Households' Perceptions and Adaptation Techniques to Climate Variability in Drought-Prone Areas of the Amhara Region, Ethiopia

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Abstract

This study examines households' perceptions to climate variability and responses taken for food security in drought-prone areas of the Amhara Region, taking Lay Gayint district as a study site. Questionnaire survey, key informants interview and focus group discussions were employed to collect the primary data. A total of 201 households participated in the questionnaire survey. The study revealed that the high inter-annual and inter-seasonal rainfall variability were the primary cause for the decline of crop production and households' vulnerability to food security. This could be the reason that the majority of the households faced food deficit for several months in the year and the gap is filled by the government safety nets and other income generating activities. In all agro-ecological zones, the majority of the households perceived that annual rainfall is inadequate to support the growing of crops and grazing of animals. The study households also predicted that recurrent droughts would occur in the future mainly due to land degradation, high population pressure and erratic rainfall. The study found that planting trees for the market, livestock fattening, and stocking seed reserves to be vital adaptive strategies employed by the majority of the better-off households while, whereas the poor and vulnerable households utilized short-term responses to meet the shortfall of consumption needs. The study recommends that households' vulnerability to climate change and food insecurity could be minimized through appropriate and targeted risk reduction and management interventions that are well integrated to households' adaptive strategies related to climate change.

Key words: Perception, climate variability, food security, adaptation, Lay Gayint, Ethiopia

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1. Introduction

Climate change is ocurring and will continue to ocurr in the future, regardless of the extent of investments in mitigation measures . This change is rapidly emerging and the world is facing a greater challenge of accelerated human-induced climate change than ever before (Klein *et al*., 2003). The tragedy is that those countries which contributed little to the causes of greenhouse gas emissions are the ones most affected by climate related shocks. For instance, Ludi (2009) and Alebachew (2011)indicated that Africa with little contribution to climate change is the hardest hit in climate related shocks. Ludi (2009) noted that frequent and extreme weather events such as droughts and increasing irregularities in rainfall patterns have immediate impacts on household food security (availability, accessibility and utilization) and human health in Africa. These problems are aggravated by the limited resilience caused by economic poverty, subsistence food production and highly variable agricultural production potential (Mertz *et al.,* 2009).

The Horn of Africa (where Ethiopia is located) is one of the most vulnerable regions to climate change and related shocks in the continent (Kinyangi *et al.,* 2009). In this region, out of the total population, some 70 million (45% of total) people live in areas that have been subjected to extreme food shortage and hunger, and experience famine at least once in every decade (FAO, 2013). According to this report, countries such as Eritrea, Ethiopia and Somalia bear the largest share of these crises. Some writers such as Tagel (2012) indicated that almost every year, Ethiopia experiences localized drought disasters causing crop failure and jeopardizing its development endeavors. Evidently, the country had faced 15 major drought episodes that led to severe famine between 1953 and 1999 (Seid, 2012; Zerihun & Getachew, 2013). Since then, drought occurrences have become frequent, short and severe, though the 1984/85, 1993/94, 2000, and 2002/03 droughts were especially most horrific as they claimed huge numbers of human and animal lives (Birhanu, 2009; Alebachew, 2011; Seid, 2012).

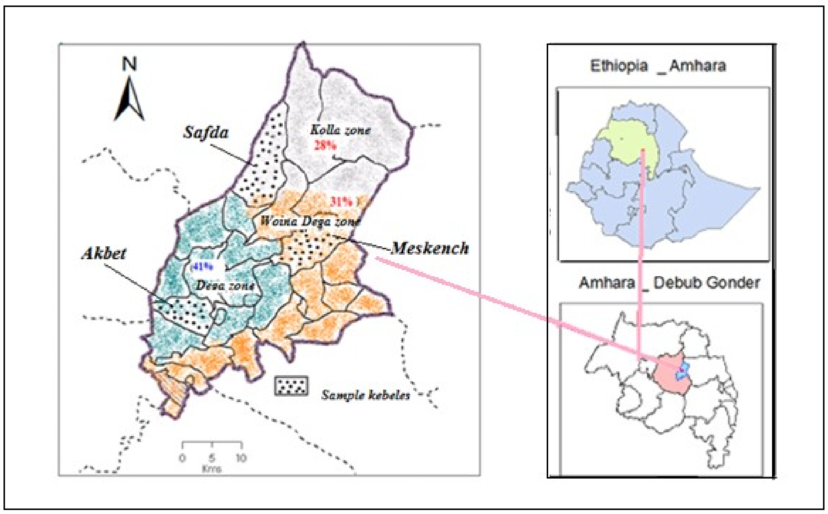
The eastern part of the Amhara Region (where Lay Gayint district is located) could be taken as the epicenter of drought and famine caused mainly by scarce and erratic distribution of rainfall. In this region, as high as 80% of the variability in the agricultural production is believed to be caused by the disturbance of weather and related factors (John *et al.,* 2009). As a result, Lay Gayint is identified as one of the districts in the Amhara Region (Arega & Woldeamlak, 2012) most vulnerable to climate variability manifested by erratic rainfall which poses a huge threat to poor farmers. This is due to the fact that about 93% of the households rely on small-scale subsistence agriculture, which is too sensitive to climate changes (Arega *et al.,* 2013). This study investigated households' perceptions about climate variability and the responses taken to counter the crises. Identifying potential long-term strategies against climate shocks can help policy makers and rural communities to mitigate adverse impacts of climate variability. The general objective of the study was to look into households' perceptions about climate variability and the responses taken to adapt to climate related shocks in the study area. The specific objectives were (i) to assess the perceptions of households' about climate variability; (ii) to assess the extent of rainfall and temperature variability in the district, and (iii) to identify the responses taken by the households against climate variability.

