ORIGINAL ARTICLE

CROP SENSITIVITY TO INTER-ANNUAL CLIMATE VARIABILITY IN LAY GAYINT WOREDA, NORTHWEST ETHIOPIA

Addisu Baye[1] and Menberu Teshome[2]

ABSTRACT

Scientific evidence indicates that climate change has posed profound effects on the wellbeing of citizens in countries throughout the world. Its impact is even stronger on the poor having limited capacity to cope-up with it. In Ethiopia, climate change risks such as droughts, floods and other extreme weather events have threatened the overall sustainability of agricultural production and, in turn, the status of food security. The objective of this study is to examine crop sensitivity to inter-annual climate variability in Lay Gayint woreda, *South Gondar Zone of Amhara Region. Simple regression and drought susceptibility indices were used to analyze the data. The statistical analysis of the climate data revealed an increase in temperature, and decrease and/or erratic distribution in rainfall. Based on these findings the paper encourages strategies that can enhance the ability of farmers and soil productivity. Additionally, water conservation projects with the active participation of the rural communities are considered as essential.*

Keywords: climate variability, crop production, crop sensitivity, drought susceptibility

INTRODUCTION

Recent assessments indicate that climate change is already having an impact on crop yields across several regions of the world. Although positive impacts are observed in some regions, negative consequences are more common globally on aspects of food security, freshwater, health, nutritional quality and safety of food, biodiversity, and ecosystems.

Ethiopia is one of the sub-Saharan Africa countries situated in the Horn of Africa. Climate change and variability have posed critical implications for the country's agriculture, water, health and forestry. Indeed, Ethiopia is among the most vulnerable entities to climate variability and extremes, given that only a small proportion of its cultivated land used for food production is through irrigation (Temesgen Deressa et al., 2006). The majority of the population is engaged in rain-fed traditional farming systems and economic development is heavily reliant on agriculture, and natural resources, which are more sensitive to climate change. Thus, vulnerable livelihoods and national economic growth are likely to be highly affected by climate

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variability and extreme weather events can be expected to have adverse consequences on poverty reduction and development efforts (Girma Mamo & Fekadu Getatchew, 2010).

According to Girma Mamo and Fekadu Getatchew (2010), a recent mapping on vulnerability and poverty in Africa categorized Ethiopia in the group of the most vulnerable countries to climate variability and change with heavy dependence on agriculture (crops and livestock production). Climate variability and the resultant deterioration of natural resource bases have challenged Ethiopia's entrance to the new millennium with high hopes of a renaissance and a dream of better life for all citizens in the coming decades. Climate variability and change will continue to affect the country's agriculture, water resources, biodiversity and ecosystems. Hence, it will threaten the livelihood of the people; large sections of the populations residing in the lowlands and highlands will probably face increasing suffering in the coming decades (Seyoum Mengistu & De Stoop, 2007).

In Ethiopia, rain-fed dependent agriculture is very sensitive to fluctuation in climatic conditions. Even if productivity grew, climate change would still have a dramatic impact. The effects of climate variability on agricultural productivity may reduce the Ethiopian average income by as much as 30 percent within the next 50 years (Mahmud Yesuf et al., 2008). Moreover, it has led to shortage of food and increased human and livestock health risks, rural-urban migration and dependency on external support (National Meteorological Agency, 2007).

The Amhara region is known for its crop production in the country and is characterized by high rainfall from mid June to early September. Over 85% of the economically active population is engaged in the agricultural sector. However, some parts of the region, especially the northeast, are exposed to shortage of rainfall, which is less than 700 mm per year (Center for Disease Control and Prevention, 2008) and shortage of food throughout the year. Many *woreda*s located in North and South Gondar zones, East Gojjam and North Shewa administrative zones were surplus-producing areas before two decades. But now they have already become food insecure and highly vulnerable to climate variability (Melesse, 2007). Thus, out of the eleven *woreda*s of South Gondar administrative zone, five *woreda*s, namely Simada, Ibnat, Lay Gayint, Tach Gayint and Libokemkem, were considered drought-affected (Marye, 2011). Lay Gayint *woreda* is one of the areas where the localized temporal rainfall and temperature variation during cropping season induces an important challenge to crop production. According to the information obtained from the Lay Gayent woreda Agriculture and Rural Development Office (2010), extreme weather events such as increased flooding, droughts, insect outbreak, spreading of alien weeds, disease, and pests are aggravating food insecurity; in consequence, all communities need to enhance their adaptive capacity to combat the present and future challenges of climate variability and extreme weather events (Adger et al., 2003).

