Indo - African Journal for Resource Management and Planning
(An International Peer Reviewed Research Journal)

ISSN 2347-1786. VOL 12 NO. 1 15, December, 2024.

Article info
Received on 30, September, 2024.
Published on 15, December, 2024.

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Impact of Climate Variability on Household Food Security in Asegede Tsimbla Woreda, Tigray Region, Ethiopia

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Abstract

All four food security components availability, accessibility, use, and stability are affected by climate variability, increasing hunger risks in the area. Rainfall shortages or excesses reduce food production, producing food instability and famine. This article examined how climatic variability affects family food security in Asegede Tsembla Woreda, Tigray Regional State. Three home kebeles were chosen using stratified random sampling, whereas 135 respondents out of 5345 households and key respondents were picked using simple random and purposive selection, respectively. Data was collected by observation, interviews, written questionnaires, and FGD. Inferential statistics (one sample t-test) and descriptive statistics (frequency, means, and standard deviation) were used for qualitative data. Data was analysed using chi-square (x2), paired t-test, and multiple regression model. Study found that the precipitation concentration index (25.64) is more than 21 and indicates significant rainfall concentration. One-sample t-test analysis showed that the poorest parts of the globe had greater food intake in Kcal/person/day than the study area. There is also substantial correlation between variability occur in your area in the last 10 years and susceptible to climatic variability $X2(1, N=135) = 58.793, P < 0.05$). There is a strong positive association between family food security and independent factors ($r=+.971, p<0.013$).

Key words: Aseged Tsimbla woreda, Ethiopia, food security, Tigray region

Introduction

Climate-induced extremities like drought, intermittent rainfall and food compromise the ability of households to meet their food requirements (IPCC, 2007). Food availability is diminished by change in agricultural productivity, and the land devoted to crop production, however, decreasing in rainfall quantity leads also to the deterioration of food availability and health (Schmidhuber & Tubiello, 2007).According to the Food Available Decline (FAD) Theory/Approach, failure in physical availability of food causes food insecurity, which is emanated mainly from the impact of natural hazards through increasing burden on the available natural resources (Kahsay, S., & Mulugeta, M., 2014).

Climate variability is not a recent situation in Ethiopia because of the numerous and frequent drought occurrences over the years: 1889–1892, 1972–1974, 1984– 1985, 2002–2003 and 2015–16, which are due to the climate variability. Climate variability increases the risks of hunger in the region as it affects all four components of food security: food availability, food accessibility, food utilization and food stability. Rainfall shortage or excess hampers, food production, causing food insecurity and the escalation of famine in the region. Bad weather also affects people indirectly through the sequential rather than direct depletion of their assets. When drought occurs, the people cannot produce enough food to meet their needs, whereas livestock suffer from the shortage of pasture. Rural farmers, therefore, revert to coping strategies, such as livestock sale to generate income and purchase food. Livestock serves as a buffer in times of hardship, with farmers disinvesting in them to buy food (Regassa N, & Stoecker BJ.2012).

From the early 1960s onwards, Ethiopia has experienced poverty and chronic food insecurity mainly caused by high population growth, land degradation, lack of appropriate technologies, land tenure insecurity, scarcity of farmland, drought, variability and unpredictability of rainfall (Arega & Weldeamlak Bewket, 2013).

Tigray is grouped under food insecure region with high levels of food insecurity caused by repeated shocks allied with diminished entitlements, low natural resource endowments and limited access to infrastructure. Since the late 1970s, the fragility of household economies in the region has increased in the face of eroded coping strategies and limited opportunities for income and employment. Consequently, malnutrition, health impairment and asset depletion have pushed households further down the poverty ladder and placing them at risk of famine (Degefa T, 2002). Drought is one of the major risks in Aseged Tsembla Woreda. It is estimated that currently 69 percent households in the Wereda are vulnerable to drought risk. Drought has come to be a common occurrence in the area. For example, the area experienced an incidence of drought in 1984/85, 2003/04, and 2009/10. The main impacts of climate variability in the Wereda include crop damage, loss of pasture and water sources, loss of animals, food shortage, disease outbreak, asset depletion, social unrest malnutrition (particularly among the children), and migration of household members Asgede Tsimbla Wereda Agriculture and natural resource Office (2017). There are few related studies such as: Woldeamlak (2009), on assessing the impacts of climate variability on food security and adaptive capacity of households in Ethiopia. And Asfaw, S., McCarthy, N., Lipper, L., Arslan, A., Cattaneo, A., & Kachulu, M. (2015). Climate variability, adaptation strategies and food security in Malawi. However, such studies hasn't been conducted in AsegedeTsembla Woreda. Therefore, the researcher inspired to fill knowledge gap with an intention of understanding the impact of climate variability on household food security and its adaptation. The objective of this paper was to investigate the impact of climate variability on household food security in Asegede Tsembla Woreda, Tigray Regional State.

