Farming Climate Change Adaptation Mechanisms and Factors Affecting Farmers' Decision to Adaptation: a case study in Meket district, North Wollo, Ethiopia

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Abstract

In fact climate has been changed in the past and continues to change in the future implies the need to understand how farmers have tried to adapt its impacts. As result, the present study attempts to examine the farming climate change and variability adaptation methods, various determinants of the households' choice of adaptation methods and the barriers to their adaptation in three Kebeles of three agro ecological zones of Meket district, Ethiopia. The data for this research were collected from household interview, key informant questionnaires and focus group discussion. Multinomial logistic regression model was used to analyze factors affecting households' adaptation decisions. The results revealed that about 83% of the households used one or more local adaptation methods like growing different varieties of crops, livestock diversification, using improved seeds, adopting soil and water conservation structures, using organic and/or inorganic fertilizers, changing into supplementary irrigation farming and livelihood diversification. Whereas, results from the model reveal that education, gender (being male), livestock ownership, size of farm land, extension service on crop and livestock production, and availability of credit have positive and significant impacts on one or more adaptation methods being used in the study area. However, household size is negatively correlated to most of the adaptation methods. So the larger number in a family mean less capacity to adaptation.

Keywords: Adaptation, Climate Change, Climate variability, climate change impact, constraint, descision, multinomial logit regression

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1. INTRODUCTION

1.1. Background Information

Anthropogenic activities, most notably through burning of fossil fuels such as coal, petroleum, and natural gas have released large quantities of greenhouse gases (GHGs) like carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) into the atmosphere. However, most developing countries in Africa have contributed least to these GHG emissions and therefore the genesis of climate change; but Africans are among the most vulnerable to the impacts of climate change (ECSNCC, 2010; Amisalu and Gebremichael, 2009). This is due to limited adaptive capacity as compared to the developed countries to cope with the impacts because of their limited financial resources, skills and technologies and their excessive reliance on climate sensitive economic sectors such as rainfed agriculture, fisheries and forestry (Orinda and Murray, 2005; Reid and Huq, 2007).

Climate change is predicted to reduce the area of land suitable for rainfed agriculture by an average of 6%, and reduce total agricultural growth domestic production (GDP) by 2 to 9% (TerrAfrica, 2009). One recent study estimated that African farmers, on rainfed land will lose $28 per hectare per year for each 1^{o}C rise in global temperatures (LaFleur et al., 2008). Developing countries also experience a greater loss of life which contributes 90% of all climate-hazard related deaths (Bank off, 1999). Moreover, climate change and varablitise resulted for water shortage. For instance, projection indicates that around 250 and 600 million peoples will be under water stress by the year of 2020s and 2050s, respectively (IPCC, 2007).

Similar to Africa, climate change and variability impact in Ethiopia is seen as a major obstacle to the nations struggle for economic development (Amisalu and Gebremichael, 2009; Tanguy and Splieman, 2008). The country's economy heavily relies upon the agriculture sector. The agricultural sector in Ethiopia is largely small scale and rainfed. It accounts for about more than 42% of national GDP, 90% of exports and 85% of employment (Tanguy and Splieman, 2008). Thus, the potential adverse effects of climate change on Ethiopia's agricultural sector are a major concern. According to the National Meteorological Service Agency (NMSA, 2001) long-term climate change in Ethiopia is associated with changes in precipitation patterns, seasonal rainfall variability, and increase in temperature, which could increase the country's frequency of both droughts and floods. Droughts in Ethiopia can shrink household farm production by up to 90% of a normal year output (World Bank, 2003) and could lead to the death of livestock and human beings.

In North Wollo Meket District, climate change poses particular risks to poor farmers who have an immediate daily dependence on climate sensitive livelihoods and natural resources. The limited economic, institutional and logistical capacity to adapt to climate change exacerbates the vulnerability of thousands of people in the study area. The impact of climate change combined with highly degraded land; make the agricultural sector of Meket district to be susceptible to environmental shocks like drought, disease, flood, hailstorms and frost. To cope with impact of climate change and to prevent excessive losses of agricultural production from climate change and variability, it needs affordable solutions based on their own resources, skills and available technologies. Despite the vulnerability of the survey area to the impacts of global climate change and weather extremes is intense; research generated knowledge on regional and local impacts of climate change, locally available and suitable adaptation measures, major constraints to adaptation and factors affecting households' choice of adaptation method are neither been researched nor tabled.

Adaptation measures are therefore important to help these communities to better face extreme weather conditions and associated climatic variations (Adger et al., 2003). Identifies the actual farming climate change adaptation strategies and factors affecting households' choice of adaptation methods at lower administrative area like Meket district are the main driving force for themselves and policy makers to initiate appropriate adaptation strategies to climate change and variability.

1.2. Objective

1.2.1. General objective

This study aims to investigate farming climate change adaptation mechanism and households' choice of adaptation method in Meket district, North Wollo

1.2.2. Specific objectives

- ✓ To investigate major practices and innovations farmers employ to adapt to climate change and variability
- ✓ To assess the constraints and challenges facing farmers as they struggle to adapt to climate change and variability; and
- ✓ To analyze the determinants of farm-level climate change adaptation strategies

1.3. Research questions

- ✓ What are the actual strategies and innovations used by farmers to adapt climate change and variability?
- ✓ What are the hindrances and challenges to adapt climate change and variability?
- ✓ What are the determinants of farmers' choice of adaptation methods?

2. RESEARCH METHODOLOGY

2.1. Site description

The rationales for the choice of Meket district as study area are its wide range of agro-ecological setting; ideal representativeness of the humid highlands, sub-humid areas at mid-altitude and semi-arid lowlands where mixed farming exists (Elias and Fentaye, 2000) and the rainfed agricultural crop production in the district is highly vulnerable to climate change (Amhara livelihood report, 2007 and Adem, 2011). Meket district is located 600 km north of Addis Ababa, in the North Wollo zone of Amhara Regional State within an altitude and longitude of $11^0$35'50''N-$12^0$2'30''N and $38^0$32'35''E-$39^0$16'40''E, respectively (Figure 1). According to the central statistical authority (CSA, 2007), the district has a total population of 227, 338; of whom 114, 731 are males and 112, 604 are females. The estimated average annual rainfall ranges from 600 mm in the lowlands to 1120 mm in the highlands, whereas, the mean maximum and minimum temperature of the area is about 24.6^0c and 12.1^0c, respectively. The main livelihood source of the local community is small scale rainfed agriculture.