Several studies have shown that climate change has the potential to have a severe negative impact on human welfare, natural resources and development activities in the country (Alebachew Adem & Woldeamlak Bewket, 2009; Mahmud Yesuf et al., 2008; Temesgen Deressa et al., 2006). However, most of these studies were carried out at macro-levels. Unless the effect of climate variability is understood by the local people at the micro-level with the right perception, it would be difficult to convince and motivate local communities to undertake adaptation actions. Although the climate-change research community has identified different adaptation methods, the specific climatic characteristics of a particular area dictates the need for a specific adaptation method to climate variability and change. Moreover, the previous studies greatly focused on technology development without due consideration to climate variability.

Climate variability responsive research aimed at providing farmers with technological recommendations for adaptation has been up to the present typically very small. To minimize the impact and reduce vulnerability of the agricultural sector to the predicted change research aimed at evaluating and availing adaptation strategies at local and community level is an urgent priority. There is a need to monitor climate variability and integrate it with policies for research and development in order to prepare Ethiopia to the projected changes. An understanding of the local effects of recent climate trends on crop yields will help to anticipate effects of future climate variability on food self-sufficiency of the study area. This study will examine crop sensitivity to inter-annual climate variability in Lay Gayint woreda, South Gondar Zone of Amhara Region.

STUDY AREA

The study was conducted in Lay Gayint *woreda*, which is located in South Gondar Zone of Amhara Regional State. It is one of the ten *woreda*s of South Gondar zone covering an area of 1320.31 km^2 and sub-divided into twenty nine rural and two urban *kebele*s (the lowest administrative tier in Ethiopia). The *woreda* is bordered by Mekiet *woreda* in the east, Ebinat and Bugina in the north, Estie and Farta in the west and Simada and Tach Gayint in the south. The *woreda* lies within the geographical grid coordinates of 11°32'-12°16' N latitude and 38°12'-38°19' E longitude (Lay Gayint woreda Agriculture and Rural Development Office, 2011).

The total area of the *woreda* is about 154,866 hectares with a crude population density of 157 persons per km^2. The area has very steep valley and incised stream channels with slopes ranging from 30.5% to 50%. The major land use patterns of the study area comprise cultivated land (44.32%), grazing land (14.31%), forest/bush land (5.26%), water body (2.38%) infrastructure and settlement (5.92%), and unproductive land (28.44%) (Table 1).

The topography of the *woreda* is mostly characterized by a chain of mountains, hills and valleys extending from Tekeze Gorge (1500) to the

