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Determenants of Farmers' Adaptation Strategies to Climate Change and Variability: The Case of Mareka District of Dawuro Zone, South Ethiopia

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Dependence on rain-fed agriculture and having low adaptive capacity make the country highly susceptible to the adverse impact of climate change and variability. This study sought to find out the determinants of farmers' adaptation strategies to climate change and variability in Mareka District of Dawuro zone, South Ethiopia. A total of 37 kebele of the district were stratified under three dominant agro-ecologies (as highland, midland and lowland). Three kebele (Eyesus, Gozo-shasho and Tarcha-zuriya) was selected randomly from the three agro-ecologies of the district. After households were grouped in to, three socio-economic categories (poor, medium and better-off) 69, 68 and 17 households (i.e. a total of 154 households) were randomly selected from the respective socio-economic category. Both qualitative and quantitative data were collected through key informant interview, focus group discussion and household survey, respectively. Binary logit model was used to examine determinants of adaptation strategies. Accordingly, education, sex, age, productive labor force, wealth, farm experience, farm size, extension contact, soil fertility, access to climate information and credit service were the major determinant factor variables to farmers' adaptation to climate change and variability. Therefore, providing new technologies (improved seed, fertilizers and chemicals and farm machineries), animal health centers, extension education (through farmers training center and formal education), implementing soil conservation, making credit service more available and accessible to farmers are recommended measures to face moderate impacts of climate change and variability.

Key Words: adaptation, climate change, determinants, variability

Introduction

Climate change is a global phenomenon. It is currently emerged as one of the most serious environmental and international development challenges of the twenty-first century. The Fourth Assessment Report of Intergovernmental Panel on Climate Change (IPCC, 2007a) concluded that warming of the climate system is unequivocal, as is now evident from observations of increase in global average air and ocean temperatures, melting of snow and ice and rising of global average sea level. The effect of continuously warming climate put the world agriculture under significant pressure to meet the demands of rising populations (Rosegrant *et al.* 2008).

Though, the impact of climate change is global in its concern, developing countries are highly vulnerable to climate change since their economies are closely linked to agriculture and a large proportion of their populations depend directly on it and natural ecosystems for their livelihoods (World Bank, 2009). Of those vulnerable developing countries, sub-Saharan Africa is the most vulnerable one; because majority of their people live in abject poverty and are heavily dependent on low yield rain-fed agriculture for their economic and livelihood sustenance (Juana *et al.* 2013). On the other hand, climate change is expected as it posed new challenges in sub-Saharan Africa (Villanueva and Hiraldo, 2011). This is mainly suggested as due to characteristics of the area having variable climate, inappropriate policies, high population growth rates and lack of significant investment in irrigation infrastructure and widespread poverty in the continent. This also made difficult for several countries in the continent to develop patterns of livelihood that intended to reduce pressure on the natural resource base to insure food security and further limits the adaptive capabilities of the continent (IPCC, 2007b). Ethiopia is among those countries most vulnerable to climate risks in Africa (USAID, 2011). According to the assessment by Ethiopian National Adaptation Program of Action (NAPA, 2007) the major causes for vulnerability to climate change and variability in Ethiopia include very high

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dependence on rain-fed agriculture which is sensitive to climate variability and change; under-development of water resources; low health service coverage; high population growth rate; low economic development; low adaptive capacity; weak institutions and lack of awareness to climate change and variability. To minimize the adverse impact of climate change and variability, farmers developed various ways of adapting the risks associated with it such as changing planting date, changing crop variety, soil and water conservation, using irrigation practice and employing livestock management (CGIAR, 2009; Jeffcott, 2013).

Though, adaptation is a must to live with already happening climate problem and people started to take actions in order to tackle it, different factors were influence them to adapt the adverse impact of climate change on agriculture (Temesgen *et al.* 2008; Bewket, 2010**;** Bewket *et al.* 2013). Therefore, it is crucial to recognize their adaptation strategy which they pursue in the response to change in their local climate and its determent; which differ from household to household depending on numerous factors such as socio-economic status, agro-ecological variation, institutional support, educational level and their endogenous knowledge.

The main objective of the study was to assess the determinants of farmers' adaptation strategies to climate change and variability in the study district. The specific objectives of the study were: to investigate locally practiced adaptation strategies pursued by farmers in the response to climate change and variability, and to examine determinants of household level adaptation strategies to climate change and variability in the study area. In light of the aforementioned research objectives this study strives to answer the following key research questions: 1. what are farmers' adaptation stagiest to perceived change in rainfall and temperature? 2. what factors influence farmers' decision to adapt to climate change and variability?

Research Methodology

Description of the Study Area

The study was conducted in Mareka district of Dawuro zone in Southern Nation Nationalities and Peoples Region State, South Ethiopia. The district comprises 37 kebeles and it is divided in to three agro-ecologic zones. These include (highland) (41.2%), Weyna Dega (midland) (50%) and Kolla (lowland) (8.8%). Of this the study was carried out in three kebeles; Eyesus (highland), Gozo-shasho (midland) and Tarcha-zuriya (lowland).The mean annual temperature and rainfall of the district is 22.3ºC and 1176mm respectively.