This study is distinct to other previous studies parts in Ethiopia (Deressa *et al.,* 2008; Woldamlak and Conway, 2007; Elisabeth, 2004; Kassa *et al.,* 2012; Kassahun, 2012; Tagel, 2012) which treated households' perceptions about climate variability and the responses taken to mitigate the shocks based on geographical location and wealth categories. Rural communities in the study area have been responding to climate shocks using their specific coping and adaptive strategies. However, there is no prior empirical study examined households' perceptions about climate variability and the coping and adaptive strategies practiced in the study area. More importantly, these previous studies provide very general data and fail short to offer specific information on household-level.

2. Materials and Methods

2.1. Description of the Study Area

The study was carried out in Lay Gayint district in the Amhara Region of Ethiopia (Figure 1). Lay Gayint covers a total area of 1320.3 km^2 and has a population density of 185 persons per km^2 (CSA, 2010), making it one of the very densely populated districts in the Region. The topography is rugged with elevations varying from 1200 m to above 4000 m asl. The area receives an annual rainfall of 898.3 mm. The mean annual temperature ranges from 4^{0}C (on top of Guna Mountains) to 28^{0}C (at the bottom of the Tekeze river valley). Based on the traditional agro-ecological classification, three agro-ecological zones are found in the area: *Dega* (cool), *Woina-Dega* (temperate) and *Kolla* (hot tropical). Small scale mixed agriculture is the dominant source of livelihood to the local people.



Figgure 1. Location map of Lay Gayint district in South Gondar Administrative Zone of Amhara Regional State

2.2. Research Methodology

Research design: The study employed concurrent mixed research design. This is due to the fact that mixed research design could help to collect and analyze quantitative and qualitative data simultaneously and allows for triangulating the results.

Study period: The fieldwork for the study started in December 2011. From December to January 2011, some preliminary survey was made to have general information about the climate change and variability and household perception to the predicaments in the district. The main survey began at the mid of March 2011 and lasted to the end of April 2011.

Sa***mpling procedures***: the study district was selected purposively based on the researcher's familiarity of the area and severity of the problem. In the district, there were 19 rural *kebele* administrations (RKAs). The specific RKAs were selected in a cluster sampling approach in which the 19 RKAs in the district were first clustered into three agro-ecological zones (*Dega,* *Woina-Dega* and *Kolla)* and three RKAs were selected usng random sampling procedure - one from each of the three agro-ecological zones .

Sample size determination: Using Kothari's (2004) sample size determination formula, the total sample size for the study was calculated as shown below:

$$n = \frac{z^2.p.q.N}{e^2.N - 1 + z^2.p.q}$$

Z= 2.005 (at 95.5% confidence level); n = total sample size; N= total population of the study, P = 0.02 (the result of past data); q = 1-p; e = the estimated made was within 2% true value

Using the above formula, a total of 197 sample households were identified for the survey questionnaire. However, to minimize the effectof missing data, the sample size for this study was adjusted to 210. In relation to this, Naing *et al.* (13) indicated that it is wise to oversample 10% - 20% in case there is missing data. Finally, 210 households were sampled for the structured interview from the three RKAs based on the sampling frames obtained from the RKA offices. Nonetheless, nine questionnaires were not correctly filled for analysis in *Kolla* agro-ecological zones; this made the total sample size to be 201in the three selected RKAs. In addition to the household survey, a total of six key informant interviews and three focus group discussions were conducted in each of the three RKAs.

Data collection techniques: The primary data from households were collected using structured interview, key informant interview, life history narratives, non-participant observations and focus group discussions. The structured interviews (questionnaires) were close ended and covered various issues: demographic and socio-economic characteristic of respondents, households' perceptions on climate change and variability and the coping and adaptive strategies employed by the households. The researcher, along with six enumerators, all speaking the local language, conducted the survey. The enumerators were first trained by the researcher about how to present and explain each question to the respondents and were advised to inform each respondent the purpose of the survey before starting the actual interview. The qualitative data on the other hand were collected from government officials, development agents, elderly and knowledgeable households, and with their consent tape recordde.

Data analysis: Information collected through key informant interview, FGDs, life history narratives and observations were documented and analyzed textually to substantiate the statistical results from the structured questionnaire. Upon completion of the quantitative data collection, the data were coded, edited and entered into SPSS version 20 and presented using descriptive statistics such as frequencies, percentages and tables. Rainfall data of the *woreda* were analyzed using the following indices.

1. **The coefficient of variation**

$$CV = \frac{standard\ deviation}{mean} x\ 100$$

2. **The precipitation concentration index**

$$\text{PCI} = \frac{\Sigma(pi)2}{(\Sigma pi)2} x\ 100$$

Where pi = the rainfall amount of the i^{th} month

PCI measures variability and concentration of rainfall

3. **Rainfall anomalies**

$$SRA = \frac{Pt - Pm}{\sigma}$$

Where SRA = standardized rainfall anomalies
Pt = the annual rainfall in year *t*
Pm = long term mean annual rainfall over a period of observation
σ = standard deviation of annual rainfall over a period of observation
SRA measures inter annual variability and severity of drought

3. Results and Discussion

3.1. Households' Perceptions about Climate Variability

Households in the study area stated that they have been observing a decline in rainfall and an increase in temperature for decades. This shows that farm households are able to recognize the changes of temperature and rainfall using their indigenous knowledge. As it is shown in Table 1, sufficiency and distribution of rainfall, changes in temperature and incidence of drought were some of the indicators of climate variability in the study area. Likewise, the main indicators of climate change according to the opinions of KIs in different agro-ecological zones were investigated. Accordingly, frequent drought, decreasing rainfall, increasing temperature and increasing wind speed are identified as indicators of climate variability in the study area. As it can be seen in Table 1, about 99% households in *Woina-Dega* and 79% in *Kolla* zone indicated that rainfall is extremely irregular during the growing of crops. In all agro-ecological zones, around 80% of the respondents confirmed that the entire distribution of rainfall was unsatisfactory. Similar studies in three Tigray districts showed that 99% of respondents evidenced the irregularity of rainfall in amount and distribution during the main rainy season (Nigussie & Girmay, 2010). The analysis of data about perceived changes in temperature also showed that 82% of respondents in all agro-ecologies ascertained the increment of temperature in their localities (Table 1). However, perceived changes in temperature varied between agro-ecological zones, in which about 98% of the respondents in *Kolla* zone and 82% in *Dega* zone agreed that temperature has increased through their lifetimes.

