoting sustainable adaptation measures.

Emelie and Anders (2013) study result revealed that climate change will present a serious threat to agriculture and human health. Hence, these threats can be minimized by implementing sustainable and effective climate change adaptation strategies both at national and local level. In harmony with this idea the local community implemented mixed farming, soil conservation practices, seasonal/temporary migration, changing crop variety and planting early maturing crops climate variability adaptation practices. In the study site mixed farming, which is implemented by 33.7% small holder farmers of the sample survey, is the main adaptation practices undertaken by smallholder farmers while planting early maturing crops (4.1%) is the least adaptation practices undertaken in the study site. This survey result is harmonized with the finding of Shiferaw (2014) regarding the widely practiced climate change adaptation practices in which he conclude that mixed farming is the most preferred climate adaptation strategy while temporary migration is the least preferred. Similarly, the survey result showed that mixed farming is the most preferred climate adaptation practice in the study area. On the other hand, the survey result contradicts with Shiferaw (2014) study result concerning the least climate change adaptation practices (temporary/seasonal migration). According to the survey result temporary/seasonal migration stands at the third place among the adaptation practices implemented by the local community and planting early maturing crops is the least adaptation practices implemented in the study site.

According to IFRC (2009) developing skills on designing sustainable adaptation strategies into today's risk and vulnerability assessment based on current climate change is necessary to strengthen response capacities and preparedness and reduce risks on expected climate change impact trends. IPCC (2014) confirmed that adaptation is mandatory to develop sustainable climate change adaptation strategies in a community which depend on agricultural income to minimize their vulnerability to climate stress and shocks. However, IPCC (2014) assure that undertaking adaptation practices is significant to reduce vulnerability; majority of the household heads (73.1%) of the study area didn't undertake any adaptation practices. Therefore, it is possible to say that climate change adaptation practices implementation is at its infancy stage in the study area, because only 26.9 % of the household heads undertaken it in the past years. This study survey result contradicts with the finding of Temesgen *et al*., (2009) study which confirmed that almost all smallholder farmers in his study area undertake different adaptation strategies to reduce the negative impacts of climate change.

Temesgen *et al*., (2009) hypothesized that different household living in different agro ecological settings use different adaptation methods. This is because climatic conditions, soil, and other factors vary across different agro ecologies, influencing farmers' perceptions of climate change and their decisions to adapt. By the same token, Di Falco (2011) stated that implementation decision of climate change adaptation practice was affected by climatic factors, (rainfall and temperature), as well as the agro-ecological setting. In line with Temesgen *et al*., (2009) and Di Falco (2011), the survey result shows that climate variability adaptation practices implementations in the study site vary among the three sub-*Weyina dega* traditional agro-ecology zones. It is good in cool & wet sub-*Weyina dega* traditional agro- ecology zone, (35.9%), and moderate in warm & moist sub-*Weyina dega* traditional agro- ecology zone, (26.7%), and is least in hot & dry & hot sub-*Weyina dega* traditional agro- ecology zone, (11.9%). This result indicates that basic features such as climate type, soil fertility, livelihood style etc. of each sub-*Weyina dega* traditional agro- ecology zone in the site determine the implementation of climate variability adaptation practices. Due to this fact implementation of adaptation practices to climate variability especially that used to increase crop yield (soil conservation) is high in warm and moist sub-*Weyina dega* traditional agro- ecology zone and low in hot & dry sub-*Weyina dega* traditional agro- ecology zone of the study site.

4.3.1 Chi-square test result

The Pearson chi square test p-value indicated that age, level of education, income diversity of household heads and their contact frequency with agricultural development agents (agricultural extensions) have a significant effect on implementation of adaptation practices in warm & moist sub-*Weyina dega* traditional agro ecology zone in the study site. But these variables have no significant relationship with implementation of adaptation practices in hot & dry, and cool & wet sub-*Weyina dega* traditional agro ecology zones of the study site. In contrary to this study result different studies revealed that age; educational level and access to agricultural extension services of the household heads have a potential impact on implementation of climate change adaptation practices by the households. Higher level of education is believed to be associated with access to information on improved technologies and higher productivity. Evidence from various sources indicates that there is a strong relationship between the education level of the household head and the implementation of adaptation practices to climate variability. Therefore, farmers with higher levels of education are more likely to implement climate change adaptation practices better than less educated farmers. Likewise, as age of farmers increase their experience on farming activity increases. Hence, age has also a significant relationship with adaptation practices. Temesgen *et al.*, (2009) study result revealed that high experience of farmers on farming increases the probability of implementing adaptation measures to climate variability especially in implementation of soil conservation. By the same token, he concludes that high educational level of the head of household increases the probability of implementing climate change adaption practices and there is positive relationship between education and adaptation to climate change. Correspondingly, Temesgen *et al*., (2014), Shiferaw (2014) and Di Falco (2011) study results indicated that age and education level of household heads has a significant relationship with implementation of climate change adaptation practices.