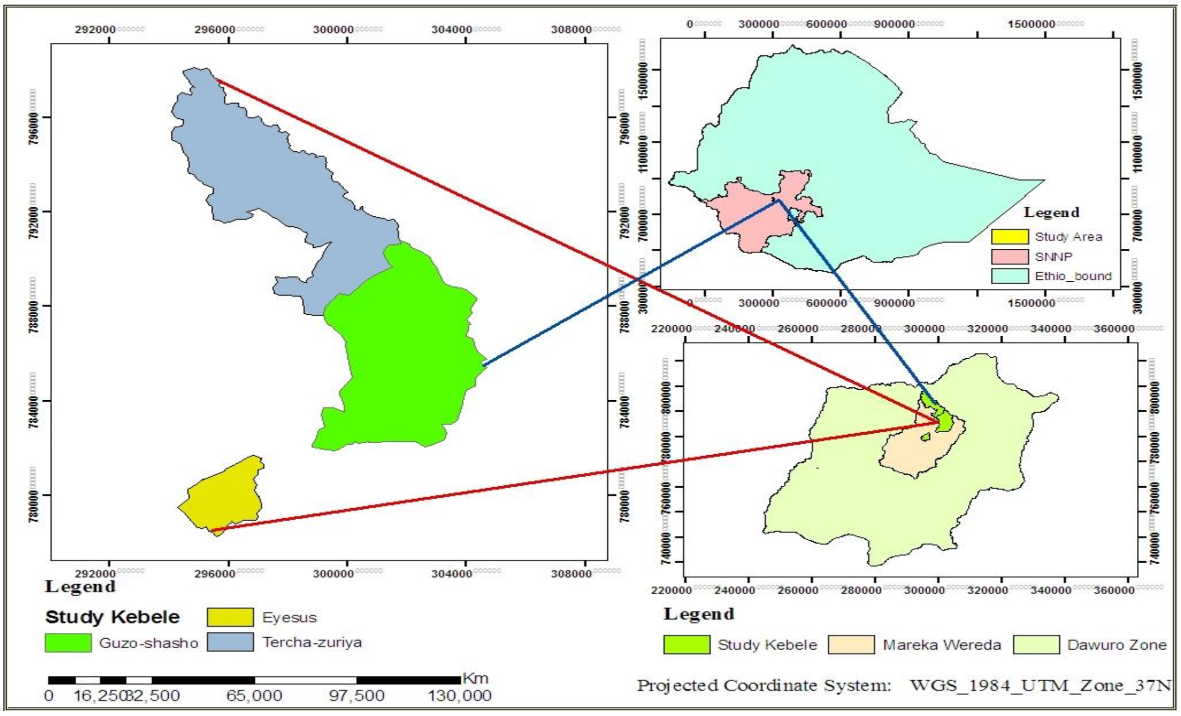

Figure 1*:* Map of the study area

Sampling Procedure

Here the researchers was focused to understand either there was any difference in the adaptation strategies followed by farmers living in different agro-ecologies and its determinant factors influencing them to adapt. Accordingly, the District was selected purposively because of its characteristics of three farming agro-ecology; as highland, midland and lowland. Following this 37 kebele in Mareka district were stratified in to three agro-ecologic zones. Then, three kebeles' from each agro-ecologic zone had taken randomly. And **154** households (**HHs)** had drawn from three stratums by employing simple random sampling technique. In addition total HHs in each kebele were stratified in to poor, medium and better-off. Finally, the sampled HHs was taken proportionally from three socio-economic categories by using simple random sampling technique. Here the analysis in relation to socio-economic difference within selected HH was to investigate how farmers with differing resource availability adapt to climate change. Finally, primary data was collected through key informants, focused group discussion and household survey respectively.

Model Specification

Determinants of farmers' adaptation strategies to climate change and variability were carried out by using binary logit model. Binary versions are employed when the number of choices available is two (whether to adopt or not) (Temesgen *et al.* 2010). Hence, it was an appropriate model since farmers were not provided with different adaptation options for a single or rank choice, rather they were asked with open ended questions to report each adaptation option(s) they employed in their farming practice in response to temperature and precipitation changes.

According to Gujirata (2003), the logistic distributions function for the decision on adoption of adaptation measures:

$$Pi = \left(\frac{1}{1+e^{-z(i)}}\right) \text{--} (1)$$

Where **P (i)** is a probability of deciding to adopt an adaptation measure for **i**th farmer and **Z (i)** is a function of **m** numbers of explanatory variables **(Xi).** Therefore, **Z (i)** is expressed as:

$$Z(i) = \beta_o + \beta_i x_i + \text{-------------} + \beta mxm \text{-------------} (2)$$

Where β_0 is the intercept and β_i is the slope parameter in the intercept model. If Pi is the probability of deciding to adopt is given by (1), then (1 − Pi) is the probability of deciding not to adopt, i.e.

$$(1\text{-}Pi) = \left(\frac{1}{1+e^{z(i)}}\right) \text{-------------------------------------} (3)$$

Taking the natural logarithms of the probability that a household willing to adopt the option to the probability that the household is not willing to adopt it will result in what is called the logit model as indicted below.

$$\ln\left(\frac{Pi}{1-Pi}\right) = Z(i) = \beta_o + \beta_i x_i + \text{-----} + \beta mxm \text{------} (4)$$

In this case, ln denotes the natural logarithm, *Pi* is the probability of that the farmers were willing to adopt the given option, β_0 is the intercept from the linear regression equation and βixi is the regression coefficient multiplied by some value of the explanatory variable *X*i. Then we can write the model in terms of **odds**

$$Pi/(1-Pi) = \exp(\beta_0 + \beta_i x_i) \text{-------------------------} (5)$$

Major findings of the study

Adaptation options across agro-ecology and socio-economic categories

Farmers in sampled kebeles of Mareka district were counted numbers of years after they started to make adjustment in their farming. However, their experience of making an adjustment to their farming activity was influenced by different factors. This includes: agro-ecologic condition and socio-economic difference. Accordingly, some adaptation options were commonly adopted across the agro-ecology and socio-economic category whereas some were significantly different for the perceived change both in temperature and precipitation. Similar observation made by Kalungu *et al.* (2013) noted that increased temperature, low or erratic rainfall, crop pests and diseases as well as lack of water are some of the challenge that hinders farmers from adapting different strategies. In addition knowledge about adaptation methods and factors affecting farmers choices challenges farmers from tackling the impact imposed by climate change and variability (Temesgen *et al*. 2009).

Changing planting date was the only adaptation option of all the farmers used across the agro-ecology (Table 1) and among socio-economic category to perceived change in precipitation (Table 3). Accordingly, farmers reported that both the sowing and harvesting period was changed in comparison to the past 20 years. Unreliability in precipitation pattern both in the distribution and volume is the main reason for this change. The possible explanation is that farmers sow early if the rain comes early and lately if the rain comes lately. Therefore, the change in the sowing and harvesting period either early or lately is the implication of precipitation pattern. Similarly, Aschalew (2014) noted that changing of planting date is one of well practiced adaptation strategies to perceived change in climate followed by farmers in Adola Rede Wereda of Oromia Region, Ethiopia. In the same token, changing planting date to corresponding change in the precipitation pattern was commonly practiced adaptation strategies across different parts of Africa

(Dejene, 2011; Acquah-de Graft and Onumah, 2011).

Land preparation: Though increasing the frequency of land preparation may disturb the soil, exposing soil to more erosion and resulting in less ability of the soil to sequester CO_2, the option is the second most important adaptation practice that farmers use in response to change in precipitation. Due to the continuous fluctuation in precipitation and less fertility of land; farmers confirmed that they were obligated to till repeatedly from three to five times for a single cropping season as it increases productivity. Accordingly, 88.9% of farmers in the highland, 91.5% in the midland and 78.9% of farmers in the lowland till their land now and then as an option to observed changes (Table 1).

As regard, though there was no statistically significant difference in adopting the option across the agro-ecology (Table 1) but not among socio-economic category (Table 3). This indicates that majority of better-off farmers use the advantage of this option than medium and poor farmers. This could be due to they have drought power to use the practice in advance. Well managed tillage practices improve soil aggregation and contribute to the improvement of nutrient and water flows in the soil (Gwambene and Majule, 2010). Similarly, frequent tillage increases soil fertility through mineralization of soil nutrients and creates a good soil tilt for root and crop growth (Oicha and Klik, 2009).

Adjustment in crop management: here most of interviewed farmers frequently mentioned that their land was extremely depleted. Farmers adjust their crop production mainly for the perceived change in precipitation in order to increase productivity. Crop rotation, inter cropping, row sowing, applying frequent cultivation and weeding are the common practice in the area. Adoption of the practice by farmers was not statistically different across the agro-ecology (Table 1).

This implies that farmers survive through increasing the productivity of their land by adjusting their cropping pattern. Similarly, in eastern Tigray of northern Ethiopia by Kassa *et al.* (2012) suggested that for reduced soil fertility in the area farmers implement crop management strategies in addition to their management by organic and inorganic fertilizer application to increase productivity. Similarly, Kalungu *et al.* (2013) revealed that water, weed and soil fertility management, as well as use of pest and disease control measures are some of the practices that gained popularity by farmers in Kenya.

Changing crop verities: Using of drought resistant, short maturing and high yielding verities of crops are among the adaptation options used by farmers across the agro-ecology to both perceived change in temperature and precipitation. Farmers in highlands reported that due to perceived change in both temperature and precipitation they use new improved variety of Wheat *(Triticum aestivum L.)*, Bean *(Mucuna pruriens)* and Maize *(Zeamays L. ssp.mays)*. Similarly, farmers in both midland and lowland indicated as they use Maize *(Zeamays L. ssp.mays)*, Teff *(Eragrostis tef zucc.)*, Sweet potato *(Ipomoea batatas)* and Taro *(Colocasia esculenta)* crops of improved varieties instead of local varieties.