Table 1. Sample households' response about climate variability (% respondents)

Options	Response	Agro-ecological zones			Average
		Dega	*Woina-Dega*	*Kolla*	
Has rainfall decreased for the last 20 years?	Yes	34.6	65.7	89.7	63.3
	No	65.4	34.3	10.3	36.7
Does the rain come on time?	Yes	42.9	1.4	65.5	17.4
	No	57.1	98.6	93.5	82.6
Do you observe enough rain at the beginning of the rainy season?	Yes	81.4	2.9	13.1	33.3
	No	18.6	97.2	86.9	66.7
Is there enough rain during the planting and growing season?	Yes	39.6	1.4	21.3	20.4
	No	61.4	98.6	78.7	79.6
Does the rain stop on time in your locality?	Yes	18.6	1.4	19.7	19.9
	No	81.4	98.6	80.3	87.1
Is there frequent rain during the harvesting period?	Yes	91.4	68.6	34.4	66.2
	No	8.6	21.4	65.6	33.8

Do you think that your RKAs will be affected by drought in the future?	Yes	66.0	96.0	95.0	84.0
	No	34.0	4.0	5.0	16.0
Do you think that food shortage can occur in your *kebele* in the future?	Yes	16	59	54	43
	No	84	41	46	57
Perceived change of temperature for the last 20 years	Increasing	82.0	67.0	98.0	82.0
	Decreasing	18.0	33.0	2.0	18.0

Supplementary information collected showed that streams/springs and in some localities, perennial rivers extremely declined or dried up during the dry season mainly due to climate change/variability. KIs also indicated that the regular seasons for planting major crops was disrupted in their localities in their localities. For the last 20 years, farmers start to grow crops in the middle or by the end of May, however, at the present situation, the planting period has been moved to the middle or end of June. This indicated that the onset of rainfall had shifted from May to June, which is unsuitable for crops such as potatoes and barley. The result was consistent with the works of Kassa et al. (2012) which state, in the remote past; people could see fully germinated crops till 12 July and matured crops till 22 August. However, the rains, which normally used to start in mid-June shifted to July and ceased much earlier (mid-September) than was normally the case.

Information from elderly and knowledgeable farmers showed that drought occurs at an interval of two to five years and this scenario is likely to continue in the future, which was not true for the last 20 years. World Bank (2006) noted that in Ethiopia, drought is a widespread phenomenon, which occurs in between three and five years. This showed that climate change related hazards are felt by the rural communities at grassroots, as manifested in erratic rainfall and an increase in temperature. In relation to this, a key informant in *Kolla* zone shared his experience as follows:

> . . . Temperature has increased and the rate of change is profound. Changes in rainfall amount and seasonal distribution are evident; the amount of rainfall tremendously dropped, and rainfall starts late and ends early. Adjusting to the changing climate is really a complex and unsuccessful task for the majority of the farmers including me. Following dry spells, the outbreak of pests and the frequency of drought occurrence have increased through time making the farming activities more complicated. Perennial rivers have become ephemeral, and springs and streams completely dried up during the dry seasons creating burden to my livestock and household consumption. During October and November, when the crops mature, a very strong wind aggravates the transpiration of crops and they soon wilt dramatically reducing the total crop production in my locality. In my opinion, all these predicaments are the result of climate change.

3.2. Households' Perceptions about the Natures and Causes of Drought

The survey data showed that sample households defined drought in different ways. About 35% of the respondents understood it as the culmination of the rainy season ahead of the maturity of crops. About 41% of them, on the other hand, defined it as a shortage of food and 82% expressed a decline of rainfall from the normal distribution. About 90% of the respondents conceived it as a failure of crop production. Households likewise held different perceptions with regard to the causes of drought. About 95% of the respondents reported erratic rainfall as the major cause of drought, while about 80% of households believed it was insteaddeforestation. On the other hand, about 33% and 94% of the sample households identified soil degradation and population pressure respectively to be the main causes of drought in their localities (Table 2).

Table 2. Sample households' perceptions about the causes of drought (% respondents)

Causes	*Dega*	*Woina-dega*	*Kolla*	Avergae
Erratic rainfall	90	97	98	95
Deforestation	75	85	80	80
Soil degradation	25	30	45	33
Overgrazing	78	89	92	86
Population pressure	94	93	94	94
Low use of inputs	15	25	19.8	19.9

Note: the total is not 100 due to multiple options

In this regard, a key informant in the *Woina-Dega* zone shared his experience as shownbelow:

> Drought is caused by deforestation, which results from over-cultivation, overgrazing and population pressure. Degradation of farmlands and soil erosion from hill lands, erratic rainfall and incidence of various natural events such as blight and frost, weather and climate changes are the major causes for the frequent occurrence of droughts in our locality. In my opinion, it is a punishment from God for our transgression.