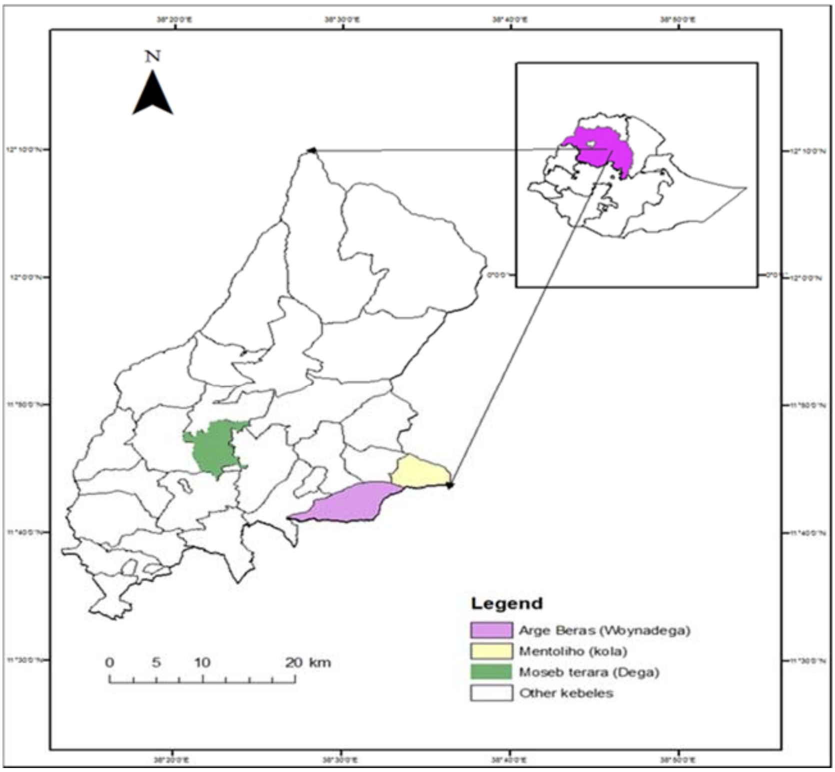

Figure 1: *Location map of the study area*
Source: Computed based on Ethio-GIS database.

summit of Guna Mountain (4230 meters above sea level). It is characterized by flat (10%), 50% undulating (50%), mountainous (15%) and gorges and valleys (5%). Agro-ecologically, the *woreda* is divided into four elevation and temperature zones, namely: lowland (*kolla*) (12.5%), midland (*woina-dega*) (39.42%), highland (*dega*) (45.39%), and *wurch* (very cold or alpine) (2.71%).

Table 1: *Distribution of land use/cover of Lay Gayint* woreda

Land use type	Ha	%
Cultivated land (annual crops)	68,649	44.32
Grazing land	22,160	14.31
Bush and shrubs	8,150	5.26
Water body	3,665	2.36
Uncultivated land	44,041	28.44
Infrastructure, settlement & others	8,201	5.29
Total	154,866	100.0

Source: Finance and economic development program of south Gondar, 2010.

Most of the rural population is settled on the highlands and plateau areas (South Gondar Zone Information and Communication Office, 2010).

The annual mean minimum and maximum temperatures range from 8° C to 29° C. The long-term average rainfall is 635 mm and is characterized by high variability and uncertainty. Problems of deforestation, overgrazing, poor quality soil, and lack of water conservation measures have contributed to the prevalence of drought in the *woreda*. The main rainy season occurs between June and September which represents the long rainy season (*meher*) and the small rainy season (*belg*) occurs between March and May. For crop production the highland areas (*dega*) depend in most cases on *belg* rain whereas the *woina-dega* and *kolla* areas depend on *meher* rain (Lay Gayint woreda Agricultural and Rural Development Office, 2010).

Most of the people in the *woreda* are engaged in mixed agriculture (crop cultivation and livestock rearing). Crop production is entirely rain-fed, except in very specific and small areas where vegetables are cultivated using traditional and small-scale irrigation. The most commonly produced crops in the study area are annual crops such as, wheat, teff, maize, sorghum, barley, chickpea, beans and oil crops.

The main soil types found in the *woreda* are brown (55%), red (15%), black (15%) grey (10%) and other soil types (5%) (Lay Gayint woreda Agricultural and Rural Development Office, 2011). The agricultural activity in the area is not productive because of the recurrent natural calamities. Natural resources are deteriorating and soil erosion is marked by the presence of expanding gullies. Rapid population growth has resulted in shrinking farmland sizes and grazing lands. Land degradation, moisture shortage, ground and surface water depletion, increasing infertility of soil and natural hazards like drought, landslide, incidence of crop pests and weed and livestock diseases, coupled with cultural and attitudinal factors are among the major problems in the study area. All these, in turn, have made the *woreda* one of the food insecure areas of the Amhara National Regional State (Lay Gayint woreda Agricultural and Rural Development Office, 2011).

DATA AND METHODS

Lay Gayint *woreda* has 29 rural *kebele*s found in different agro-ecological zones. Therefore, we used stratified, simple random and systematic sampling techniques to select the sample *kebele*s and household heads. Stratified sampling helped us to group *kebele*s within the same agro- ecology (*dega, woina-dega* and *kolla*) and then simple random sampling was used to select the three sample *kebele*s from each agro-ecological zone. These were Moseb Terara (*dega*), Arge Beras (*woina-dega*) and Menteleho (*kolla*).