Farmers, use improved varieties instead of local verities in order to compensate for yield loss as their land is getting poorer and poorer in fertility through time. Similar survey conducted by Kassa *et al.* (2012) suggested that in eastern Tigray of northern Ethiopia due to decreased precipitation farmers shifted towards drought-tolerant crops to maximize the productivity. Similarly, planting of drought resistant crop varieties that have a wide range of maturity with climate variability are sustainable adaptation strategies in Nigeria (Abaje *et al.* 2014). The option was found to be statistically significant (P=0.000) across the agro-ecology to perceived change in temperature but not to precipitation (Table 1). Its use is also skewed to better-off farmers than the poor (Table 3).

Use of fertilizers and chemicals: the soil that farmers depend across the agro-ecologies has become very unproductive due to continuous cropping and use of the same plot of land for livestock grazing. Accordingly, 75.6%, 78.9% and 60.5% farmers in the highland, midland and lowland respectively reported that they use inorganic inputs as an option in response to changes in precipitation (Table 1). The utilization of option is not significantly different across agro-ecologic zone (Table 1) but not among socio-economic category (Table 3). This implies that poorer farmers were disadvantaged than those of resource endowed farmers in taking the advantage of this option. Despite the wealth variations with in households application of fertilizer to improve crop yield in the face of climate change and variability was taken as one of sustainable adaptation strategies in Nigeria (Abaje *et al.* 2014). Similarly, in Nigeria about 95.7% and 84% of farmers adopted and applied fertilizer and chemical respectively and agreed as an important strategy to curb the impact of climate change in the area (Ogunleye and Yekinni, 2012).

Crop diversification: according to the survey result, 40%, 29.6% and 21.2% of farmers in the highland, midland and lowland respectively use crop diversification as an adaptation strategy to the perceived change in temperature (Table 1). Whereas, 53%, 60.6% and 55.3% of farmers in the highland, midland and lowland respectively took the advantage of this strategy in response to change in precipitation (Table 1).

Cereal crops, Maize *(Zeamays L. ssp.mays)* and Teff *(Eragrostis tef zucc.)*, which were more common in the lowland over the last 20 years period they are becoming dominant crops in the highlands today. In addition fruit trees such as Bananas *(Musa acuminata)* and Avocado *(Persea Americana)* were not common in the area 20 years before, but now particularly avocado have become common fruit trees in the highland area. Although not as avocado, banana is also in the way of adapting to the area. Farmers in the midland adopted improved verities of Taro *(Colocasia esculenta)*, Sweet potato *(Ipomoea batatas)* and fruit trees of Mango *(Mangifera indica* L.*)* crops mainly to the perceived change in temperature. The practice were also similar in lowland agro-ecology as well but the only difference was farmers in the lowland were adapted Ginger (*Zingiber officinale*) in addition to that.

Adoption of the practice was significantly different among socio-economic category (Table 3) but across the agro-ecologic zone (Table 1). This is in line with Temesgen and Hassan (2009) who stated that diversifying plantation of early-maturing and drought-tolerant crop varieties was a recommended adaptation strategy in Ethiopia. Similar finding by Sofoluwe *et al.* (2011) indicated that diversifying crop variety to corresponding changes in precipitation pattern was accepted adaptation strategies in Africa.

As adjustment in livestock management farmers in the study area noticed the increased temperature in their area not only affected crop production but also the livestock production. During the survey time, farmers mentioned animal diseases that were not common in the area and one that was there in the past but increased in its occurrence and pathogenity. In addition farmers in lowland aggressively reflected that since the last, 10 years we were not able to rare the equines family, mule. However, it was commonly reared in the area in some 10 to 20 years ago. In addition it was becoming serious also for donkey as well. Due to this reason farmers in the area were obligated to take their animal to the health center nearby their community, even within fifteen days interval.

In the highlands, farmers use cut and carry system to feed their animals whereas in the lowlands they go to distant areas in search of grazing and water for their animals. In this regard adoption of the practice was not significantly different both across the agro-ecology (Table 1) and among the socio-economic category (p<0.01) (Table 2). This indicates that even though livestock rearing is most seriously affected in the lowland agro-ecology in the current climate condition is also threatening livestock rearing in the midland and highland agro-ecologies as well. In the same token its impact also puts farmers in similar challenge with different socio-economic category. To curb the impact of climate change implementing livestock management (i.e. keeping animals under shade to reduce heat stress, feeding them more frequently than before and monitoring their health) was an important adaptation strategies (Ifeanyi-obi and Nnadi, 2014).

Implementation of soil conservation: according to the survey result 98%, 89% and 95% of respondents in highland, midland and lowland, respectively reported as their soil is very less fertile, less fertile and perceived as not fertile at all. Accordingly, 40% in the highland, 35.2% in the midland and 18.4% of respondents in the lowland agro-ecologies implemented soil conservation as one of the adoption option to perceived change in precipitation. Farmers asked the reason for their comparatively low adoption of the option, mentioned the lack of awareness until recent times. In addition, farmers and key informant noticed that even this much of adoption of the practice was also implemented after the district level agricultural office has taken action in filling the awareness gap through mass mobilization. Similarly, farmers who claimed to have observed changes in climate over the past 20 years in Nile Basin implemented soil conservation as one of the major adaptation options to reduce the negative impacts of climate change (Temesgen *et al.* 2010).

Farmers experience of adopting the option across the agro-ecology shows significant difference (P=0.019) (Table 1). The difference shows that low adoption in lowland relatively to midland and highland was due to topography (plainness). However, the deference among better-off and poor farmers was not statistically significant (Table 3).

Off-farm activities are one of the important adoption options across the agro-ecology to both perceived change in temperature and precipitation. The result of Table 1 indicates that 26.7%, 19.7% and 26.3% of farmers in the highland, midland and lowland respectively practiced the option for perceived change in temperature. On the other hand 44.4%, 23.9% and 50.0% of farmers in the highland, midland and lowland respectively reported as they engaged in this activity to perceived change in precipitation (Table 1). The commonly practiced activities include, being guard in the nearby organization (include cooperative association and school), generating income from town house rent, being laborer force both in the nearby community and migrating to distant areas, petty trading (such as local drink, *Hareqe, Tela* as well as firewood and charcoal selling). The activities were also similar in lowland agro-ecology as well but the only difference was farmers in the lowland were not migrating to distant area in search of employment than working in nearby town. This could be due to the positional advantage that lowland area found in the nearby town. Similarly, farmers in eastern Tigray follow off-farm activities within and out of villages as a common strategy to compensate agricultural loss committed by climate variability (Kassa *et al.* 2012).

Accordingly, though there were no significant variation across the agro-ecology in adopting the option for perceived change in temperature (Table 1) but there was variation (P=0.011) for perceived change in precipitation (Table 1). Adoption of the option was not significantly different among the socio-economic category across two agro-ecologic zones, highland and midland but it were different (P=0.009) among the socio-economic category in the lowland agro-ecology to perceived change in temperature (Table 2). In spite of wealth difference involvement in off-farm income generating activities was taken as one of the important adaptation strategies in Africa (Fosu-Mensah *et al.* 2010).

Planting fodder as animal feed is a recent practice in the study area. However, about 24.4% and 2.8% of respondents in the highland and midland respectively took the advantage of this practice. The result shows that farmers in the highland experienced more than the midland. This is mainly due to the area is populated and has no separate grazing land relative to both midland and lowland. By contrast, farmers in the lowland did not practice the option. This is because they have an opportunity to use communal grazing land since their area was not populated compared to highland and midland. The statistical analysis also shows the existence of significant variation (P=0.005) across the agro-ecology (Table 1) and among socio-economic categories of the same agro-ecology (Table 2). This implies that the resource endowed farmers have good experience than the poor. McDermott *et al.* (2010) stated that tree fodder plantation in East Africa region including Ethiopia is an important adaptation strategy where livestock-keeping is crucial for both the current and future well being. This was mainly due to fodder trees are more resistant to drought and can provide protein during the dry season when high-quality feed is scarce to livestock (Dawson *et al.* 2014).