Drought has direct and indirect impacts on the livelihoods of communities. The survey result showed that 87% of the respondents associated the direct impact of drought with the loss of crop production. About 34% and 27% of the respondents perceived that the declining water levels and the loss of wildlife are the direct impact of droughts, respectively. About 69% of the respondents indicated that reduction of income level (increased poverty) was the primary manifestation of the indirect impacts of drought while 58% of those sampled allude this to social instability. Considerable number of respondents also attribute the increase in the price of food (84%) and the conflict over the use of water resources (68%) to the indirect impacts of drought in their localities. The impacts of drought could be manifested through social, economic, institutional and environmental situations. In this regard, decrease in crop and livestock production and loss of income were mentioned by 79% and 32% of the respondents, respectively as the major economic impacts of drought in their localities. For about 75% of the respondents land degradation was the major environmental impact of drought whereas for 38% others it was rather the loss of biodiversity. About 52% of the respondents explained that conflicts arising from shortage of water are causes of social unrest and are the main institutional impacts of drought in their localities. These findings corroborated that drought is the single most important climate related natural hazards impacting the livelihoods of the rural poor at most.

3.3. The Nexus between Rainfall Variability, Crop Production and Food Security: Households' Perceptions

The major livelihood of the sample households in the study area is mixed farming dominated by crop production. As the practice of crop production is highly dependent on climate related factors, droughts associated with erratic rainfall operate as the major causes for the decline of crop production, and subsequently force households' to be vulnerable to food insecurity. Thus, changes in precipitation patterns and amount, and changes in temperature could influence crop growth through changes in soil water content, runoff and erosion, nutrient cycles, salinization, biodiversity, and soil organic matter (Verchot *et al.,* 2007).

Sample households' perceptions about the general trends of crop production and food security for the last 20 years were assessed. The indicator variables were agro-ecology, age, household size and sex of the heads (Table 3). This is because of the assumption that households who have long experience in farming can predict the trends of crop production better than those with little experience . As it is shown in Table3, households who perceived that crop production has increased for the last 20 years were relatively aged farmers. About 56% of the households who responded that there was an increment of crop production were between the ages of 40 and 49 years. In contrast, about 83% of the male-headed and 100% of the female-headed households had perceived that there was a decline of crop production for the last 20 years. Agro-ecologically, respondents from *Dega* (68%), *Woina- Dega* (96%) and *Kolla* (90%) believed that crop production has shown a decreasing trend for the last 20 years (Table 3). Birhanu (2009), in a study made in the south Gondar administrative zone of the Amhara Region, found out that in 2001, crop production in Lay Gaint district was 409,877 quintals and had decreased to 341,421 quintals in 2005, and it dropped to a little greater than 250,000 quintals in 2013 (Figure 2). Of the three agro-ecological zones, households' perceptions for getting worse of crop production were the highest in *Woina-Dega* (96%) and *Kolla* (90%) (Table3). Of the 27 respondents who replied that crop production had increased, 74% were from *Dega* zone*,* 18% from *Kolla* and the rest were from *Woina-Dega* zone. The survey data also revealed that 41% of the sample households in *Dega* zone were food secure as compared to 6% in *Woina-Dega* zone. Though the regional government is working hard to increase crop production to realize food self-sufficiency at household level, the program is not successful in many drought-prone areas such as Lay Gayint in which erratic rainfall is the major challenge for crop production.

Table 3. Households' perceptions about the trends of crop production for the last 20 years (% respondents)

		Got worse	Got better	No change
Agro-ecological zone	*Dega*	68.6	28.6	2.8
	Woina-Dega	95.7	2.9	1.4
	Kolla	90.2	8.2	1.6
	Average	85.0	13.4	1.6
Sex	Male	82.8	15.5	1.7
	Female	100	-	-
Age	20-29	5.8	-	34.3
	30-39	14.6	7.4	-
	40-49	32.7	55.6	66.7
	50-59	21.0	29.6	-
	≥ 60	25.7	7.4	-
	Total	100	100	100

Households' perceptions about the trends of individual crop production for the last 20 years were also examined. Accordingly, the average crop production in all agro-ecological zones exhibited a negative trend (r = - 0.42, at p < 0.01) over the years. Among the crops grown, triticale, wheat and barley showed significant positive correlation (r = 0.76, 0.65 and 0.48, respectively, at p < 0.01), while crops such as *faba* bean, field peas and *tef* had shown statistically significant but negative correlation (r = -0.87, - 0.56, -0.34, respectively, at p < 0.05). Inconsistent with the above results, Kassa et al. (2012) reported that barley, wheat and chickpea showed a significant and negative correlation with *r* values of - 0.69, - 0.51 and - 0.49, respectively.

As it is shown in the preceding discussions, crop production for some selected crops, which could be taken as the major means of livelihood for the majority of the sample households showed a declining trend over the years. The reasons for the decline of crop productions, according to the survey respondents, were erratic rainfall (98%), lack of capital to buy inputs (97%), land scarcity/too small a plot (89.7%), soil fertility decline (81.7) and soil erosion (83%) (Table 4).

Table 4. Households perceived causes for the decline of crop production

Perceived causes	**% respondents**
Soil infertility	81.7
Soil erosion	83
Water logging	29
land scarcity/too small a plot	89.7
Rugged topography	67.9
Drought/erratic rainfall	98
Pests and diseases	51
Shortage of labor	23
Scarcity of farm oxen	67
Lack of capital to invest on inputs	97
Weak extension system	45

Note: the total is not 100 due to multiple options

KIs and FGD participants were also asked to list down the constraints of crop production based on severity. Accordingly, rainfall variability, drought, land degradation and shortage of land were the major constraints of crop production ranked as *very high* in all agro-ecological zones. Likewise, feed shortage, livestock and crop diseases and pests, hail damage, shortage of oxen, high cost of input packages, lack of adequate supply of improved varieties and rugged topography were ranked as *high* in the three agro-ecological zones. The multiple response results showed that use of compost (91%), terracing (91.5%), crop rotation (73.6%), chemical fertilizers (48%), fallowing (18.3%), tree planting (60.7%), and contour plowing (93%) were the measures taken to increase crop production in the study area. The low response rate for chemical fertilizers was associated with the high cost of price and the low purchasing capacity of the sample households, the severe land degradation and the erratic rainfall and/or drought. Woldeamlak (2003) substantiated that the use of artificial fertilizers and other factor inputs that will improve productivity (such as improved seeds, herbicides, pesticides) is very low, and indeed beyond the reach of the majority of the poor farmers. As a result, sample households consumed on average less than half a quintal of chemical fertilizers and insignificant amount of improved seeds and no one reported the use of pesticides and herbicides in 2010/2011 cropping year. Sample households were also asked about the situations of food security for the last 20 years. About 82% mentioned that the situations got worse, while 13.4% indicated better (Figure2). The reasons given for the decline of food security were land degradation, high population pressure and erratic rainfall.