Considering the homogeneity of the population in each agro-ecology, time, finance and other resources, a total of 200 household heads were taken from the selected *kebele*s for questionnaire survey. To determine the sample size for each *kebele,* the statistical formula of Tare Yamane referred in Israel (1992) was used. The total sample size was allocated for the three *kebele*s using probability proportional to size method by the following formula:

Where, ni= the total sample for ith stratum

$$Ni = \frac{\mathrm{Ni\ (S)}}{\sum \mathrm{N}}$$

Ni= represents total households of each *kebele*

S= refers total number of sampled household in the study area

∑N =refers to Summation of total number of households in the study area

The list of households registered was obtained from the representative *kebele* administrations and local development agents. From these the sample households were obtained using systematic random sampling method.

Two research designs (cross-sectional and longitudinal designs) and two data sources (primary and secondary sources) were employed to generate data for this study. Cross-sectional designs were followed to gather information from farming households using a questionnaire survey at a point in time. Longitudinal designs were used to record monthly climatic values from the Ethiopian National Meteorological Agency and other governmental and non-governmental offices. The primary data were gathered

Table 2: *Distribution of sample* kebeles *and household sample size*

No	Selected *kebele*s in the study areas	Agro-ecological zone	Number of population	Number of household heads	Sampled household heads
1	Moseb Terara	Highland (*dega*)	4410	682	84
2	Arge Beras	Midlands (*woina-dega*)	5835	767	94
3	Menteleho	Lowlands	1092	182	22
Total			11,337	1631	200

Source: Lay Gayint woreda Agricultural and Rural Development office, 2011.

from January to February (2012) using structured questionnaire surveys of 200 rural households, field observations and key-informant interviews. Secondary data used in the research were assembled from both published and unpublished sources available at different government offices. The major data in this case was a longitudinal time series monthly precipitation record (1980-2010) based on daily data for gauged stations obtained from the Ethiopian National Meteorological Agency (Bahir Dar Branch) and crop production and land-use data from the w*oreda* Agriculture Office.

The data gathered through different methods were analyzed using descriptive statistics (mean, percentage) and drought susceptibility index. Draught susceptibility index (DSI) was used to analyze the collected data to predicted yield stability of different crops, resulting from the yield difference between strain and non-strain situation. DSI was calculated on the bases of differences between yields under non-stress condition to the stress conditions based on Rashid et al. (2003).

$$DSI=(1-YdYn)/D$$

Where, DSI = Drought susceptibility index, Yd = average yield of each crop under drought and Yn = average yield of each crop under non-drought/ normal conditions. While $D = 1 - (\hat{Y}d/\hat{Y}n)$, whereas D is environmental pressure/strain, $\hat{Y}d$= average yield of all crops under drought and $\hat{Y}n$= average yield of all crops under non-drought/normal conditions. This index provides a measure of relative drought tolerance based on minimization of yield loss under drought. Values >1.0 indicate greater than average drought susceptibility while values <1.0 indicate greater than average drought resistance. This was analyzed with the Statistical Package for Social Sciences (SPSS) and Microsoft Excel.

RESULTS AND DISCUSSION

Agricultural and farming practices

Like in many parts of Ethiopia, the farming system in the survey sites is still very much traditional relying on plough and yoke (animal-drawn power). It thus demands major means of labour production during land preparation, planting and post-harvest processing. It is also evident that out of the total sample households, 54.5% practice crop farming while 40.0% practice mixed farming (Table 3). The remaining 4.0% of the respondents were involved in other activities.

The agricultural sector in Ethiopia is the mainstay of the economy. It provides the livelihood of large segments of the population. This sector is mainly rain-fed, relying on relatively backward technologies. Hence, production and productivity remain extremely low (Degefe Befekadu & Berhanu Nega, 2000). Rain-fed agriculture is a common practice for many farming households (81.5%), with only 12.5% using both rain-fed and irrigated water to grow their crops (See Table 3).

Climate variability

Scholars worry about climate change. Different researchers have concluded that Ethiopian climate is changing. Still the rate of change differs within localities and it is difficult to conclude that the change is homogenous throughout the country. In this section the trends of climate variability (temperature and rainfall) of the *woreda* are briefly analyzed based on historical meteorological data using line graphs. Moreover, farmers' perception to climate change and variability in their locality is presented in this section (Figures 2 and 3).