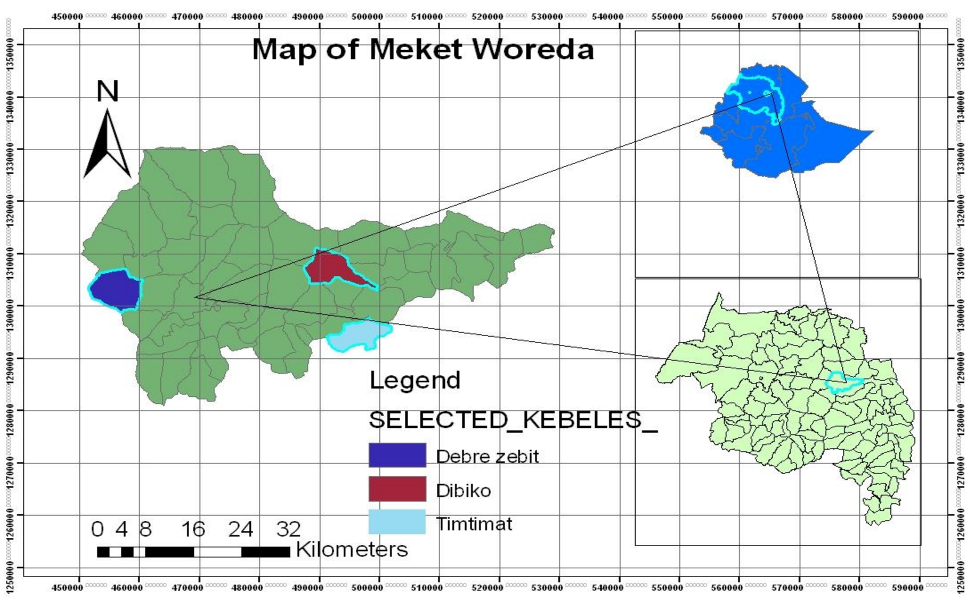

Figure 1. Map of Meket Woreda

2.2. Data collection

The qualitative and quantitative data for the study were collected from both primary and secondary sources. Primary data were obtained from sampled household interview, key informant questionnaires, focus group discussions (FGDs) and direct observation. In an attempt to investigate the socio-economic characteristics (factors affecting households' choice of adaptation method), the respondents were asked questions related to demographic characteristics (like gender, age, household size and education), access to credit and extension survives, ownership of farm area and livestock and the like. The other set of questionnaires were mainly focused on adaptations strategies being used by farmers, barriers to adaptation and determinants (factors) affecting households choice to adaptation. On the other hand, secondary data were procured from available meteorological records, published and unpublished documents, and various activity reports of governmental and non-governmental institutions.

2.2.1. Preliminary Survey

A half weeklong initial field visit was carried out. The main objective of this visit was to become familiar with the study area such as geographical situation and social structure. It helped to identify socio-economic and bio-physical conditions of the environment.

2.2.2. Household survey

The primary data were obtained through structured and semi-structured questionnaires administered to various groups of respondents at the Kebele level. The questionnaires were prepared, pre-tested, and amended to fulfill the objectives of the present study. The survey was carried out in the humid highlands (Dega), sub-humid areas at mid-altitude (Woyina Dega), and the semi-arid lowlands (Kolla). Three representative sample Kebeles (one from each agro-ecological zone) were selected purposively. In the Kebele, up-to-date list of farmer households' name was obtained from the respective Kebele offices. Then these farmers in each Kebele were stratified based on wealth group into rich, medium and poor. Within each wealth group random sampling procedure based on equal sample was applied to select a total of 135 households (45 from each Kebele which consist 15 poor, 15 wealth and 15 rich).

2.2.3. Key Informant interviews

For this study key informants were defined as people who are knowledgeable about climate change and/or have been living in the locality at least for 30 years. From each sampled kebeles, six older headed farmer households (3 men and 3 women); one Keble's leader (mostly the chair person), one model farmer and two developmental agents (DAs) were selected by employing a purposive sampling technique. The key informative discussions were conducted by applying well designed semi-structured questionnaires with logical and specific content including questions related to understanding the effects of climate change on agriculture, adaptation measures being used, challenges and opportunities in climate change and variability adaptation and factors affecting household's decision in climate change adaptation.

2.2.4. Focus group discussions

FGDs using checklists of questionnaires were conducted with selected member of community to supplement and triangulate information gathered from the household interview and key informant questionnaires. It was held separately for age and gender groups. In each Kebele four FGDs were made; 1 for women, one for men, one for youth and the fourth was for mixed. One FGD had 8-10 individuals.

2.3. Analytical framework

Farmer's decision to use or not to use any adaptation option could fall under the general framework of utility and profit maximization (Gbtibouo, 2009). The assumption here is that farmers adopt a new technology only when the perceived utility or profit from using this new technology is significantly greater than the traditional or the old method. Suppose that Y_j and Y_k represent a household's utility for two choices, which are denoted by U_j and U_k, respectively. The linear random utility model could then be specified as:

$$U_{ij} = \beta_j' x_i + \varepsilon_j \text{ and } U_{ik} = \beta_k' X_i + \varepsilon_k \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots 1$$

Where, U_{ij} and U_{ik} are the perceived utility by farmer i of adaptation options j and k, respectively; X_i is a vector of explanatory variables that influence the choice of the adaptation option; β_j and β_k are parameters to be estimated; and ε_j and ε_k are the error terms.

Consider a rational farmer who seeks to maximize the present value of expected benefits of production over a specified time horizon, and must choose among a set of J adaptation options.

The farmer i decide to use j adaptation option if the perceived benefit from option j is greater than the utility from other options (say, k) depicted as:

$$U_{ij} = (\beta_j' x_i + \varepsilon_j) > U_{ik} = (\beta_k' X_i + \varepsilon_k), k \neq j \ldots\ldots\ldots\ldots\ldots\ldots 2$$

Under the revealed preference assumption that the farmer practices an adaptation option that generates net benefits and does not practice an adaptation option otherwise, we can relate the observable discrete choice of practice to the unobservable (latent) continuous net benefit variable as Y_{ij} =1 if $U_{ij} > 0$ and $Y_{ij} = 0$ if $U_{ij} < 0$. In this formulation, Y is a dichotomous dependent variable taking the value of 1 when the farmer chooses an adaptation option in question and 0 otherwise.