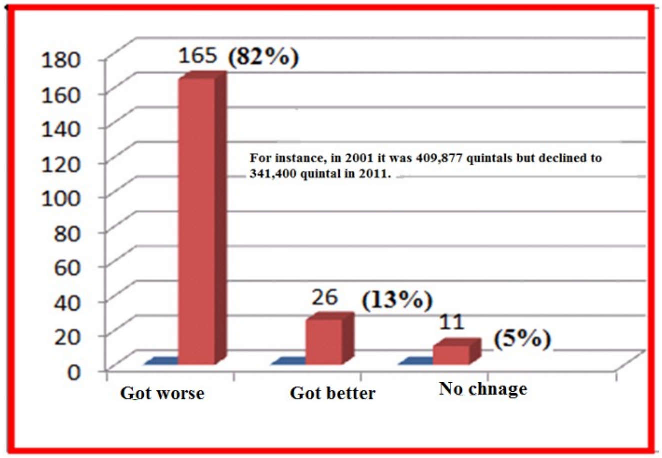


Figure 2. Household perceptions on food security

3.4. Crop Production and Rainfall Trends in the Study Area

As it can be seen in Figure 3, the general tendency of crop production in the study district exhibited a declining trend with high inter-annual variations. In some years, production was higher, and lower in others. For example, between 2009 and 2011 production was higher but abruptly decreased in 2013. Hence, the variations of crop production, which are the main cause of food insecurity, are the direct reflection of rainfall variability. As depicted in Figure 3, as rainfall increases, crop production also increases. The bivariate correlation result showed that there is a strong correlation between crop production and rainfall distribution ($r = 0.88$, at $p < 0.001$).

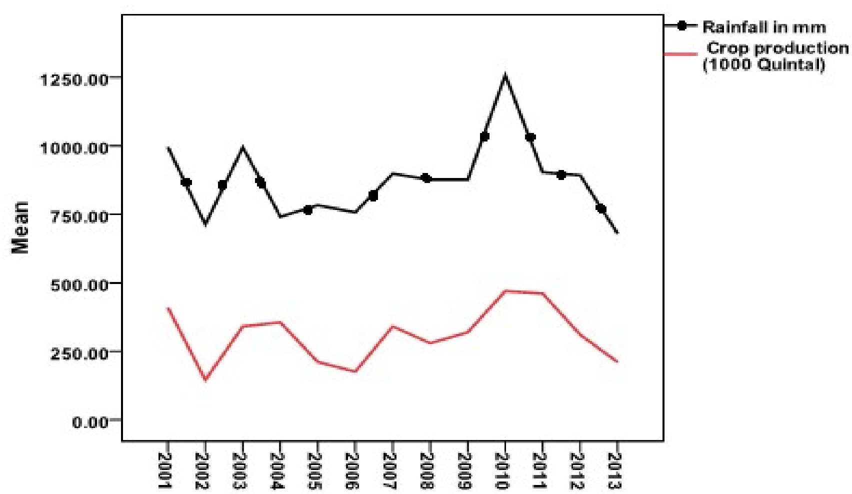


Figure 3. The relationship between crop production and rainfall trends *in* Lay Gayint district (2001-2013)

So far, households' perceptions about climate variability and trends of crop production were discussed. In the sections which follow, the meteorological data obtained at Nefas Mowcha (11^0 04' N latitude and 38^0 12' E longitudes) is compared to households' perceptions to climate variability. For this purpose, the monthly rainfall and temperature data for 26 years (1986-2011) were employed for the analysis.

3.5. Analysis of Climate Data of Lay Gayint District

3.5.1. Rainfall Variability

The main rainy season in the study area, which is also true to the north central highlands of Ethiopia, is determined by the Inter-Tropical Convergence Zone (ITCZ), which covers the north-west of the country, and is commonly referred to as summer rain. The general distribution of annual rainfall is seasonal and varies in amount, area and time as it moves from the southwest to the northeast of Ethiopia (EDHS, 2012). The study area enjoys the maximum rain during the northern summer originating from the Atlantic Ocean, which spans from June to September. However, the spring rain, which extends from January to April and which originates from the Indian Ocean, yields little rain to the study area. Due to the effect of climate variability, there is high inter-annual rainfall variability in the study area. For instance, in 1991 the mean annual rainfall recorded was 605.1 mm and greatly increased to 1192.2 mm in 1998 and dropped to 700 mm in 2002 (Figure 4). As it is shown in Figure 4, the amount of rainfall showed a decreasing trend, negatively affecting the planting and growing periods of crops. Woldeamlak & Conway (2007) indicated that the total rainfall in the north central highland of Ethiopia (where the current study is located) remarkably declined in the second half of the 20th century.