Table 3: *Distribution of agricultural and farming practices of sample household*

Variables		Freq.	%
Farming practice	Crop farming	109	54.5
	Mixed farming	80	40.0
	Others	8	4.0
Agricultural practice	Rain-fed	163	81.5
	Rain-fed and irrigated	25	12.5
	Others	6	3.0

Source: Survey result, 2013.

The two climate elements (temperature and rainfall) were considered for analysis because of their importance for agriculture as well as data availability. Monthly rainfall and temperature data from 1979 to 2010 for Nefas Mewucha meteorological station were obtained from National Meteorological Agency. However, rainfall data for some months of the year were missing. Hence, the missing values for the rainfall and temperature records at the station level were interpolated and replaced using SPSS software.

Trend analysis and evaluation of the changes in major climate variables were crucial. To establish a priori evidence for existence of climate variability in the study area, temperature and rainfall were taken. According to meteorological data, the trend line estimated for average annual maximum temperatures in the study area was $y = 0.0745x + 25.923$. The trend line had a positive slope indicating the maximum temperature increased by 2.31° C over the time period of 1979 to 2010 (Figure 2). The analysis of temperature data obtained from the National Meteorological Agency tends to support the perception of a majority of respondents regarding increasing temperature trend.

Similarly, the estimated trend line for average annual minimum temperature was $y = 0.0277x + 9.3238$ (Figure 2). The trend line has a positive slope indicating that over the last three decades the minimum temperature rose by 0.86° C. This finding is consistent with studies by Tadege (2007), who states that the average minimum and maximum temperatures has increased by

0.25° C and 0.1° C respectively over the past decades, whereas the rainfall is characterized by very high levels of variability over the past 50 years. The range and duration of temperature is crucial to growth and productivity in the agricultural sector. According to Intergovernmental Panel on Climate Change (2001) an increase in average temperature will adversely affect crops, where already heat is a limiting factor of production.

In terms of rainfall, analysis of data from National Meteorological Agency (2007) indicated that the average annual rainfall for the period 1979-2010 was 635.7 mm with standard deviation of 145.37 mm. The highest annual average precipitation (890.48 mm) was recorded in 1987, whereas the lowest (482.6 mm) was recorded in 2002. As stated in Figure 3, the trend line estimated for average annual rainfall in the study area was y = -8.4956x + 775.88 with a slope of -8.4956, the estimated trend line is negative and the average annual rainfall decreased by -263.36 mm through the period 1979-2010. The analysis showed that perceptions of farmers with respect to decreasing trends of rainfall was in line with empirical analysis of rainfall trends using the data obtained from the meteorological stations.

In Ethiopia changes in rainfall are likely to affect agricultural productivity, food and water security, livelihoods and economic growth. Crop yield is strongly correlated with rainfall variability. Thus, the amount and temporal distribution of rainfall is the most important factor in determining national crop production levels (Girma & Fekadu, 2010).

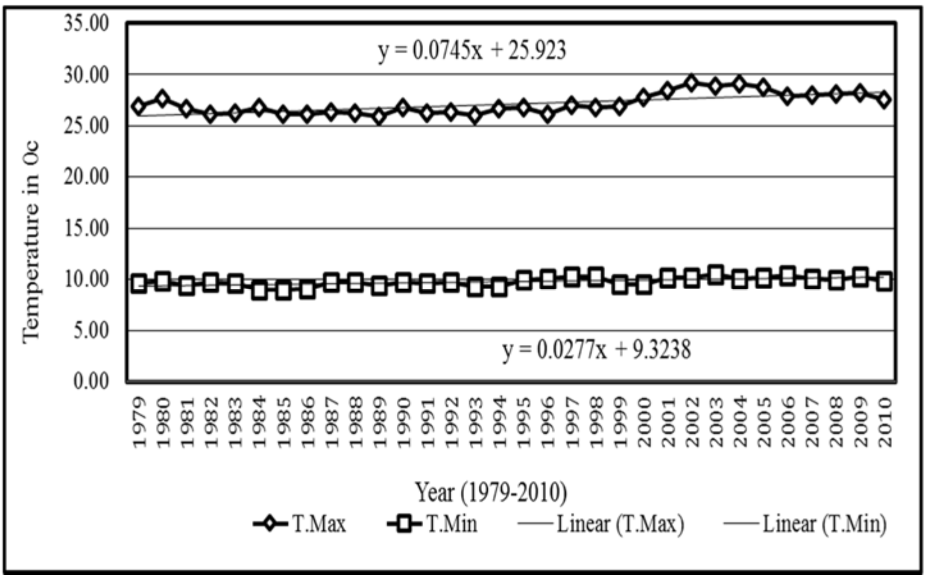

Figure 2: *Trends of annual average maximum and minimum temperature in the study area*
Source: National Meteorological Agency, 2011.