The probability that farmer i will choose adaptation option j among the set of adaptation options could be defined as follows:

$$P(y = j/x) = P_{ij} > U_{ik}/x$$

$$P(ß_j' X_i + \varepsilon_j - (ß_k' X_i + \varepsilon_k > 0/X$$

$$P(ß_j' - ß_k') X_i + \varepsilon_j - \varepsilon_k > 0/X$$

$$P(ß^* X_i + \varepsilon^*) > \frac{0}{x} \ldots\ldots\ldots\ldots\ldots\ldots 3$$

Where, ε* is a random disturbance term, β* is a vector of unknown parameters that can be interpreted as the net influence of the vector of explanatory variables influencing adaptation.

2.3.1. Empirical Model

When the probability is between 0 and 1 (adapting and not adapting) models such logit and probit models are the mostly used in the literature (Greene, 2003). However, several adaptation choices have been investigated, the appropriate econometric model that was used in this study is a multinomial logit (MNL) regression model (Kurukulasuriya and Mendelsohn, 2006; Seo and Mendelsohn, 2006; Madalla, 1983; Wooldridge, 2002; Koch, 2007).

This model estimates the effect of hypothesized variables which affect farmers' decision to adaptation (identified explanatory variables) like farmer's age, gender, education, family size, farming experience, access to credit and extension service, livestock ownership e.t.c on dependent variables (adaptation strategies) like Planting different varieties of crops, diversifying the livestock, using of drought resistant improved seed, implement soil and water conservation techniques, the use of chemical and/or organic fertilizer, changing/shifting to supplementary irrigation farming and integrating livestock into cropping or crop in to livestock.

To describe the MNL model, let y denotes the dependant variable (adaptation method being used in the study area) has J categories that are y = 1, 2 …j positive integer and let x denote a set of explanatory variables like P_1, $P_2 \ldots P_j$ as associated probabilities, such that $P_1+P_2+\ldots+P_j = 1$. The equation tells as how a certain changes in the elements of x affect the response probabilities P(y = j / x), j =1, 2, ...J. Since the probabilities must sum to unity, P(y = j / x) is determined once we know the probabilities for j = 2,...J.

$$P(y = 1/x) = 1 - (P_2 + P_3 + \cdots P_j \qquad \ldots\ldots 4$$

The usual thing is to designate one as the reference category. The probability of membership in other categories is then compared to the probability of membership in the reference category. Consequently, for a dependent variable (DV) with j categories, this requires the calculation of j-1 equations, one for each category relative to the reference category, to describe the relationship between the DV and the independent variables (IVs). The choice of the reference category is arbitrary but should be theoretically motivated. The generalized form of probabilities for an outcome variable with j categories is:

$$\Pr(y_i = j/x \; = \Pr_{ij} = \frac{\exp(x'\beta j)}{1 + \sum_{j=2}^{j} \exp(x'\beta j)}, j = 1,2 \ldots j \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots 5$$

For j> 1

2.4. Study Framework

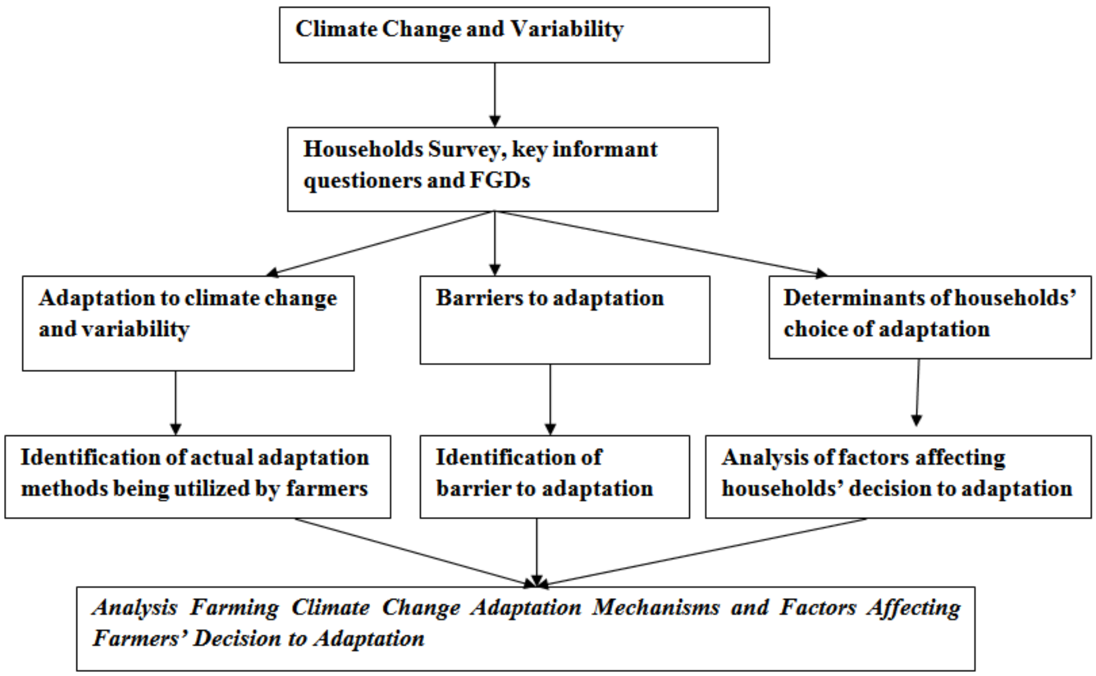

Figure 2. The study framework

2.5. Data analysis

The survey was generated both qualitative and quantitative data; then data were summarized and categorized, and the qualitative data were code into a numeric values. STATA statistical program was used in data analysis. Besides, Microsoft-word and Microsoft-excel program were also used for data processing, analysis and interpretation. The results are then presented in the form of tables, graphs, charts and pictorial devices.