Small scale irrigation: In the study area even though the practice was poorly implemented, farmers in the highland and midland adopt it compared to the lowland. The major reason for farmers in the lowland not to adopt the option was due to lack of water resource. However, farmers in the highland and midland also adopted it not for producing field crop instead they adopted it only to produce vegetables, fruit trees and seedling mainly by using water buckets and rarely by diverting small river. Accordingly, the practice was significantly different (P=0.034) across the agro-ecology (Table 1) and among socio-economic category (P=0.013) mainly in the highland (Table 1). The finding of Kinfe (2012) agrees to this result, he stated that farmers in Central Tigray perceived irrigation practice as one of important strategies for climate change at the household level. Similarly, increased use of irrigation practice as an adaptation strategy to minimize the risk associated with low water availability caused by climate change was one of the major strategies in Africa (Juana *et al.* 2013).

Table 1: Relative frequency (%) of households who positively responded towards adaptation option to perceived change in temperature and precipitation

	Agro-ecology Zone									
Adaptation option	Highland (n=45)	Mid-land (n=71)	Lowland (n=38)	Overall (n=154)	χ^2	Highland (n=45)	Mid-land (n=71)	Lowland (n=38)	Overall (n=154)	χ^2
Changing planting dates						100	100	100	100	------
Land preparation						88.9	91.5	78.9	87.7	3.72(NS
Adjustment in crop manage-						88.9	78.9	89.5	84.4	3.08(NS
Changing crop variety	24.4^{a}	71.8^{c}	34.2^{b}	48.7	29.0***	75.6	78.9	60.5	73.4	4.42(NS
Using of fertilizers & chemi-						75.6	78.9	60.5	73.4	4.42(NS
Adjust to livestock management	62.2	62.2	76.1	71.4	2.71(NS)					
Diversifying crop	40.0	29.6	21.1	30.5	3.54(NS)	53.3	60.6	55.3	63.0	0.66(NS)
Off-farm activities	26.7	19.7	26.3	23.4	0.99(NS)	44.4^{b}	23.9^{a}	50.0^{b}	36.4	9.06**
Planting fodder as animal feed	24.4^{c}	14.1^{b}	0.0^{a}	13.6	10.48**					
Small scale irrigation	11.1	2.8	0.0	4.5	6.77(NS)					
Soil conservation	40.0^{c}	35.2^{b}	13.2^{a}	31.2	7.92**	40.0^{c}	35.2^{b}	13.2^{a}	31.2	7.92**

*** and *** Significant at p<0.05and p<0.01respectively and NS = Not significant*

Table 2: Local adaptation strategies to perceived change in temperature across agro-ecology

Socio-economic group	**Changing crop variety**		**Diversifying crop**		**Small scale irrigation**		**Adjustment in livestock management**		**Planting fodder for animal**		**Off-farm activities**	
	No	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**
Highland												
Better-off (n=4)	4	100.0	4	100.0	2	50.0	4	100.0	3	75.0	2	50.0
Medium (n=22)	7	31.8	9	40.9	3	13.6	15	63.6	7	31.8	5	22.7
Poor (n=19)	0	0.0	5	26.3	0	0.0	9	47.4	1	5.3	5	26.3
Overall (n=45)	**11**	**24.4**	**18**	**40.0**	**5**	**11.1**	**28**	**60.0**	**11**	**24.4**	**12**	**26.7**
Pearson – χ^2	**19.16***		**7.49***		**8.64***		**4.54 (NS)**		**9.97****		**1.29 (NS)**	
Midland												
Better-off (n=10)	10	100.0	7	70.0	0	0.0	10	100.0	5	50.0	1	10.10
Medium (n=33)	29	87.9	11	33.3	2	6.1	26	78.8	5	15.2	5	15.2
Poor (n=28)	12	42.9	3	10.7	0	0.0	18	64.3	0	0.0	8	25.6
Overall (n=71)	**51**	**71.8**	**21**	**29.6**	**2**	**2.8**	**54**	**76.1**	**10**	**14.1**	**14**	**19.7**
Pearson – χ^2	**19.74*****		**12.85*****		**2.37 (NS)**		**5.41(NS)**		**15.28*****		**2.42 (NS)**	
Low land												
Better-off (n=3)	3	100	3	100.0	0	0.0	3	100.0	0	0.0	3	100.0
Medium (n=13)	6	46.2	3	23.1	0	0.0	10	76.9	0	0.0	2	15.4
Poor (n=22)	4	18.2	2	9.1	0	0.0	15	68.2	0	0.0	5	22.7
Overall (n=38)	**13**	**34.2**	**8**	**21.1**	**0**	**0.0**	**28**	**73.7**	**0**	**0.0**	**10**	**26.3**
Pearson – χ^2	**9.1****		**13.18****		**0**		**1.49 (NS)**		**0**		**9.35*****	

, ** and * Significant at p <0.1, p<0.05and p<0.01 respectively and NS = Not significant*

Table 3: Local adaptation strategies to perceived change in precipitation across agro-ecology

Socio-economic group	**Change planting date**		**Land preparation**		**Change crop variety**		**Using fertilizers & chemicals**		**Diversifying crop**		**Adjustment in crop management**		**Soil conservation**		**Off farm activities**	
	No	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**
Highland																
Better-off (n=4)	4	0.0	4	100	4	100	4	100	4	100	4	100	3	75.04	2	50.0
Medium (n=22)	23	0.0	22	100	20	90.9	20	90.9	14	63.6	19	86.4	9	0.931	7	31.8
Poor (n=19)	20	0.0	14	73.7	10	52.6	10	52.6	7	31.6	17	89.5	6	.6	11	57.9
Overall (n=45)	**45**	**0.0**	**41**	**88.9**	**34**	**75.6**	**34**	**75.6**	**22**	**53.3**	**40**	**88.9**	**18**	**40.0**	**20**	**44.4**
Pearson – χ^2	**0**		**7.8****		**9.51*****		**9.51*****		**8.05****		**0.65 (NS)**		**2.61 (NS)**		**2.86 (NS)**	
Midland																
Better-off (n=10)	10	0.0	10	100	10	100	10	100	10	100	9	90.0	5	50.03	1	10.0
Medium (n=33)	33	0.0	33	100	30	90.9	30	90.9	25	75.8	25	75.8	12	6.428	11	33.3
Poor (n=28)	28	0.0	22	78.6	16	57.1	16	57.1	8	28.6	22	78.6	8	.6	5	17.9
Overall (n=71)	**71**	**0.0**	**65**	**91.5**	**56**	**78.9**	**56**	**78.9**	**43**	**60.6**	**56**	**78.9**	**25**	**35.2**	**17**	**23.9**
Pearson – χ^2	**0**		**10.07****		**13.48*****		**13.48*****		**21.70*****		**0.94 (NS)**		**1.52 (NS)**		**3.24 (NS)**	
Low land																
Better-off (n=3)	3	0.0	3	100	3	100	3	100	3	100	3	100	1	33.31	3	100
Medium (n=13)	13	0.0	13	100	11	84.6	11	84.6	11	84.6	12	92.3	2	5.49.	5	38.5
Poor (n=22)	22	0.0	14	63.6	9	40.9	9	40.9	7	31.8	19	86.4	2	1	11	50.0
Overall (n=38)	**40**	**0.0**	**30**	**78.9**	**23**	**60.5**	**23**	**68.4**	**23**	**55.3**	**34**	**89.5**	**5**	**13.2**	**19**	**50.0**
Pearson – χ^2	**0**		**7.37***		**8.66****		**8.66****		**11.85*****		**0.69 (NS)**		**1.44 (NS)**		**3.69 (NS)**	