According to the Intergovernmental Panel on Climate Change (2001), there are no statistically significant trends in rainfall. However, more recent research results suggest that rainfall during the 'long-rains' decreased. Ethiopia's climate, in particular, is highly variable and there is a need to tackle existing climate risks effectively, as well as to plan for future changes. In addition to variations across the country, the climate is characterized by a history of climate extremes such as drought and flood as well as increasing trends in temperature and decreasing trends in precipitation (Ministry of Agriculture, 2000).

Crop production trend

Ethiopia's crop agriculture is complex. It often involves substantial variation in crops grown across the country's different regions and ecologies. It continues to be dominated by the country's numerous small farms that cultivate mainly cereals for both own-consumption and sales. Five major cereals (teff, wheat, maize, sorghum and barley) are the chief source of food. These account for about three-quarters of the total cultivated area (Central Statistical Agency, 2012).

In Lay Gayint *woreda*, crop production is characterized by rain-fed, traditional, small scale, subsistence orientated and labor intensive based on family labor. Different types of crops such as cereals, pulses and oilseeds as well as root crops like potatoes are cultivated in accordance with the

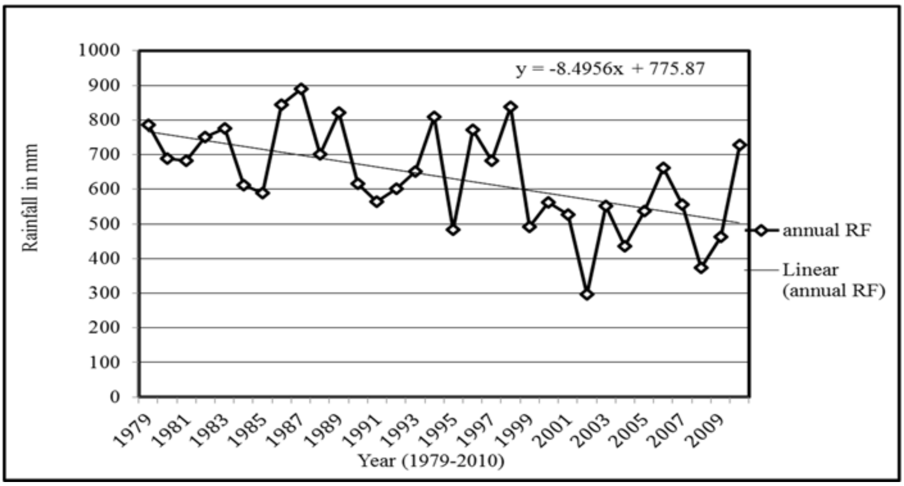

Figure 3: *Annual rainfall trend and variability of Lay Gayint* woreda
Source: National Meteorological Agency, 2011.

diversity of climatic and soil conditions. The *woreda*'s agricultural office has given high priority to the agricultural sector and has taken major steps to improve its efficiency. However, various problems are holding this back. One major cause of underproduction is climatic extremes such as drought and floods. Temperature and precipitation are two of the primary factors of the quality and quantity of crop yield in a given year. Variations in either temperature or precipitation can significantly alter the outcome of crop productivity (Intergovernmental Panel on Climate Change, 2001). Often crop failure results in famine. Such climate-related disasters made the area remain dependent on food aid for the past two years. According to the agricultural office, at the present time even if productivity would grow, climate change would still have a dramatic impact.