3. RESULTS AND DISCUSSION

3.1. Impact of climate change and variability

In Meket District agriculture is the mainstay of the community and more than 85% sampled household follow a traditional cultivation practices that rely on seasonal rain water. However, changes in the patterns of rainfall and temperature have already created pressure on agriculture in general and on the available water, forest, and range resources in particular which exacerbating food and feed shortages, and making the environment more vulnerable and less resilient to future climatic changes. The FGDs also confirmed that erratic rainfall patterns contributed to soil erosion, landslides in the upstream and flooding and sedimentation in the downstream sites. Those have resulted in loss of soil fertility, and decreased crop yields as well as causes crop damage.

Interviewed households also claimed that climate change and variability have both positive and negative impact on rural livelihood that depends on small scale rain feed agriculture; 21.5% sampled household reported that the changed climate has increased their overall agricultural production while 71.1% sampled households confirmed that changed climate has reduced the overall agricultural production. Only 7.4% of the households didn't perceive the effect of climate change (Figure 3).

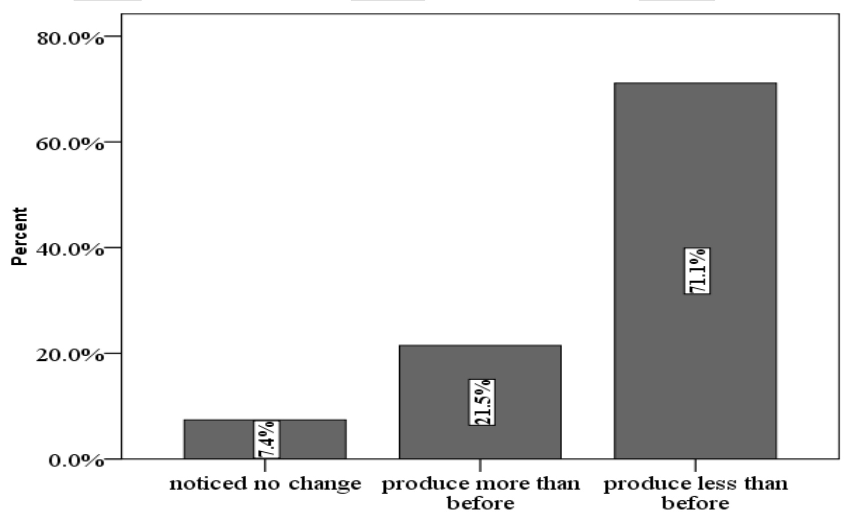

Figure 3. Households' response on impact of climate change on overall agricultural production (n=135)

In humid highlands part of the study area farmers have started growing new varieties of crops like Teff, Chickpeas, Wheat, Cauliflower, Cabbage, Tomato and Millet, which need relatively moderate temperature to grow and survive. Growing of those crops and vegetations in the highland part of the district before 15-20 years was unexpected. Thus, starting to grow these agricultural crops and vegetations including Enset (*Ensete ventricosum*) has increased agricultural production for some households who lives in highland part of Meket district. These strengthen 21.5% of household's response. However, according to 71.1% of household's response, climate change and variability has put a great stress on agriculture. Complete crop failure due to adverse climatic conditions like prolonged drought, crop destructive frost, heavy rain, hailstorm and seasonal flooding was visible for majority of the sampled households (Table 1). For instance, 94% of households were encountered at least one time complete crop failure in the last twenty years. Moreover, 62%, 90%, and 89% of households also were perceived an increment of frost, heavy rain and hailstorm on crop, and seasonal flooding problems, respectively on agricultural crops (Table 1).

Table 1. Major climate change induced problems identified by households (n= 135)

problems	Households Response in %		
	yes	no	Don't know
Diversity of crops is declining	71	28	1
Encountered complete crop failure	94	6	0
Increase frost problem on agricultural crops	62	38	0
Increased impact of heavy rain and hailstorm on crops	90	10	0
Increase in impact of seasonal flooding on agricultural land and crops	89	11	0

The household's response was verified by group discussion and key informant interview. During FGDs erratic rainfall, prevalence of diseases (especially malaria), flood and prolonged drought, agricultural crop destructive hailstorm and frost, spread of agricultural pests, insect and weeds were outbreak due to changed climate and variability. From the discussion it was understood that the most types of disease that have affected agricultural crops includes rust, smith, powdery mildew and yellow spot.

Impact of climate change is not the same for all farmer households in Meket district. In Meket 10.5% of the households were found below poverty line (Woreda's Media and Communication Office document, 2011). Poor farmers are likely to experience much adverse impacts from climate change. According to 87% of the respondents' opinion, the poor households are mostly affected by the incidence of climate change and variability (Figure 4). The possible reason for this result might be due to low adaptation capacity with marginal changes in their yields or income, whereas richer farmers can buffer their loss by depending on savings or sale of some of their assets. This result is in line with Deressa et al. (2008b) shows poor farmers in Ethiopia were highly vulnerable to climate change: they tried to point out 50 percent reduction in yield due to climate change do not mean the same for poor farmers that it does for rich farmers.

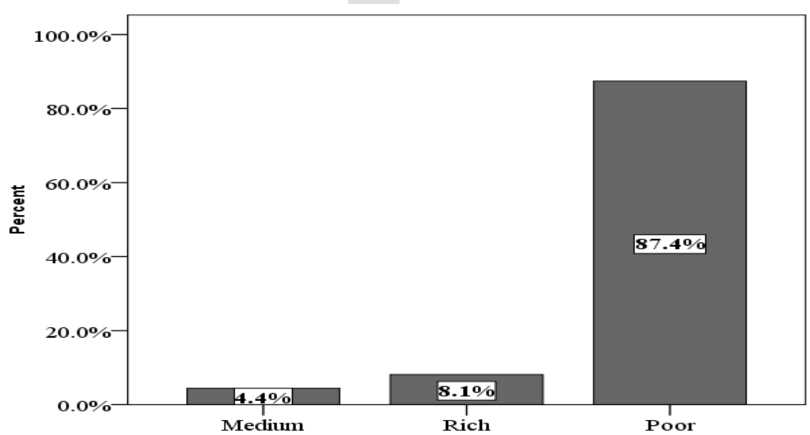

Figure 4. Farmers' response on impact of climate change on local community who have different socio-economic status (n=135)

As it was recognized from the local community, impact of climate change and variability in the study area was a multidirectional. Figure 5 reveals that climate change and variability were resulted for food insecurity, health problem on communities and livestock, disaster instigating, reduction biodiversity quality and sustainability, and fuel wood shortage.