, ** and * Significant at p <0.1, p <0.05and p<0.01 respectively and NS = Not significant*

Determinants of adaptation strategies to changes in temperature

Out of thirteen hypothesized determinants of adaptation strategies to perceived change in temperature, five variables were found to have significant influence. This includes:

Productive labor force: Contrary to the expectations as set in the hypothesis, the variable is negatively associated with the adaptation strategies except to adjustment in animal management and off-farm activities. The inverse odds ratio of 3.8 of the odds ratio of 0.263 indicates that farmers with additional productive labor force within the household is by 3.8 times less intended to adopt new crop verities to perceived change in temperature compared to base category (no additional productive labor force) at P<0.05 level. This implies that a farmer with additional labor within the household is less intended to adapt new crop varieties. The possible explanation here is that farmers with more labor force within the household may intended to adopt other adaptation strategy than this strategy. This could be the increase in temperature may challenge farmers to undertake on-farm activities and enforce to participate in other adaptation strategy in the area.

Farm experience: farmers with medium experience are positively related with mutually exclusive adaptation strategies. Furthermore the computed odds ratio indicates that a farmer with medium farm experience is 4.59 times more motivated to engaged in off-farm activities compared to base category (farmers with short farming experience) at P<0.01 level. This may be because those farmers are financially matured to be involved in off-farm activities like building house in nearby town to get additional income from its rent. The result is in line with Aemro *et al.* (2012) they noticed that experienced farmers have positive relation to adopt the option because they have more knowledge and information about climate change and agronomic practices.

Extension contact: As proposed the variable is positively associated with the adaptation option of adjustment in animal management. As result farmers who are occasionally and frequently visited by extension workers are 6.909 and 12.818 times more motivated to make an adjustment in animal management to perceived change in temperature compared to base category (rare visit by extension agent) and this is significant at P<0.05 and P<0.01 level, respectively. This indicates that as the frequency of contact with extension worker increases the tendency of farmers to make an adjustment in animal management increases. This is could be due to the frequency of contact have positive influence in their awareness to take sick animal to health post as well as the feeding of their animals such as collect hay for their feed in the dry season. This implies that farmers who have access to extension services are more likely to be aware of climatic conditions and knowledge of various management practices (Gbetibouo, 2009).

Access to credit: the variable is negatively associated with relative adaptation strategies except to small scale irrigation. The computed inverse odds ratio of 2.98 and 12.19 of the odds ratio of 0.336 and 0.082 indicates that compared to the base category (no access to credit), farmers who have access to credit service are 2.98 and 12.19 times less motivated to change crop variety and planting fodder for animal feed to perceived change in temperature and this is significant at P<0.1 and P<0.05 level, respectively. This implies that if farmers get credit they are not motivated to adopt the strategies and could more intended to other adaptation strategy. Contrary to this Aemro *et al.* (2012) argued that institutional support has important role in promoting the use of adaptation options to reduce the negative impact of climate change and variability.

Access to climate information: farmers who have access to climate information have positively responded to adaptation strategies except for off-farm activities. The computed odds ratio indicates that farmers who have access to climate information are 2.852 times more motivated to adapt new crop variety in comparison to base case (no climate information) and this is significant at P<0.1 level. This implies that farmers who have more and more access to climate information are more and more motivated to accept new crop varieties instead of local variety to perceived change in temperature in the area. The result is in line with Baethgen *et al.* (2003) who, stated that availability of better climate information helps farmers to make better decisions among alternative adaptation options.

Table 4: Binary logistic regression analysis regarding the effects of various independent variables on the adaptation option of farmers in Mareka district to changes in temperature

Explanatory variable	**Changing crop variety**	**Diversifying crop**	**Adjustment in animal management**	**Planting fodder for animal feed**	**Irrigation**	**Off-arm activities**
Read & write	0.118(0.176)	2.635(0.575)	1.084(0.943)	$1.203x10^{9}$(0.998)	0.000(0.996)	0.126(0.099)
Primary school	1.281(0.939)	3.405(0.427)	1.263(0.853)	$1.715x10^{9}$(0.998)	0.000(0.996)	0.215(0.088)
Secondary school	1.801(0.770)	5.184(0.318)	4.737(0.373)	$2.109x10^{10}$(0.998)	0.000(0.996)	0.281(0.214)
Male farmer	0.778(0.867)	0.426(0.488)	0.493(0.325)	1.036(0.983)	$1.200x10^{10}$(1.000)	1.692(0.571)
Between 35-65 years	7.520(0.123)	0.130(0.204)	0.0230(0.080)	0.279(0.596)	$1.151x10^{9}$(0.999)	3.403(2.377)
Above 65 years	1.930(0.591)	0.378(0.191)	0.458(0.359)	0.333(0.645)	0.000(0.998)	2.377(0.326)
Medium family size (5-8)	0.280(0.149)	1.243(0.833)	1.431(0.470)	2.454(0.576)	0.001(1.000)	0.295(0.160)
Large family size (> 9)	2.883(0.409)	2.020(0.248)	1.678(0.501)	9.080(0.086)	$2.421x10^{13}$(0.998)	1.315(0.561)
HHs with add.pro. lab.force	0.263**(0.015)	0.182(0.256)	1.838(0.740)	0.279(0.596)	0.000(0.996)	5.739(0.832)
Medium resource owned	0.000(0.999)	1.481(0.804)	0.000(0.998)	0.031(0.117)	0.000(0.998)	2.020(0.360)
Resource rich farmer	0.000(0.999)	2.497(0.526)	0.000(0.998)	3.743(0.408)	0.000(0.999)	1.650(0.488)
Medium experienced	1.361(0.807)	4.589(0.647)	3.911(0.858)	1.609(0.845)	$6.320x10^{12}$(0.999)	4.591***(0.005)
Long experienced	5.967(0.957)	7.509(0.298)	2.532(0.250)	4.774(0.584)	0.000(0.999)	1.914(0.553)
Medium farm size	0.972(0.966)	2.251(0.320)	0.378(0.136)	0.369(0.474)	$1.331x10^{15}$(0.998)	1.530(0.472)
Large farm size	2.722(0.154)	1.147(0.862)	0.279(0.445)	0.573(0.643)	0.001(1.000)	0.527(0.337)
Less fertile soil	0.600(0.694)	$3.170x10^{8}$(0.999)	0.985(0.989)	$2.203x10^{8}$(0.999)	0.031(1.000)	$1.129x10^{9}$(0.999)
Very less fertile soil	1.483(0.773)	$4.248x10^{8}$(0.999)	1.848(0.568)	$2.676x10^{8}$(0.999)	0.000(0.999)	$2.801x10^{8}$(0.999)
Infertile soil	1.773(0.675)	$5.391X10^{7}$(0.999)	2.172(0.445)	$2.042x10^{7}$(0.999)	0.000(0.996)	$4.660x10^{8}$(0.999)
Occasional visit by DA	0.625(0.644)	0.018(0.0705)	6.909*(0.043)	0.126(0.227)	0.000(0.999)	1.013(0.991)
Frequent visit by DA	0.766(0.784)	0.045(0.202)	12.818***(0.009)	0.035(0.14)	0.000(0.999)	1.698(0.610)
Access to credit	0.336*(0.038)	0.534(0.271)	0.632(0.318)	0.082**(0.017)	$1.438x10^{3}$(1.000)	0.954(0.923)
Agro-ecology change	0.554(0.350)	1.840(0.362)	2.352(0.120)	0.119(0.214)	0.064(1.000)	1.318(0.610)
Access to climate information	2.852*(0.050)	2.035(0.252)	1.043(0.926)	2.983(0.280)	$2.689x10^{6}$(0.999)	0.988(0.980)