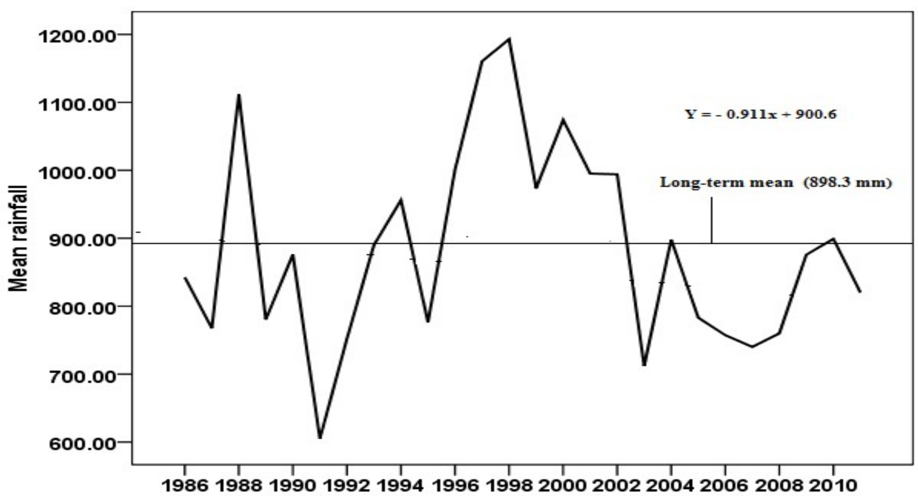


Figure 4. Mean annual trends of rainfall at Lay Gayint district (1986-2011)
Source: ANRS meteorological office

In addition to the inter-annual variability, there is also *spatial variability* of rainfall in the study area (Figure 5). Average rainfall was the least in the northeastern and eastern parts of the study area, while the southern and southwestern areas receive relatively higher amount of rainfall explained by variations in elevation (Figure 5). The study area located in less-favored and moisture deficit areas of the north central highland of Ethiopia have suffered from agricultural, meteorological and hydrological droughts. As observed in the field, there is a clear soil moisture stress and many of the rivers, streams and springs were without water and/or dried up in many parts of the study area during the dry seasons. With the exception of few wet summer months, spring and winter in most cases are recognized by prolonged deficit of precipitation. This, in turn, affects the agricultural activities practiced during the spring season, which are used for the growing of barely, cabbage and potatoes- what McCann (1990) called 'food stopgaps'.

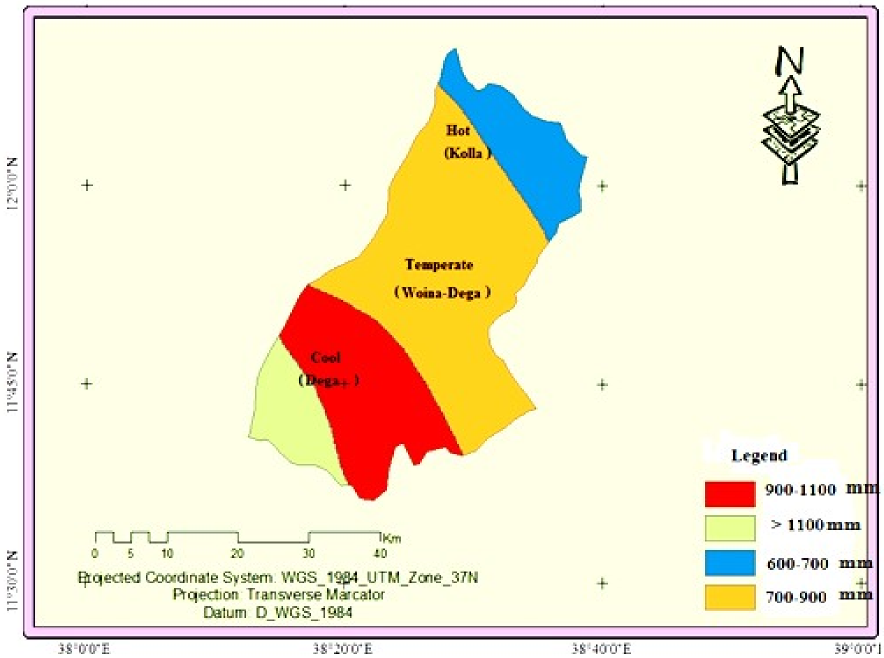


Figure 5. Spatial distribution of mean annual rainfall in mm of Lay Gayint district

3.5.2. The coefficient of variation and precipitation concentration index

The mean annual rainfall in Lay Gayint district for the last 26 years was 898.3 mm with a standard deviation of 165. The mean annual rainfall could be sufficient for crop production, if the amount of rainfall were distributed fairly for the growing months. However, this is not the case for the study area. For example, the long-term mean annual rainfall showed that about 70% of the total amount of rainfall is concentrated into two wet months (July and August) aggravating soil erosion, floods and landslides. The coefficient of variation for the 26 years was 20.5%. As it is shown in Figure 6**,** the coefficients of variation ranges from a little lower than 12% to above 24%, indicating that there was considerable variability of rainfall between years. The result was consistent with the works of Rosell & Holmer's (2007), Woldeamlak & Conway (2007), Kassa et al. (2012) and Elisabeth (2004).

The calculated precipitation concentration index (PCI) for the study district was about 21%. Woldeamlak and Conway (2007) showed that a PCI of less than 10 indicates uniform distribution, between 11% and 20% shows high concentration and greater than 20% indicates very high concentration. This result showed that the rainfall distribution in the study area was highly concentrated in the few wet months (July, August and September). The percentage distributions of rainfall for the 26 years was found to be 8.7% for winter, 75.6% for summer and 15.7% for spring season. Woldeamak and Conway (2007) noted that the contribution of summer rain to the annual total ranges from 64% in Combolcha to nearly 85% in Gorgora.