The p-value of the chi square test result shows that land holding capacity, number of livestock, amount of crop cultivated, and income from agriculture of household have a significant relationship with implementation of climate change adaptation practices in warm & moist and in cool & wet sub-*Weyina dega* traditional agro ecology zones of the study site.

Much research points out that the implementation of agricultural technologies requires sufficient financial wellbeing. As a result, farmers who have relatively high number of livestock, high on farm income, large farmland size and cultivate better amount of crop may be less affected by climate change impact risks and have more access to information. This study result is supported by Shiferaw (2014) study result that conclude farm income, farmland size and number of livestock owned by household heads are significant factors that affect implementation of adaptation practices to climate change. Likewise, Temesgen *et al.*, (2009) study result showed that ownership of livestock positively related to the implementation of climate change adaptation measures such as conserving soil, planting trees, and changing planting dates. By the same token, he conclude that farm income of the households has a positive and significant impact on implementation of climate change adaptation practices such as conserving soil, using different crop varieties, and changing planting dates. But these variables have no significant effect on implementation of climate change adaptation practices in hot & dry sub-*Weyina dega* traditional agro ecology zone of the study site. In contrary to this result Yirga, (2007) study result indicated that livestock plays a significant role by serving as a store of value and by providing adhesion and manure required for soil fertility maintenance.

The Pearson chi square test p-value showed that access to climate change information has no relationship with implementation of climate change adaptation practices in the three sub-*Weyina dega* traditional agro ecology zone of the study site. This study result opposes with different research results. For example, Yirga (2007) pointed out that various studies in developing countries, including Ethiopia; reported a strong positive relationship between access to climate change information and the implementation of climate change adaptation practices by farmers, and access to information through agricultural extension increases the likelihood of adapting to climate change. Similarly, Shiferaw (2014) study result indicated that access to agricultural extension service is a significant factor that affects implementation of adaptation practices to climate change.

The chi-square test p- value indicated that sex and family size of household heads have no significant relationship with adaptation practices implementation in the three sub- *Weyina dega* traditional agro- ecology zones of the study site. This study result contradict with Temesgen *et al.*, (2009) study result which stated that male-headed households are more likely to get information about new technologies and undertake than female-headed households. Similarly, he indicated that larger family size are more likely to adopt agricultural technology and use it more intensively because they have fewer labor shortages at peak times and are more likely to adapt to climate change. Likewise, Temesgen *et al*., (2014) and Shiferaw (2014) study results also indicated that sex of household heads and family size have a significant relationship with implementation of climate change adaptation practices.

5. CONCLUSION

Rising rainfall during autumn and spring seasons accompanied with temperature variability is causing crop and animal product yield loss towards the recent years in the study site. Currently, the increasing variability of both rain fall and temperature in the study area increases the vulnerability of the local community, especially food insecurity. However, all agro ecology zones of the study area are currently vulnerable to climate change their level of adaptation capacity, exposure and sensitivity make it different among each agro ecology zone. Though, the implementation of adaptation practices in the study site is at an infancy stage, the local community tried to use two new adaptive practices on their farmland to reduce soil erosion. The one is area enclosure: planting trees surrounding their farmland particularly at the steep slope areas to reduce the runoff from top to down. The second is growing two different crops namely maize and taro or "*godere*" on the same plot of farmland during the same season. The existence of climate variability accompanied with low adaptation practices erodes the food security of the community in the district.

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7. Declaration of interest statement

I, Kassahun Yemane Birhanu, do hereby declare that this article is my original work and that it has not been submitted to any publishing journal.