, ** and * Significant at p<0.1, p<0.05and p<0.01respectively*

Determinants of adaptation strategies to changes in precipitation

The econometric result in table 5 shows among the thirteen hypothesized determinants of adaptation strategies to perceived change in precipitation ten variables were found significant. This includes the following variables:

Educational status: the result revealed that farmers with good achievements in educational status are positively associated with the adoption option of adjustment in crop management and soil conservation and this is significant at P<0.05 and P<0.01 level, respectively. Accordingly, farmers who completed secondary school have 8.59 and 3.499 times greater tendency to accept the option to perceived change in precipitation in comparison to the base category (i.e. illiterate farmers). This is in agreement with Dhaka *et al.* (2010) who argued that the respondent's level of education greatly increases the probability of adaptation.

Sex of farm household head: As expected, the sex of household head is significantly and positively associated with adaptation strategies. Male headed farm households are 11.88 and 5.608 times more motivated than female headed households to increase the frequency of land preparation and involvement in off-farm activities respectively and this is significant at P<0.1 level. In addition male headed households are 32.278 times more apt to adopt improved crop verities and apply fertilizer and chemicals compared to female headed households and this is significant at P<0.01 level. This is in line with the finding of Aemro *et al.* (2012). They argued that male-headed households are relatively flexible and in a better position to pull their labor force in order to adapt improved crop varieties and other option.

Age of household head: The result showed that farmers within the age category between 35 to 65 and farmers with age above 65 years respond positively towards the adaptation options of adjustment in crop management. The computed odds ratio indicated that the above mentioned age category farmers are 4.941 and 9.856 times more prone to adopt the option of adjustment in crop management than the base category (farmers with less than 35 years of age). This implies that when the age of farmers increases the ability to adjust crop management increases. The present result is in agreement with Apata (2009) who stated that increase in age positively influences farmers' adaptation to climate change and variability.

Productive labor force: is positively and significantly related with the adaptation options of crop management and soil conservation at P<0.01level. The result of odds ratio indicates that households that have additional productive labor forces are 16.638 and 10.961 times more motivated to make adjustment in crop management and soil conservation than the base category (i.e. no additional productive labor force). This implies that farmers with only two parents do not intended to adopt both mentioned option in comparison to those who have additional labor force in their households. This may be because the mentioned two adaptation options need more productive labor force to be implemented (Bewuketu, 2010).

Wealth status of farmers: As hypothesized farmers who are relatively endowed with resource are positively related with adaptation option for the perceived change in precipitation. Those medium farmers are positively and significantly related to the adoption option of new crop varieties, crop diversification and to use fertilizer compared to the base category (poor farmers) and this is significant at P<0.01 level. The computed odds ratio indicates that the acceptance of farmers that new crop varieties, crop diversification and using of fertilizer as an adaptation strategy increases by 5.87, 4.247 and 5.87 times greater than the poor farmers in the area. On the other hand relatively better-off farmers with the other in their community is initiated to respond positively to accept new crop varieties and use fertilizers by equal number of 12.979 and soil conservation by 7.065 than poor farmers at P<0.01 level. In addition better-off farmers are by 6.501 times more intended than the poor to adopt crop diversification at P<0.01 level. The result of this study is in agreement with Nhemachena and Hassan (2008) who suggested that wealth is an important factor to taking up and positively influence adaptation to climate change.

Farm experience: as expected this variable is positively related with a number of adaptation options. Farmers with long experience positively and significantly respond to the adaptation option of changing crop varieties and fertilizers. I.e. farmers with long experience in farming are 14.426 times more initiated to accept improved crop verities and fertilizers in comparison to base category farmers (farmers with short experience). In addition farmers who have long experience in farming are 17.211 times more initiated to diversify their crop as an adaptation strategy to the perceived change in precipitation. This implies that farmers with advanced experience in farming have better tendency to adopt the adaptation strategies of changing crop verities, using of fertilizers and crop diversification in comparison to farmers with low experience in farming. The present study is in agreement with Dhaka *et al.* (2010) who reported that more experienced farmers are more likely to take up an adaptation measure.

Farm size: is significantly and negatively associated with three adaptation option. The inverse odds ratio of 3.58 and 6.49 of the computed odds ratio of 0.279 and 0.154 indicates that farmers who owned medium and large farm size are 3.58 and 6.49 times less initiated, respectively to implement soil conservation relative to farmers with small size of farm land. This implies that farmers with small farm size are more intended to implement soil conservation as an adaptation strategy than those farmers who owned medium and large farm size. This could be due to the characteristics of the farm land; some part of the farm may need the strategy and the other may not. The result of this study is in line with Temesgen *et al. (*2008) who reported that adaptation is plot specific; mean it is not the size of the farm, but the specific characteristics of the farm; that dictate the need for a specific method of adapting to climate change.

Soil fertility: As hypothesized, this variable is positively related to various adaptation strategies. Accordingly, the computed odds ratio indicates that farmers that have less fertile, very less fertile and infertile land are 12.051, 12.878 and 18.226 times more prone to change their crop variety, using of fertilizers, and chemicals as an adaptation strategies than farmers with fertile land, respectively and this is significant at P<0.01level. This implies that farmers' tend to change crop variety and use fertilizers and chemicals are with decreasing trend of soil fertility. Similarly, farmers who perceived as their land is less fertile, very less fertile and infertile are 8.377, 11.389 and 13.166 times more initiated to implement soil conservation in comparison to base category and is significant at P<0.01 level (Table 5). The possible explanation is that the farmers who perceived their land is fertile are less initiated to implement soil conservation than those who perceived the soil is less fertile. The present finding is in line with Bewuketu *et al.* (2013) who stated that farmers who perceive their soil is fertile are discouraged towards the use of adaptation strategies to climate change.

Contact with extension agent: As expected, the frequency of farmers contact with extension agent is positively associated with mutually exclusive adaptation strategy except with off-farm activities. The result shows that farmers who have access to occasional and frequent visit by extension worker are 9.263 and 12.79 times more tendency to accept new crop varieties and use fertilizers respectively compared to farmers who are rarely visited by extension worker and this is significant at P<0.01 level. This implies that farmers who get more and more access to be visited by extension worker are more and more motivated to adopt the strategy than those who have no access. Compared to base category, a unit increases in the frequency of occasional and frequent visit by extension worker would increase the probability of adapting crop diversification by 7.164 and 12.953 times higher and this is significant at P<0.01 level. Similarly, farmers who have access to occasional and frequent visit by extension workers are 5.100 and 7.250 times more initiated to implement soil conservation in comparison to the base category farmers and this is significant at P<0.01 level (Table 5). In addition farmers who are visited frequently by extension worker are 13.971 times more intended to make an adjustment in crop management. Contrary to this, a unit increase in frequency of occasional contact by extension worker would decrease the probability of farmers' involvement in off-farm activities. This result might be because of the fact that high focus and emphasis was given to the agricultural production related technologies and capacity building to farmers by the government. This is in agreement with Fatuase and Ajibefun (2013) who reported that access to extension services have a significant and positive relationship with the likelihood of choosing adaptation measures.