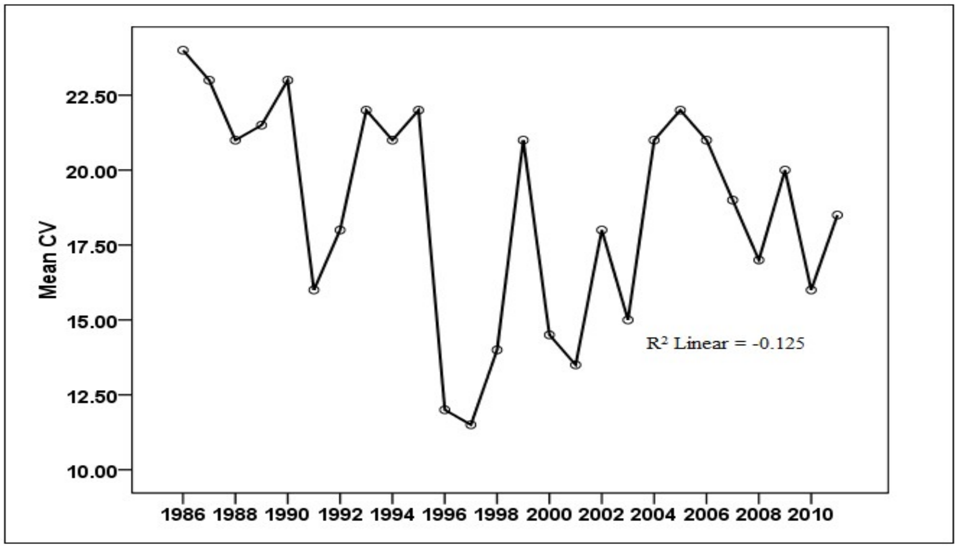


Figure 6. Coefficient of rainfall variation of the study area (1986-2011)
Source: ANRS meteorological office

3.5.3. Standardized Rainfall Anomalies (SRA)

As it is shown in Figure 7, from the 26 years of SRAs, about 53% were negative. In this regard, Hauskin (2000) stated that above 50% of rainfall anomalies below the mean are considered as severe metrological drought. Thus, the study area has experienced severe meteorological drought for the last couple of decades and there is a tendency towards greater frequency of dry years. Figure 7 also shows the three years in which the most severe or extreme drought occurrences were recorded (i.e. year 1988, 1991 and 2002).

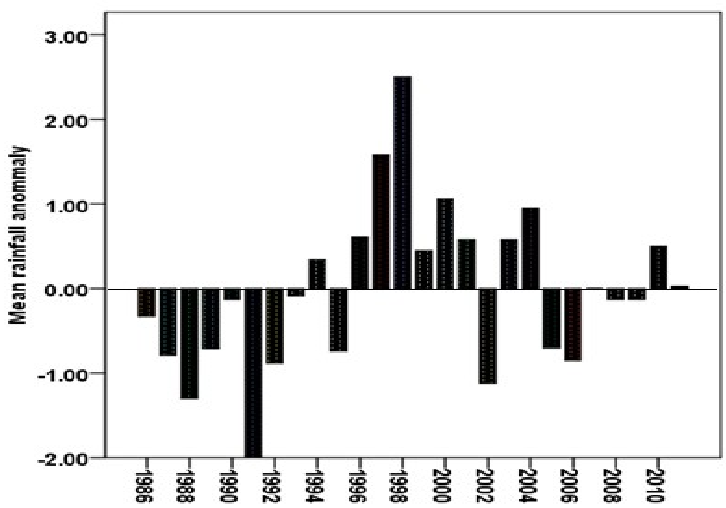


Figure 7. Standardized rainfall anomalies of the study area (1986-2011)

The overall results showed that the study area, like most of the northern highlands of Ethiopia, was predominantly characterized by moderate to severe drought. From the total SRAs calculated, 55% were found between moderate and extreme drought. Years with no drought accounted for 45% indicating that drought is a serious problem in the study area (Table 5).

Table 5. Drought severity classes in the study area (1986-2011)

Drought severity classes	Status of drought	% Total
- 2.0 and less	Extreme drought	3.8
- 1.5 to -1.99	Severe drought	7.7
- 1.0 to -1.49	Moderate drought	43.5
- 0.99 or above	No drought	45.0
	Total	100

3.5.4. Temperature Variability of the Study Area

The mean annual temperature showed that there was a great change of temperature in Lay Gayint district (Figure 8). The paired t-test indicated that the variability of temperature over the years was statistically significant (at $p < 0.01$). More importantly, the result of the temperature data in the study area revealed that there was an increase of temperature by about 1.25^0C for the last three decades.

Likewise, Keller (2009) indicated that the patterns of temperature in Ethiopia showed an increasing trend but the increase is more pronounced since 2000 onwards. The Spearman's rho test, for example, evidenced that there is a positive and statistically significant change in mean temperature over the years in the study area ($r = 0.56$, at $P < 0.01$). An increase in temperature, especially in the degraded and drought-prone areas, aggravates evaporation directly affecting the moisture absorbing capacity of the soils. Tropical diseases such as malaria, yellow fever and meningitis (among others) are newly emerging diseases mainly caused by temperature variability/change.

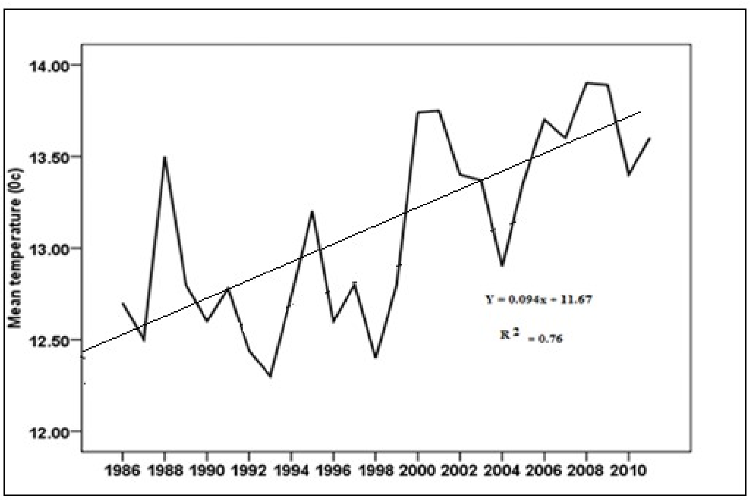


Figure 8. The trend of temperature in Lay Gayint district (1986-2011)