REFERENCES

- Abebe, T. (2007). Climate change national adaptation programme of action of Ethiopia.The federal democratic republic of Ethiopia ministry of water resources national meteorological agency.
- Adger, W. N., Agrawala, S., Mirza, M. M. Q., Conde, C., O'Brien, K., Pulhin, J., ... & Takahashi, K. (2007). Assessment of adaptation practices, options, constraints and capacity. Cambridge University Press, Cambridge, UK, 717-743.
- Alemayehu, M. (2003). Country Pasture/Forage Resource Profiles. Available at: www.fao.org/ag/agp/agpc/doc/counprof/ethiopia/ethiopia.htm
- Aung, T., Guido, V., & Stijn, S. (2015). Determining factors for the application of climate change adaptation strategies among farmers in the Magwe District: Conference on International Research on Food Security, Natural Resource Management and Rural Development, Humboldt-Universität Zu Berlin, and the Leibniz Centre for Agricultural Landscape Research. Berlin, Germany.
- Chris, F., Jim, R., Gary, E., Emebet, K., and Nigist, B., Libby, W., & Gideon, G. (2012). Famine Early Warning Systems Network-Informing Climate Change Adaptation Series. A Climate Trend Analysis of Ethiopia. USAID-funded FEWS NET agreement with USGS. USA.
- Kothari, C. R. (2004). Research methodology: methods and techniques. (Second revised edition). New Age International (P) Ltd., Publishers. New Delhi.
- Desalegn, O., Gemeda, A., & Akalu, D. (2015). The impacts of climate change on African continent and the way forward. *Journal of Ecology and the Natural Environment*, 7(10), 256-262.
- Di Falco, S., Yesuf, M., Kohlin, G., & Ringler, C. (2011). Estimating the impacts of climate change on agriculture in low-income countries: household level evidence from the Nile basin, Ethiopia. Environ Resource Econ, pp 52, 457–478, DOI 10.1007/s10640-011-9538-y.
- Emelie, C., & Anders, E. (2013). Ethiopia environmental and climate change policy brief. Sida helpdesk for environment and climate change. Addis Ababa, Ethiopia. Emergency Events Data Base (EM-DAT) (2016). International Journal of Environmental Research and Public Health. Available at www.emdat.be/ {viewed on 13/12/2016}.
- Getachew, G., Solomon, T., & Uttama, R. (2014). Climate variability and its local perception and adaptation measures in weliso woreda, Ethiopia, East Africa. International journal of science and research, 3(11). Har Amaya University, Ethiopia.
- Gutu, T., Bezabih, E., & Mengistu, K. (2012). Analysis of vulnerability and resilience to climate change induced shocks in North Shewa, Ethiopia. Agricultural Sciences, Vol.3, No.6, 871-888. HEZBEZ Business and Consultancy PLC, Addis Ababa, Ethiopia. Available at: http://dx.doi.org/10.4236/as.2012.36106.
- Hirut, G., & Kinde, T. (2015). Analysis of risk in crop production due to climate change in the central rift valley of Ethiopia. *African journal of agricultural research*, 10(16).
- IFRC, (International Federation of Red Cross and Red Crescent Societies). (2009). Climate change adaptation strategies for local impact. Technical paper for the IASC task force on climate change.
- IPCC. (2007). Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva, Switzerland.
- IPCC. (2007). Summary for Policymakers. In: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK, 7-22.
- IPCC. (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva, Switzerland.
- Kefyalew, G. (2011). Ethiopia: A country confronted by climate change, population growth, poor agriculture & bad governance. Special report to FAO/WFP crop and food security assessment mission to Ethiopia.

- Mburu, B., Kung, J., & Muriuk, J. (2015). Climate change adaptation strategies by small-scale farmers in Yatta District, Kenya. African Journal of Environmental Science and Technology, 9(9), pp. 712-722. Nairobi, Kenya.
- Mikias, B. (2014). The effect of climate change and variability on the livelihoods of local communities: in the case of Central Rift Valley Region of Ethiopia. Open Access Library Journal, 1: e453. http://dx.doi.org/10.4236/oalib.1100453.
- National Meteorological Agency. (2007). Federal Democratic Republic of Ethiopia Ministry of Water Resources and National Meteorological Agency. Climate change national adaptation program of action (NAPA) of Ethiopia. Addis Ababa, Ethiopia.
- Shiferaw, A. (2014). Smallholder farmers' adaptation strategies to climate change in Ethiopia: evidence from Adola Rede Woreda, Oromia Region. *Journal of economics and sustainable development*, 5(7).
- Sweeney, C. New, L., & Lizcano, G. (2010). UNDP climate change country profiles, Ethiopia. Available at http://country-profiles.geog.ox.ac.uk
- Temesgen, D., Yhualashet, H., & Rajan D. (2014). Climate adaptations of smallholder farmers in Southeastern Ethiopia. Academic Journals. Journals of agricultural extension and rural development. Vol.6 (11), pp. 354-366. Farm Africa, Ethiopia.
- Temesgen, D., Rashid, M., & Claudia, R. (2008). Measuring Ethiopian farmers' vulnerability to climate change across regional states: International food policy research institute. IFPRI discussion paper 00806. Environment and production technology division.
- Temesgen, D., Rashid, M., Hassan, C., Tekie, A., & Mohamud, Y. (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile basin of Ethiopia. Global environmental change, Doi: 10.1016/j.gloenvcha.2009.01.002
- Woldeamlak Bewket. (2009). In: Proceedings of the 16th International Conference of Ethiopian Studies. Rainfall variability and crop production in Ethiopia: case study in the Amhara region, Trondheim.
- Yirga, C. T. (2007). The dynamics of soil degradation and incentives for optimal management in Central Highlands of Ethiopia. Ph.D. Thesis. Department of Agricultural Economics, Extension, and Rural Development, University of Pretoria, South Africa.