Climate information: as hypothesized, farmers who have access to climate information positively responded to mutually exclusive adaptation strategies except for off-farm activities. Having access to climate information increases the tendency of farmers to adopt new crop varieties and fertilizer by 9.955 times greater than the base category and this is significant at P<0.01 level. Similarly, farmers who have access to climate information are 2.623 and 4.815 times more initiated to diversify crop and to make an adjustment in crop management. In addition having access to climate information initiates the tendency of farmers to increase the frequency of land preparation by 9.224 times more than the base case. The present study is in line with the result of Aemro *et al.* (2012) who reported that access to climate information from different sources has significant impact on adaptation measure of farmers to climate change and variability.

Table 5: Binary logistic regression analysis regarding the effects of various independent variables on the adaptation option of farmers in Mareka wereda to changes in precipitation

Explanatory variable	Land preparation	Changing crop variety	Diversifying crop	Adjustment in crop	Fertilizer application	Soil conservation	Off-arm activities
Read & write	9.430(0.092)	3.271(0.279)	0.537(0.540)	0.855(0.869)	3.271(0.279)	1.255(0.756)	2.794(0.080)
Primary	$5.584x10^8$(0.998)	$1.707x10^9$(0.998)	1.088(0.903)	1.130(0.854)	$1.707x10^9$(0.998)	2.213(0.165)	3.585(0.132)
Secondary	$2.022x10^9$(0.998)	$5.926x10^8$(0.999)	3.801(0.254)	8.588**(0.020)	$5.926x10^8$(0.999)	3.499***(0.003)	0.585(0.594)
Male headed	17.880*(0.036)	32.278***(0.000)	4.125(0.998)	$9.173x10^{10}$(0.998)	32.278***(0.000)	1.581(0.660)	5.608*(0.032)
Age 35-65 year	$3.626x10^{10}$(0.998)	0.000(0.995)	0.928(0.961)	4.941***(0.009)	0.000(0.995)	1.979(0.176)	0.941(0.959)
Above 65 years	$7.837x10^{18}$(0.999)	0.000(0.999)	21.734(0.127)	9.856***(0.014)	0.000(0.999)	1.672(0.376)	0.737(0.824)
Medium family size (5-8)	4.921(0.283)	6.290(0.104)	2.004(0.477)	1.997(0.607)	6.290(0.410)	1.386(0.666)	1.927(0.441)
Large family size (> 9)	13.111(0.088)	8.540(0.207)	14.861(0.101)	2.543(0.298)	8.540(0.207)	1.779(0.361)	1.255(0.642)
HHs with add.Pro.Lab.fo	2.059(0.277)	4.476(0.654)	3.178(0.250)	16.638***(0.003)	4.476(0.654)	10.961***(0.004)	3.098(0.163)
Medium	4.892(0.055)	5.870***(0.006)	4.247***(0.003)	1.075(0.899)	5.870***(0.006)	2.800(0.352)	2.587(0.064)
Better-off	$2.222x10^9$(0.998)	12.979***(0.000)	6.501***(0.009)	1.595(0.650)	12.979***(0.000)	7.065***(0.002)	3.530(0.139)
Medium experience	7.508(0.594)	3.614(0.216)	6.424(0.147)	1.0251(0.970)	3.614(0.216)	1.273(0.809)	0.758(0.064)
Long experience	8.497(0.449)	14.426**(0.011)	17.211*(0.023)	2.704(0.448)	14.426**(0.011)	3.862(0.159)	0.914(0.933)
Medium farm size	1.416(0.740)	1.245(0.741)	0.693(0.580)	0.828(0.777)	1.245(0.741)	0.279*(0.045)	2.089(0.231)
Large farm size	2.914(0.220)	2.251(0.278)	0.182(0.073)	0.408(0.264)	2.251(0.278)	0.154***(0.011)	0.853(0.820)
Less fertile	3.578(0.450)	12.051***(0.001)	3.194(0.217)	$4.125x10^8$(0.997)	12.051***(0.001)	8.377***(0.003)	1.237(0.799)
Very less fertile	4.807(0.391)	12.878***(0.006)	5.504(0.063)	$4.652x10^8$(0.997)	12.878***(0.006)	11.389***(0.015)	1.854(0.476)
Infertile	4.899(0.346)	18.226***(0.000)	4.348(0.142)	$5.129x10^8$ (0.998)	18.226***(0.000)	13.166***(0.007)	1.668(0.602)
Occasional visit by DA	-	9.263***(0.000)	7.164***(0.001)	2.576(0.371)	9.263***(0.000)	5.100***(0.002)	0.263**(0.019)
Frequent visit by DA	16.930*(0.037)	12.79***(0.000)	12.953***(0.000)	13.971**(0.011)	12.79***(0.000)	7.250***(0.000)	-
Access to credit	-	3.681(0.998)	0.612(0.465)	0.764(0.722)	3.681(0.998)	-	0.673(0.536)
Agro-ecology	1.217(0.849)	1.026(0.961)	-	2.348(0.116)	1.026(0.961)	-	1.213(0.677)
Access to climate information	9.224**(0.024)	9.955***(0.000)	2.623*(0.044)	4.815*(0.034)	9.955***(0.000)	3.888(0.082)	0.360(0.131)

, ** and * Significant at p<0.1, p<0.05and p<0.01respectively*

Note: Illiterate, female headed household, farmers with age below 35 years, small family size, no additional productive labor force, poor, farmers with short farming experience, small farm size, fertile soil, rare visit by extension agent, no access to credit, highland agro-ecologic and no climate information are recognized as base category.

Conclusion and Recommendation

For the observed change in climate and its variability in terms of increasing trend in temperature, great unpredictability in precipitation as well as increase in frequency of drought and flood in sampled kebele of Mareka district farmers forced to change their manual way of farming in different way. This includes making adjustments to their planting and harvesting date, increasing the frequency of land preparation, changing crop variety, applying fertilizers and chemicals, making an adjustment to crop and livestock management, diversifying crop, implementing soil conservation, engaging in off-farm activities, planting fodder as animal feed and used small scale irrigation as the major adaptation strategies to recognized change in temperature and precipitation.

However, households who are wealthier and with long experience in farming, have better education, and households who are male headed and with aged farmers, with more productive labor force, who owned less fertile farm land, who have access to credit, extension service as well as climate information were more initiated to adopt alternative adaptation options towards perceived changes in temperature and precipitation than their counter part. Therefore, establishing early warning system and farmers training center which due focus on provision of timely and accurate information, and enhancing farmers' awareness on climate change and variability. In addition policies designed to promote and develop climate change adaptation strategies in the area should give due attention and be pertinent to household characteristics, socio-economic status and local agro-ecology. To point out one more recommendation governmental and non-governmental organizations should work closely to enhance the adaptive capacity of farmers by reducing the factors that adversely influence them from adapting to climate change and variability must take superior emphasis.

References

Abaje, I.B., B.A. Sawa, and F.O. Ati. 2014. Climate variability and change, Impacts and adaptation strategies in Dutsin-Ma Local Government Area of Katsina State, Nigeria. *Geography and Geology* 2(6): 103-112.

Acquah-de Graft, H. and E. Onumah. 2011. Farmers' perceptions and adaptations to climate change: An estimation of willingness to Pay. *Agris 3* (4), 31-39.

Aemro, T., H. Jemma and K. Mengistu. 2012. Climate change adaptation strategies of smallholder farmers. *Economics and Sustainable Development* 3(14): 1-13.

Aschalew, S. 2014. Smallholder farmers' adaptation strategies to climate change in Ethiopia: Evidence from Adola Rede Woreda, Oromia Region. *Economics and Sustainable Development* 5(7): 162-182.