As can be seen from Figure 4, there is high variability in crop production trend. The crop production declined in 2000/01, 2002/03, 2004/05 and 2009/10, which is mainly attributed to extreme weather events such as drought, late onset, erratic rain and early offset of the rain. Alebachew Adem and Woldeamlak Bewket (2011) noted that besides the very low levels of productivity, Ethiopian agriculture is characterized by wide fluctuations in total output from year to year. The year-to-year fluctuations are caused mainly by the inter-annual rainfall variability. The highest crop productions were recorded in 2010/11 and 2012/13. The report regarding crop production trend from Lay Gayint woreda Agricultural and Rural Development office was contrary to the view of farmer's perception on trends of crop production in the study area. That means gaps between official agricultural statistics and households' responses regarding crop yield were identified. The *kebele* agricultural experts, reported 40 – 70 quintals of crop yield per hectare in the fragile land of the study sites which is quite implausible and hence not useful to substantiate the findings on crop yield.

Experts working in the field have a tendency to inflate production figures because their work performance is mostly evaluated based on the reported figures. Triangulation was done by taking this report to older household heads. They absolutely rejected the experts' reports. Information provided by the households does justify that crop yields are gradually going down in their locality though it seems somewhat deflated for outside observers and general national observers. In addition, as they were born, grew up, and worked in the farming households, crop yield is going down particularly in the fragile landscapes of northern Ethiopia. Triangulation was also done through visiting the households when they harvested and threshed their crops in the field, which further justified the households' responses.

The above results do not mean that there is no growth in total production of the country. Indeed, growth in total agricultural production has been observed in some households living in modest environmental conditions, thanks to new technology packages, good land management practices and irrigation that increased crop productivity over time. However, some scholars also related the effectiveness of new technology packages (at least partially) in boosting crop production with good weather conditions (Alemayehu Seyoum Taffesse et al., 2011). They also argued that rather than technology adoption, the major factor behind the growth of total production in Ethiopia has been the expansion of cultivated land area. For example, grain production has registered a growth of 74%, with yield growing by only 18% and area cultivated by 51% between 1989/90 and 2003/04. From 1994 to 2002, 70%

of cereal production increases resulted from expansion of cultivated land area (Alemayehu Seyoum Taffesse et al., 2011) and it is in an increasing trend in recent years. However, cultivable lands are already exhausted in the study area, so that there is no possibility of expanding agricultural land by households. Hence, the results seem logical for the fragile landscapes of northern Ethiopia where rain-fed crops are more sensitive to climatic anomalies. Rainfall variability is important determinant contexts of livelihoods of the community in Ethiopia. A favourable climate is needed in order to keep a sustainable agricultural production that affords better livelihoods to the households.

For rural communities, crop production constitutes one of the major sources of livelihood. Farmers in the study area grow a diverse range of crops as it is shown in Table 4. The data obtained from household survey indicates that wheat, teff, barley, bean and pea are the major crops grown by the majority of the respondents. However, the proportion of farmers that are growing haricot bean and sunflower are few in number.

In the study area, drought, pests and disease, and soil erosion are recurring problems affecting agricultural activities and human wellbeing. Significantly, farmers pointed out that the yield of their fields is declining from year to year.

Drought has been a recurring phenomenon in Ethiopia for millennia, being recorded at least as early as 253 B.C. Modern rainfall records for Ethiopia

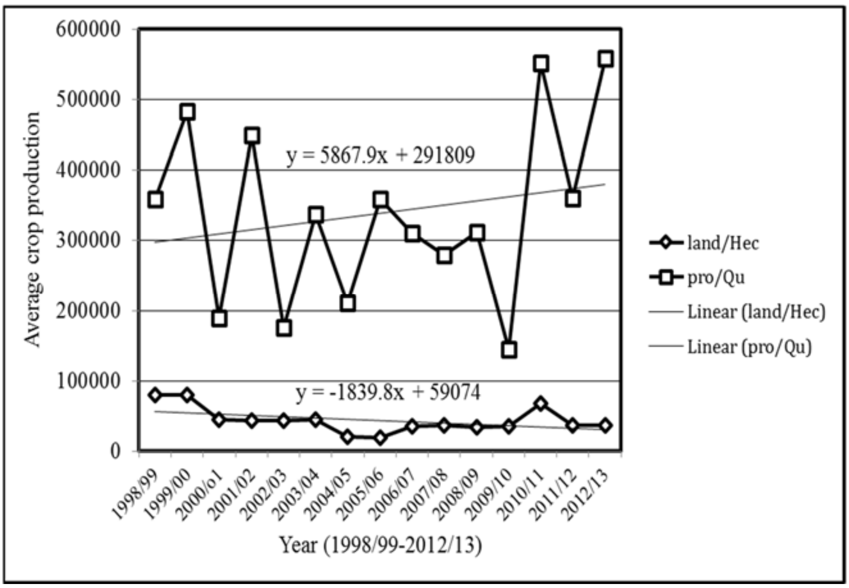

Figure 4: *Crop production trend in Lay Gayint* woreda
Source: Lay Gayint woreda Agricultural and Rural Development office, 2012.