(Figure 5 here)

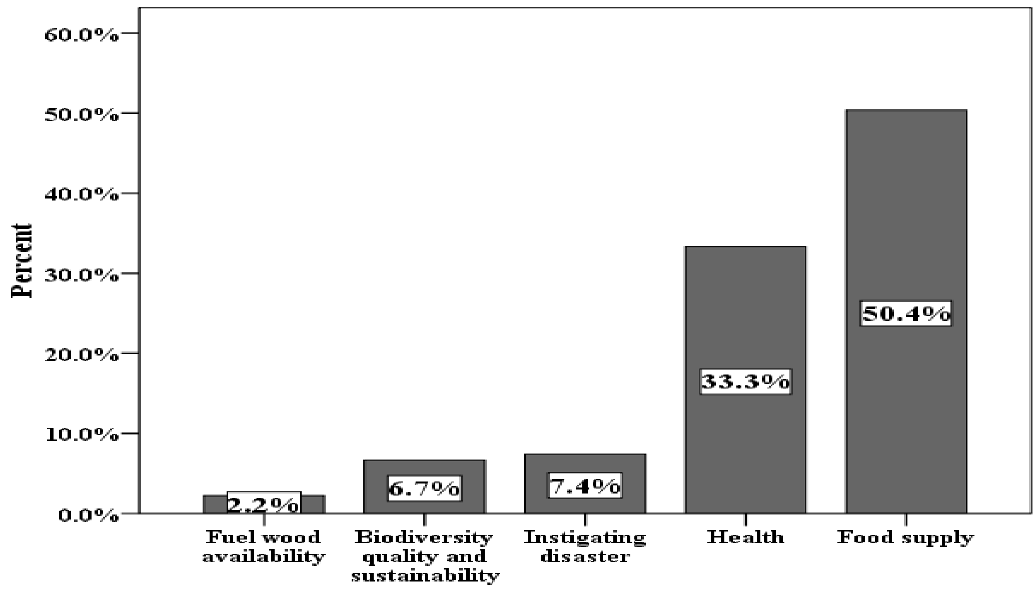

Figure 5. Households' response on impact of climate change for different sectors (n= 135)

3.4. Households' adaptation strategies to climate change and variability

As described previously more than 85% of the local communities' livelihood was depend on climate sensitive small scale farming activity. This high degree of dependence on farming activities calls for designing and implementing different adaptation strategies. As result, farmer households in the study areas have tried to reduce impact of climate change and variability using different adaptation and coping mechanisms. The adaptation measures reported by farmers might be profit driven rather than climate change and variability. Despite this missing link, the assumption in this research is that their actions were driven by climatic factors as reported by farmers themselves which consolidates the studies by Madison (2006) and Nhemachena and Hassan (2007).

As we moved from lowland (kola) to highland (dega) part of Meket district, various types of adaptation methods were practiced by local peoples to adapt the consequences of climate change so far and to manage future patterns in climate variability and change. The major farming adaptation strategies being implemented by the local community in the study area were cultivating different varieties of crops (13%), planting improved seed (11%), implementing soil and water conservation (24%), using both organic and inorganic fertilizer (12%), livelihood diversification (10.5%), changing into supplementary irrigation

(7.4%) and livestock diversification (5.2%). However, 17% of the sampled farmer households were not used either one neither more adaptation strategies (Figure 6).

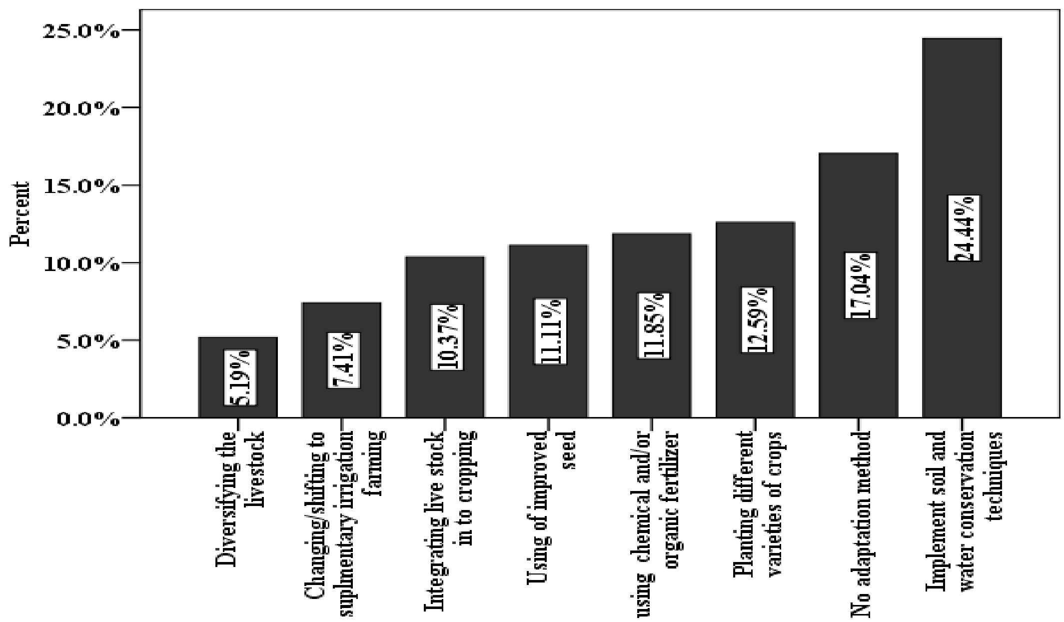

Figure 6. Households' Responses on different alternative of adaptations methods (n=135)

Growing a number of different crops in the same plot or in different plots reduces the risk of complete crop failure as different crops are affected differently by climate events. In the three agro-ecology of Meket district different varieties of crops were cultivated. For instance, sorghum and maize were the main crops in lowland part of the district which were not growing in high land while barley and wheat were the main crops in highland part of the district. This might be due to deferent varieties of crops need different climatic condition to germinate and grow to give the end fruit. Furthermore, households were growing different improved seeds. The major types of improved seed that households were used include varieties of wheat (C1, C2, HAR 604, HAR 1685, EA and ET 13), Teff (DZ, CR 13), barley and chickpea (IRT). Some of the improved seed which delivered to farmers are depicted in Table 2.