Baethgen, WE., H. Meinke and A. Gimene. 2003. Adaptation of agricultural production systems to climate variability and climate change: Lessons learned and proposed research approach. Insights and tools for adaptation: Learning from climate variability, 18–20 November, 2003, Washington, DC.

Bewket, A., A. Azemeraw, and D. Andent. 2013. Farmers' perception and adaptive capacity to climate change and variability in the upper catchment of Blue Nile, Ethiopia. *African Technology Policy Studies Network,* 77.

Bewket, A.B. 2010. Analysis of farmers' perception and adaptation to climate change and variability: The case of Choke Mountain, East Gojjam. Master of Arts (MA) in Development Studies. MA Thesis. Addis Ababa University, Ethiopia, 1-147.

Consultative Group on International Agricultural Research (CGIAR). 2009. Climate, Agriculture and Food Security. *Climate change agriculture and food security,* 1-48 p.

Dawson, IK., S. Carsan, S. Franzel, R. Kindt, P. van Breugel, L. Graudal, J-PB. Lilles, C. Orwa and R. Jamnadass. 2014. Agroforestry, livestock, fodder production and climate change adaptation and mitigation in East Africa: issues and options. ICRAF Working Paper No. 178. Nairobi, World Agroforestry Centre. DOI: http://dx.doi.org/10.5716/WP14050.PDF

Dejene, K.M. 2011. Farmers' perception and knowledge of climate change and their coping strategies to the related hazards. *Agricultural science* 2(2): 138-145.

Dhaka, B.L., K. Chayal and M.K. Poonia. 2010. Analysis of farmers' perception and adaptation strategies to climate change. *Libyan Agriculture Research Center* 1(6): 388-390.

European IFSA Symposium, Vienna (Austria), July 4-7; 2010. Contribution of tillage practices on adaptation to climate change and variability on agricultural productions in semi-arid areas of central Tanzania. Gwambene, B. and E.A. Majule. *Climate change: Agriculture, food security and human health, 1300-1306.*

Fosu-Mensah, B., P. Vlek and M. Manschadi. 2010. Farmers' Perceptions and Adaptations to Climate Change: A Case Study of Sekyedumase District in Ghana. Paper presented at World Food Systems Conference in Tropentag, Zurich: 14^{th} -16 September.

Gbetibouo, G. 2009. Understanding farmers' perceptions and adaptations to climate change and variability, the case of the Limpopo Basin, South Africa: IFPRI Discussion paper

Gujarati, D. 2003. Essentials of Econometrics. Irwin McGraw-Hill Book Co. Singapore.

Ifeanyi-obi, C.C and F.N. Nnadi. 2014. Climate change adaptation measures used by farmers in south Nigeria. *Environmental Science* 8(4): 1-6.

Impacts World 2013, International Conference on Climate Change Effects, Potsdam, May 27-30, 2013. Adaptation to climate change: A case study of rural farming households in Ekiti State, Nigeria. Fatuase, A.I. and A.I. Ajibefun, Potsdam. 1-10 p.

Intergovernmental Panel on Climate Change (IPCC). 2007a. Summary for policy makers. Climate change 2007: Synthesis Report. Fourth Assessment Report of the Intergovernmental Panel for Clima te Change.

Intergovernmental Panel on Climate Change (IPCC). 2007b. Special Report: The regional impacts of climate change: an Assessment of Vulnerability. Summary for Policymakers.

International Association of Agricultural Economists, Beijing, China, August 16-22, 2009, Analysis of climate change perception and adaptation among arable food crop farmers in South Western Nigeria. Apata T.G., K.D. Samuel and A.O. Adeola. Beijing, China.1-15.

Jeffcott, J. 2013. Adaptation to climate change and variability in Eastern Ethiopia. 3(1):1-10.

Juana, S.J., Z. Kahaka and F.N. Okurut. 2013. Farmers' perceptions and adaptations to climate change in Sub-Sahara Africa: A synthesis of empirical studies and implications for public policy in African Agriculture. *Science and Education* 5(4): 121-135.

Kalungu, W.J. and D. Harris. 2013. Smallholder farmers' perception of the impacts of climate change and variability on rain-fed agricultural practices in Semi-arid and Sub-humid Regions of Kenya. *Environment and Earth Science* 7(3): 129-140.

Kassa, T.A., V. Rompaey, J. Poesen, W. Yemane and J. Deckers. 2012. Impact of climate change on smallholder farming: a case of eastern Tigray, northern Ethiopia. *African Crop Science* 20(2): 337 – 347.

Kinfe, A. 2012. Farmers' perception on climate change adaptation strategies: a case study from the irrigation schemes of Central Tigray Regional State, Ethiopia. *Microbiology and Biodiversity (EJMB)* 1(1): pp1-6.

McDermott, J.J., S.J. Staal, H.A. Freeman, M. Herrero and J.A. Van de Steeg. 2010. Sustaining intensification of smallholder livestock systems in the tropics. *Livestock Science* 130: 95-109.

NAPA. 2007. Climate change National Adaptation Program of Action (NAPA) of Ethiopia Country Report. Addis Ababa, Ethiopia.

Nhemachena, C. and R. Hassan. 2008. Determinants of African farmers' strategies for adapting to climate change. *Agricultural and Resource Economics* 2 (1): 83–104.

Ogunleye, Y.K. and T.O. Yekinni. 2012. Crop farmers' knowledge level of climate change in Ilorin east local government area of Nigeria.*Developing Country Studies* 7(2):6-13.

Oicha, T. and A. Klik. 2009. Impact of tillage practices on dry soil aggregate distribution in different soil types in Austria. Conference on International Research on Food Security, University of Hamburg, October 6-8, 2009: Institute of Hydraulics and Rural Water Management, University of Natural Resources and Applied Life Sciences Vienna, Muthgasse 18, A-1190, Vienna Austria.

Rosegrant, W.M., M. Ewing, G. Yohe, I. Burton, S. Huq, and R. Valmonte-Santos. 2008. Climate change and agriculture. Threats and Opportunities.

Sofoluwe, N.A., A.A. Tijani and O.I. Baruwa. 2011. Farmers' perception and adaptation to climate change in Osun State, Nigeria. *Afr J Agri Res* 6(20): 4789–4794.

Temesgen, D., R. M. Hassan, A., Tekie, Y., Mahmud and R., Claudia. 2008. Analyzing the determinants of farmers' choice of adaptation methods and perceptions of climate change in the Nile Basin of Ethiopia. Environment and Production Technology Division.

Temesgen, D., R. M. Hassan, A., Tekie, Y., Mahmud and R., Claudia. 2008. Analyzing the determinants of farmers' choice of adaptation methods and perceptions of climate change in the Nile Basin of Ethiopia. Environment and Production Technology Division.

Temesgen, D., R.M. Hsssan, and C. Ringler. 2010. Climate change and agriculture paper Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia. *Journal of Agricultural Science.* Cambridge University Press 2010.

Temesgen, D., R.M. Hassan, C. Ringler, A. Tekie and Y. Mahmud. 2009. Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. *Global Environmental Change* 19: 248-255.

United State Agency for International Development (USAID), 2011. Climate change and conflict in pastoralist regions of Ethiopia: Mounting Challenges, Emerging Responses. Stark, J., K. Terasawa and M. Ejigu, Washington, DC 20523, 1-64 P.

Villanueva, S.P. and R. Hiraldo. 2011. Climate change and agriculture in Sub-Saharan Africa: New Concerns, Old Arguments? Occasional Paper 003- Available at www.future-Agricultures.Org.

World Bank. 2009. Response strategies to climate change in agricultural systems in Latin America. Washington, DC 20433, USA.