Table 4: *Average yield of major crops and land allocation for the 2011/2012* meher *season*

Major crops	Area coverage in ha	Average productivity yield/ha
Wheat	58.97	10.67
Teff	30.42	15.83
Barley	26.88	8.39
Pea	24.99	13.33
Beans	15.38	13.51
Lentil	11.94	18.80
Sorghum	8.00	8.70
Chickpea	2.75	13.00
Haricot bean	2.00	11.15
Sunflower	1.38	14.05

Source: Survey result, 2013.

have demonstrated large differences from year to year as well as great local variability (Fasil G. Kiros, 1993). The effects of drought in Ethiopia in the last two decades have been drastic (10-100% yield loss). Prolonged drought

Table 5: *Productivities of major crops under non drought conditions (Yn) and drought conditions (Yd) and corresponding DSI in 2011/12 growing year*

Major crops	Productivity/ha in non-drought condition (Yn)	Productivity/ha in drought condition (Yd)	Drought suscepti-bility Index (DSI)
Wheat	5.03	1.87	0.96
Teff	2.76	1.07	0.94
Barley	5.65	1.81	1.04
Pea	3.05	0.90	1.08
Beans	3.19	1.02	0.90
Lentil	2.64	1.10	0.90
Sorghum	5.70	2.56	0.85
Chickpea	3.80	1.40	0.97
Haricot bean	1.39	0.56	0.91
Sunflower	1.88	0.94	0.77
Mean yield	3.51	1.33	

Source: Survey result, 2013.

has lowered production of major food crops, resulting in an acute and recurrent shortage of food. The farmer's ability to adjust to drought depends upon available technology and the production system in use (Habtamu Gessesse, 1999).

A dimensionless slope termed drought susceptibility index (DSI) was suggested by Fischer and Maurer (1978) as a useful way of comparing crop yield performances between drought levels and non-drought condition and a measure of yield stability. It expresses the separate effects of yield potential and drought susceptibility on yields under drought. In these terms, lower drought susceptibility is considered synonymous with higher drought resistance.

Drought susceptibility index values ranged from 0.77 to 1.08 (Table 5). The result indicates that barley and pea are relatively drought susceptible (DSI >1.0), while wheat, teff, beans, lentils, sorghum, chickpea, haricot bean and sunflower were relatively drought resistant (DSI <1.0). Crops with DSI values <1.0 can be considered to be drought resistant, because they exhibited smaller yield reductions under drought condition compared with non-drought condition. This result is in accordance with Alebachew Adem and Woldeamlak Bewket (2011), who state that drought is the major physical challenge to agriculture in the Amhara National Regional State and the effect of rainfall variability on crop production varies with the crops cultivated, types and properties of soils and climatic conditions of a given area.

CONCLUSIONS

Like in most rural areas of Ethiopia the source of income for most of the people in Lay Gayint woreda is agriculture, mainly crop production. It is characterized by rain-fed, traditional, small scale, subsistence orientated and labour intensive based on family labor. Due to the diversity of climatic and soil conditions, different types of crops are grown, of which cereals, pulses, oil seed and root crops like potatoes are the major ones. Drought is the major constraint, which reduces the productivity of crop. However, there is a greater variability for yield performance of different crops under drought situation. Drought susceptibility index values ranged from 0.77 to 1.08 (Table 5). The result indicates that barley and pea are relatively drought susceptible (DSI > 1.0), while wheat, teff, beans, lentils, sorghum, chickpea, haricot bean and sunflower were relatively drought resistant (DSI < 1.0). The study findings also indicated that all studied parameters have an important role in drought tolerance and could be used effectively for selecting drought-tolerant varieties particularly at reproductive stage.

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