Table 2. Types and amount of improved seed distributed to farmers as a credit base (2011)

Type of improved seed	Amount (100 kg)
chickpeas	20
Teff (DZ)	31,5
Wheat C1, C2	1212.54
Barley	21
Wheat (E/Africa)	3.5
Vegetables	13.4
Total	1270.44

SOURCE: District Agriculture and Rural Development Office (unpublished document)

The other important climate change adaptation strategy being used by the local community was conservation of natural resource. In Meket Woreda soil and water conservation (mostly watershed management) at both households and community level was a day to day activity. Besides soil conservation, households were adopting water maximization through the practice of moisture conservation technique and rain water harvesting. Properly managing rainwater was viewed as essential for improving crop and livestock farming, which will hopefully increase the overall living situation for households in Meket. Rain water harvesting in the study area was practiced by creating small reservoirs to be used to store water when rains are low or when there are floods as a means to divert water.

In Meket district, farmers built soil and stone bunds structures to control runoff and thus increase soil moisture and reduce soil erosion. Grass strips and contour leveling, sometimes incorporating trees or hedgerows also used to reduce runoff velocity and allow water to be infiltrate and trap sediments. In addition, the built waterway has assisted the direct precipitation flows along specified pathways in farm fields. The water-harvesting structures like dams, ponds, and diversions were ensured water availability in the dry season. This is in line with Huber and Pedersen (1997) recommendation, increase in temperature and decrease in rainfall also leads to soil moisture loss; this instigates increase in the use of soil and water conservation techniques.

Regarding to soil fertility improvement, 12% of sampled households strongly emphasized on the use of fertilizer (either commercial fertilizer like UREA and DAP, or organic fertilizer like compost and humus) as climate change adaptation strategy. Use of fertilizer has dual benefit for agricultural crop production: 1) it has increased soil fertility, and 2) shorting growing period by providing necessary nutrients to the crop. Table 3 below shows that the amount of fertilizer being used by households to adapt the changing climate has increased from years to years.

Table 3. Types of fertilizer and their amount used at different years

Types of fertilizer	Unit	Year (E.C.)					
		1998	1999	2000	2001	2002	2003
DAP	100kg	33351.0	2819.6	1296.35	6346.5	8369.5	8507.3
UREA	100kg	1728.8	1881.8	1801.7	3376.5	4543.6	4477.6
Compost	M^3	312468	480631	577401	837424	894225	1350025

As the response of 5% households, cultivating variety of crops and rearing diversified livestock also important to adapt change in climate. Those strategies are recommended by Seo and Mendelsohn (2006) that farmers in warmer temperatures tend to choose goats and sheep as opposed to beef cattle and chicken: goats and sheep can do better in dry and harsher conditions than beef cattle. Hence, different varieties of livestock have different capacity to resistance to climate change and variability. According to 10% the response given by the participant, integrating the livestock into cropping or cropping into livestock was used as a strategy for adaptation to climate variability and change.

3.5. Hindrances to adapt climate change and variability

As described in section 3.4, households were tried to use one or more farming adaptation methods. However, majority of households have low adaptive capacity because of very limited financial, natural, physical, human and social capital. Climate change adaptation requires recourse, technology, knowledge, infrastructure and the fourth. Households' response depicted in figure 7 reveals that there are eight major constraints to adopt more than one adaptation methods in Meket district. These are shortage of improved seed (10%), lack of access to water for irrigation (24%), lack of current knowledge on adaptation methods (15%), lack of information on weather incidence (7%), shortage of labor (4%), lack of money to acquire modern adaptation technology (18%), lack of infrastructure (13%) and lack of institutions that support the community to adapt climate change and variability (10%). These constraints plus highly degraded drought prone area in Meket district made adaptation to climate change and variability to be an acute challenges and constraints.

(Figure 7 here)

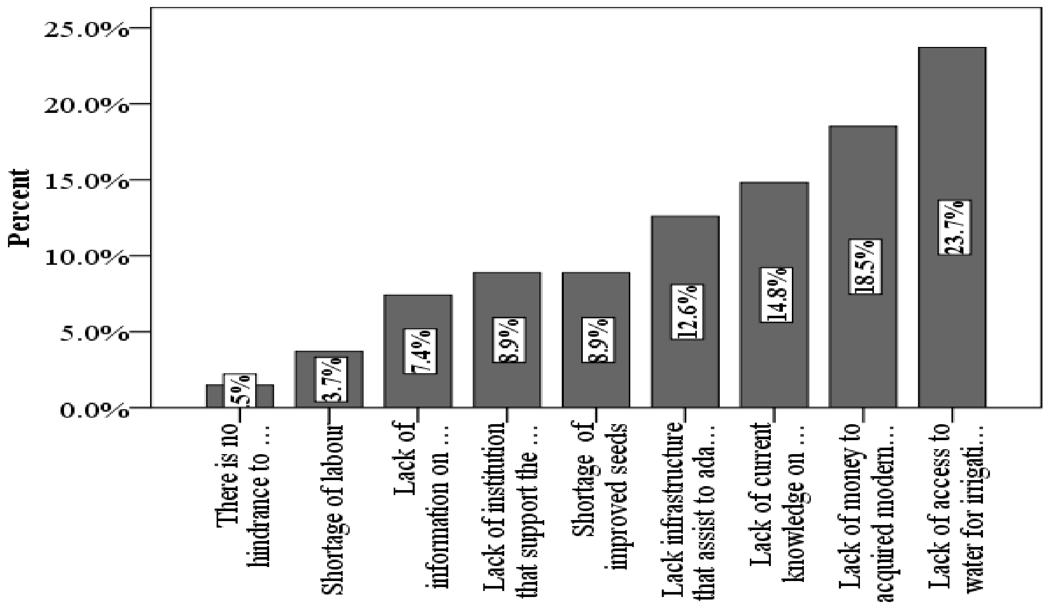

Figure 7. Households' responses on various hindrances to adopt modern technology to

The other most important hindrance of adaptation climate change that was reported by sampled households in the district is lack of information on weather incidence. Lack of information on incidence of weather and using appropriate adaptation options could be attributed to the dearth of research on climate change and adaptation options in the district. It could also be attributed to inefficient extension service in the district.

3.6. Modeling Farmers' Adaptation Options to Climate Change and Variability

The estimation of the multinomial logit (MNL) model for this study was undertaken by normalizing one category, which is normally referred to as the reference state or the base category. In this analysis, the last category ("no adaptation method used") was a reference state. It is important to note that the estimated coefficients should be compared with the base category of not adopting any of the adaptation choices.