3.6. Households' Coping and Adaptive Strategies

The study investigated that the decline in crop production and the increase in the number of safety nets beneficiaries were due to erratic rainfall, land degradation, high population pressure and the increasing frequency of droughts. Consequently, households in the study area suffered from chronic and transitory food insecurity for many years; and the extent of the crisis is becoming more broad and deep. Failure or unpredictable rainfall is the main cause for the decline of crop production and incidence of food insecurity. Thus, food self-sufficiency at household level is mainly caused by drought and erratic rainfall. To this end, response measures such as coping and adaptive strategies are commonly practiced to ensure food self-sufficiency and hence food security in the study area. According to Halonen et al. (2009), taking the potential increase in climate extremes into account, Ethiopia will have to find ways to adapt to these scenarios. Likewise, Thomas et al. (2007) underscored that individuals, communities, and nations have to cope with and adapt to climate variability to mitigate the changes.

The study revealed that the major coping strategies taken by the households during crises times include reducing the quantity of meals (69%), postponing special festivals (78%), selling small ruminants (64%), harvesting immature food crops (58%), selling old livestocks to buy food (54%) and receiving productive safety nets (56%) (Table 6).

Table 6. Households' coping strategies (% respondents)

Coping strategy	*Dega*	*Woina-Dega*	*Kolla*	Average
Reductive strategy (minimizing risk)				
Reducing the quantity of meals	81.4	71.4	44.3	65.7
Reducing the numbers and types of meals	8.2	65.7	77.1	50.3
Postpone special festivals	67	78	89	78.0
Selling small ruminants	75.7	75.7	36.1	62.5
Selling charcoal and fuel wood	22.9	42.9	36.1	34.0
Depleting strategy (absorbing risk)				
Harvesting immature food crops	82.9	52.9	36.1	58.0
Selling old livestock to buy food	54.3	75.7	27.9	54.0
Consuming seed reserves	52.9	54.3	37.7	49.0
Selling expensive assets	18	13	16	15.6
Maintaining strategy (risk taking)				
Out-migration of family members	51.4	30.0	61.0	47.0
Going without food throughout the day	54.3	31.4	11.5	33.0
Selling land to purchase food	14.3	25.7	47.5	28.0
Consuming wild foods	40.0	28.6	9.8	27.0
Begging	7.1	1.4	21.3	9.0
Regenerative strategies (livelihood diversification)				
Engaging in casual labor	41.4	31.4	37.7	37.0
Engaging in petty trade	28.6	28.6	24.1	27.1
Changing coping into adaptive strategies	18.0	12.0	14.8	14.9

On the other hand, long-term (planned) strategies employed by the households fearing of future crises include diversification of crops (72.2%) such as barely, triticale, wheat and pulses; diversification of livestock kept (72.5%) including sheep, goats, cow, donkey and chickens; seed reserves (64.4%); growing of eucalyptus trees and fruits such as apple (~ 64%) and use of water harvesting technologies (20.4%) (Table 7).

Table 7. Adaptive strategies of the sample households by agro-ecological zones (% respondents)

Adaptive strategies	*Dega*	*Woina-Dega*	*Kolla*	Average
Diversifying crops	89.7	79.6	67.2	72.2
Diversifying livestock	98.6	82.9	36.1	72.5
Seed reserves	95.7	84.3	13.1	64.4
Growing eucalyptus trees and fruits	94.3	78.6	18.3	63.7

Fattening livestock	85.7	61.4	21.3	56.1
Growing fast maturing plants	92.8	31.4	34.4	52.9
Diversifying plots	88.6	61.4	0.0	50.1
Livelihood diversification	39.5	21.8	14.9	25.4
Water harvesting	28.6	30.0	0.0	20.4
Saving expensive materials	8.6	34.3	0.0	14.4
Natural resource conservation	76.4	56.5	23.5	52.1

From the qualitative data collected, it can be recapitulated that the poor households in all agro-ecologies were engaged primarily in coping strategies to avert the unfavorable situations, while the better-off farmers were engaged dominantly in planned strategies. Petty trading, livestock fattening, livestock diversification, growing perennial trees such as eucalyptus and apple fruits were commonly employed by the better-off households in the study area. Smoothening consumption, borrowing from relatives, public works, sale of charcoal/fuel wood, sale of cake dung, being engaged in causal labor, and desperate out-migration are strategies commonly practiced by the poor households in the study area.

4. Conclusions

Located in the drought prone part of the region, households in Lay Gayint district (the study area) commonly experience irregularity in the arrival of the first rains, inadequacy in the amount received and failure in the middle of the growing of crops; however, the problem is more severe in *Woina-Dega* and *Kolla* agro-ecological zones. There is also high inter-annual and inter-seasonal rainfall variability which resulted in the decline of crop production and exposes households' to vulnerability to food insecurity. This could be the reason that the majorities of the households faced food deficit for six months and attempted to fill these gaps through the government's safety nets program and other income generating activities. To minimize the risk of harvest failure, farmers in the study area opted for short maturing crops rather than long cycle crops and developed water-harvesting techniques though poorly implemented. The study found out that not all households sampled were involved in all the adaptation strategies identified because of variations in asset ownership and the capacities and skills equipped in ameliorating the predicaments. The results and findings demonstarte that studies in relation to households' perception to climate variability have paramount importance for water resource management, sustainable agricultural development planning, land resource management and household food security outcomes.

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