In the initial run, the three agro-ecologies (Dega, Woina-Dega and Kola) where sampled household farmers have been lived were added to the model, but they were dropped, as they were not significant. Then after, the model was run and tested for the validity of the independence of irrelevant alternatives (IIA) assumption by using Hausman specification test procedure. The test failed to reject the null hypothesis of independence of the excluded "implement soil and water conservation techniques," suggesting there was no evidence against the correct specification for the adaptation model, $\chi2 = 1.78$ with P value of 0.991. This indicates that the multinomial logit model (MNL) specification is appropriate to model adaptation strategies of smallholder farmers.

The result of the MNL model indicates that different socio-economic and demographic factors were affected household's choice of adaptation methods. The model (Table 5) reveals that the set of significant explanatory variables varies across the groups in terms of the levels of significance and signs of regression coefficients. These factors affected household's choice of adaptation methods were gender of household head, age of household head, education, family size, farming experience, livestock ownership, access to credit, and access to extension service on crop and livestock production. The description of variables that were affected household's decision to climate change adaptation is shown in Table 4.

Table 4. Description of the independent variables

Variable	Mean	Std. Dev.	Description
Gender of head of household	0.80	0.40	Dummy, takes the value of 1 if male and 0 otherwise
Age of head of household	36.69	9.05	Continuous
Year of education	2.67	3.50	Continuous
Household size	4.19	1.59	Continuous
Farming experience (year)	20.60	12.77	Continuous
Farm area (in hectare)	0.67	0.55	Continuous
Access to credit	0.44	0.50	Dummy takes the value of 1 if there is access and 0 otherwise
Access to extension	0.40	0.49	Dummy takes the value of 1 if there is

			access and 0 otherwise
Livestock ownership	0.73	0.45	Dummy takes the value of 1 if owned and 0 otherwise
Access to information to climate change	1.69	0.46	Dummy takes the value of 1 if accessed and 0 otherwise

As indicated earlier, the parameter estimates of the MNL model provide only the direction of the effect of the independent variables on the dependent (response) variable: estimates do not represent actual magnitude of change or probabilities. Thus, the results of the estimated equations are discussed in terms of the significance and signs of the parameters. The positive signs suggest an increase in the probability of sampled farmers in using any of the adaptation options relative to the reference group (not using any adaptation method in this case) as the explanatory variables increase. The implication is that the probability of the farmers deciding on those adaptation options is greater than the probability of opting for the reference group. The negative and significant parameter means that the probability of opting for such options is lower relative to the probability of being in the reference group.

Gender of respondent (being male) was positively and significantly related with planting different varieties of crops, livestock diversification, sowing improved seeds, implementing soil and water conservation techniques, using fertilizer as land input, changing into supplementary irrigation farming and integrating into cropping or cropping into livestock (Table 5). This indicates that male headed households are better to use all climate change adaptation option than female headed households. The possible reasons for these results were, male households are better exposed to modern agricultural technologies and have more power to make adaptation decision than female households, and the gender related effects of climate induced hazards. For instance, women were suffered the immediate effects of water and food shortages in the household as a result of changes in the rainfall patterns and extreme temperature because they are normally responsible for providing water and cooked food for their households. As result, women were spent their much time on searching firewood, water, food and the like rather than participating in any of adaptation methods. This result is similar with the arguments that male-headed households are often considered to be more likely to get information about new technologies and take risky businesses than female-headed households (Asfaw and Admassie, 2004), and a unit change from being headed by a female household to male increases the probability of adapting to climate change by 18% Deresa and Rashid (2009).

The second very important explanatory variable that has affected the outcome (adaptation methods) was age of the households. Age of the household head has a positive and negative impact on adaptation methods. Coefficient on age of household was significantly and positively related with changing into supplementary irrigation farming. It was also positively but not significantly related with using drought resistant improved seed. Even if it is not significant, age has a negative impact on the remaining five adaptation methods. The some result was found by Deressa et al. (2008a); a unit increase in age of the household head resulted in a 9 percent increase in the probability of soil conservation, a 12 percent increase in changing of crop varieties, and a 10 percent increase in tree planting while Shiferaw and Holden (1998) on the contrary indicates that a negative relationship between age and adoption of improved soil conservation practices. Sometimes, age of the head of household can be used to capture farming experience (Deressa and Rashid, 2009) but there is no specific age for the respondents to start farming. Therefore, one might be old and start farming late while another might be young and start farming at his/her early age. As a result, the effect of age is generally location or technology specific.

Education of the head of household increased the probability of adapting to climate change. As Table 5 reveals that, education was positively but not significantly related with planting varieties of crops, livestock diversification, changing into supplementary irrigation farming, integrating livestock into cropping or cropping into livestock and use of organic and/or inorganic fertilizer. Moreover, it was positively and significantly related with the use drought resistance improved seed. The significant and positive relationship between coefficients of education with using drought resistance improved seed emphasized that educated farmer households give more weight for this technology as a best strategy to adapt than others. The possible reason for this result might be some adaptation methods like improved seed and irrigation scheme needs knowledge on modern agricultural technology to use at the right time and place than other alternatives like soil and water conservation practices. Soil and water conservation techniques are mostly labor intensive as compared to advanced knowledge requirement. Hence, educated farmers have an increased likelihood of using more adaptation alternatives than uneducated once. This result confirms the findings of Deresa et al. (2008b) in similar study of adaptation in Nile basin of Ethiopia.

Household size was related significantly and negatively with the use of fertilizer. This could be mostly due to households with a large family size need high expense to feed their family rather than purchase fertilizer, improved seed, and investing on irrigation; it is directly or indirectly related with poverty. Though, not significant it is negatively related with planting different varieties of crops, use of improved seed, implementation of soil and water conservation measures, fertilizer application, integrating livestock into cropping or cropping into livestock and livestock diversification (Table 5).

The coefficient of farm size was correlated positively but not statistically significant with changing into supplementary irrigation farming and use of either organic or inorganic fertilizer (Table 5). Indeed, farmers who have large farm area are more likely to adapt irrigation farming because they have better capital and resources than farmers who have small farm area. Therefore, they can easily invest in irrigation technologies, which demand relatively high investment costs. Farmers with large farm area, i.e. where their farm lands are found in different location could also have a better chance to access water for irrigation. This increased the likelihood of using irrigation farming. This result is inline with the findings of Deressa and Rashid (2009) in Nile Basin of Ethiopia which indicates farm size was positively related to adaptation alternatives, and Gbetibouo (2009) in Limpopo Basin of South Africa also shows coefficient on farm size is significantly and positively correlated with adaptation. In contrast, coefficient of farm area is negatively but not statistically significant related with the remaining adaptation options (Table 5). Farmers with larger area leave it as fallow land or do not fully utilize due to lack of labor. For instance, planting different varieties of crops and soil and water conservation practices on large farm size were needed high intensive labor force. Farmers who have large farm area also didn't invest on livestock diversification. The possible reason might be most of the time farmers do not have the capacity to manage large areas (Ouedraogo et al. 2006).

As expected, experienced farmers have an increased likelihood of using all adaptation options. Coefficient of farming experience was related significant and positively with the use of fertilizer and changing into supplementary irrigation farming (Table 5). Though, it was not significant, farming experience has a positive impact to the rest of adaptation methods. Experienced farmers have high skills in farming techniques and management and are able to spread risk when facing climate variability by exploiting strategic complementarities between activities such as crop-livestock integration and planting varieties of crops.

Like many predictor variables, access to credit also increased the likelihood of adaptation. Poverty or lack of financial resources is one of the main constraints to adjust the farming activities to changing climate (Gbetibouo 2009). Despite numerous adaptation options that farmers were aware of and willing to apply, the lack of sufficient financial resources to purchase the necessary inputs and other associated equipments (e.g., purchasing seeds and fertilizer, acquiring transportation, hiring temporary workers) is one of the significant constraints to adaptation. In this study, 18% of the respondents were faced with lack of financial resources as the main constraint to adaptation (Figure 7). Table 5 shows that access to credit has increased the likelihood of farmers to use livestock diversification, improved seed and supplementary irrigation farming. This indicates that households with access to a loan/ credit will have a better chance of adopting these techniques than those how haven't accessed. This result indicates that the important role of increasing institutional support in promoting the use of adaptation options to reduce the negative impact of climate change. This result confirms the finding of Gbetibouo (2009) in a similar study of adaptation in the Southern Africa indicates access to credit increases the likelihood that farmers will take up portfolio diversification and buy feed supplements for their livestock by 3 percent.

Having access to extension service on crop and livestock production increased the likelihood of adopting soil and water conservation techniques. As indicated in Table 5, coefficient on access to extension related significantly and positively to soil and water conservation, changing into supplementary irrigation farming and integrating livestock into cropping or cropping into livestock. It also appears to increase the use of the other adaptation methods, although the results were not statistically significant.

Table 5. Parameter estimates of the multinomial logit climate change adaptation model, Meket Woreda

Explanatory variable	Planting different varieties of crops	livestock diversification	Using improved seed	Adopting Soil and water conservation	Fertilizer application	Changing into supplementary irrigation	Integrating livestock into cropping
Gender	2.613*** (.006)	1.808* (.093)	2.900** (.024)	2.344*** (.002)	2.386** (.030)	.055 (.611)	2.744** (.022)
Age	-.029 (.618)	-.127 (.218)	.016 (.817)	-.043 (.398)	-.055 (.544)	.319* (.055)	-.070 (.312)
Education	.033 (.768)	.093 (.535)	.127 (.336)	-.029 (.787)	.230* (.085)	.856 (.319)	.158 (.166)
HH size	-.363 (.167)	-.360 (.319)	-.177 (.504)	-.179 (.404)	-1.227*** (.005)	.088 (.856)	-.300 (.262)
Farming experience	.046 (.263)	.087 (.266)	.059 (.237)	.056 (.124)	.144* (.066)	.737* (.088)	.062 (.232)
Farm size	-.218 (.673)	-.471 (.672)	-.015 (.984)	-.963 (.200)	.288 (.653)	.251 (.737)	-.128 (.835)
Access to credit	-.299 (.767)	2.565** (.021)	4.511*** (.000)	.646 (.398)	4.563*** (.000)	.006 (.251)	-.090 (.931)
Access to Extension	-.742 (.391)	-.272 (.799)	.116 (.896)	1.284* (.051)	-.576 (.540)	.398*** (.006)	1.445* (.082)
Livestock ownership	.061 (.944)	.997 (.446)	-.230 (.814)	.135 (.854)	1.426 (.303)	.834 (.398)	.559 (.560)
Number of observation 135							
LR Chi- square 141.61							
Log likelihood -197.16							
Pseudo R- Square 0.662							

Notes: ***, **, * = significant at 1%, 5%, and 10% probability level, respectively

Ownership of livestock was positively but not significantly related with most of the adaptation options such as conserving soil and water, planting varieties of crops, and changing into supplementary irrigation farming, using of fertilizer and integrating crop with to livestock. Livestock ownership was negatively related with the use of improved seed, although not significantly (Table 5).

4. CONCLUSION AND RECOMMENDATIONS

This study was based on the analysis of the farm level climate change and variability adaptation mechanisms and focused on the tactical and strategic decisions of farmers in response to climate change and variability. These tactical decisions were influenced by a number of socio-economic factors. The MNL model indicates that education of the head of the household, gender of the head of the household being masculine, livestock ownership, extension on crop and livestock production, availability of credit have positive impact on most adaptation methods to climate change while household size was found negatively related with most of adaptation methods.

The major visible climate change related problems for sampled household being interviewed in the district were seasonal drought, flooding, complete crop failure, climate change induced health problem on human and livestock. Even though, households tried to offset the impact of climate change and variability using different adaptation strategies, there were eight major constraints like shortage of improved seed, lack of access to water for irrigation, lack of current knowledge on adaptation methods, lack of information on weather incidence, shortage of labor, lack of money to acquire modern adaptation technology, lack of infrastructure and lack of institutions that support the community to adapt climate change and variability affecting the household to not use more than one adaptation method.

those suggests that the educating farmer households through formal or informal mechanism, adjusting the farming activity to changing climate, climate forecasting mechanism, institutional supports like providing credit and extension service, improved infrastructure, expanding the social services and infrastructures like school, hospital, road, access to input and output market etc have been found an important policy measure for stimulating farm-level climate and variability adaptation strategies.

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