Description of the study area

Asgede Tsimbla is one of the woredas in the Tigray regional state. Part of Northwestern zone,AsgedeTsimbla is bordered along the south by the Tekezeriver, which separated the woreda on the south from,Tselemit and to the west by the Western zone, on the north west by TahtayAdiabo , on the north by LaiayAdiabo , on the north east by Tahtay Korero and on the east Medebayzane. The administrative center of this woreda is IndaAbagune. The absolute location of AsgedeTsimblaWoreda in North West Tigray is 14^{0}42'to14^{o} 11' N latitude and 37^{0}34'to 38 ^{0} 19' E longitude (Fig. 3.1). Asgedetsimblaworeda is found 22km away from Shire town, Zone capital city or about 111km far Aksum town and 329 km away from Mekell, the capital city Tigray regional state (AsgedeTsimbla information bureau, 2019).

Asgede Tsimbla is characterized by arid, semiarid , and dega climatic condition the average with an annual temperature in generally ranging from 24 to 29^{o}c .The recorded daily maximum between 37 and 40 ^{0}c and the minimum 15 to 19 ^{0}c .There are two rainy periods , and the first is June - September with highest seasonal rainfall being 500- 850 mm and the lowest seasonal rainfall is recorded in autumn middle February to April is about 25 mm. According to the agricultural office of Asgede Tsimbla, the worede is characterized by plains, river valleys and plateau with an altitude ranging from 800 to 2300 meters. Most of land surface is highland with ridged terrain and the area in this woreda have is different climatic conditions.

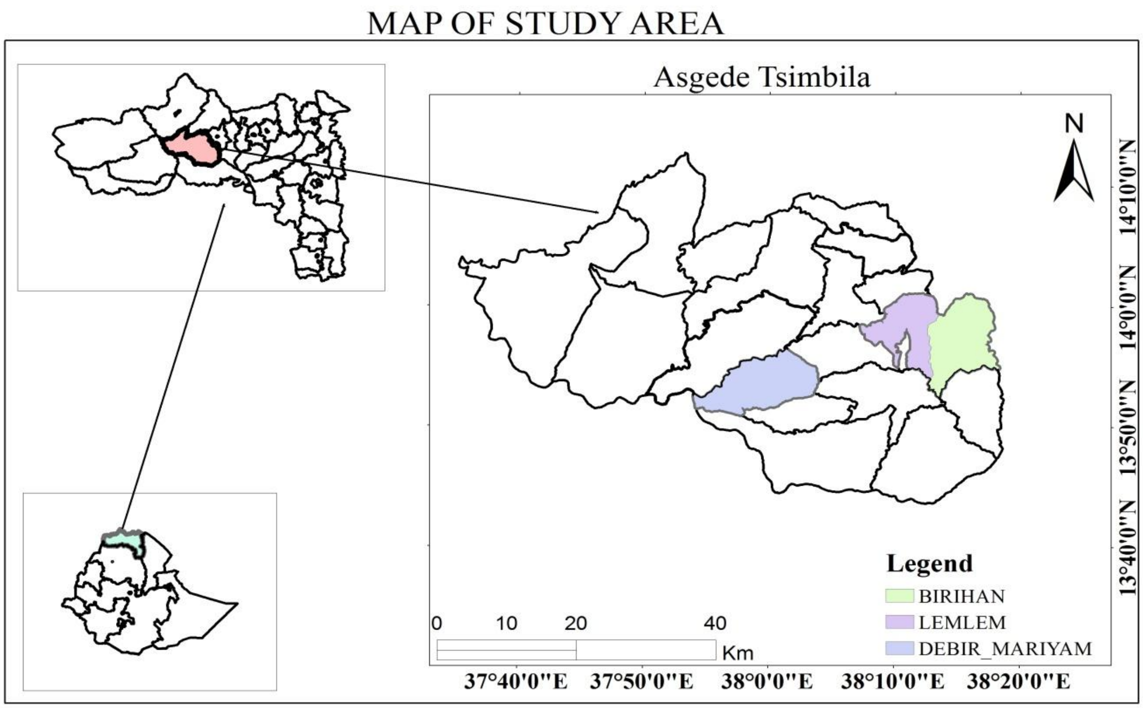

Figure 3.1. Map of Asgede Tsimbla.

Methods and materials

Source of data

As far as the source of data for this study is concerned both quantitative and qualitative data *were collected* from both primary and secondary sources by using the different techniques of data collection.

Data collection instrument

The data were collected from household heads who are occupied in the study area and the document which is found in the agricultural office of north Asgede Tsimbla in the various mechanisms such as; interview, questionnaire, field observation and FGD.

Interview - Under this data collection was applied using face to face communication the researcher and interview in order to obtain a correct data about the impact of climate variability on household food security in Asegede Tsimbla Woreda,. The researcher was used direct content interview with the DA respondents in order to get relevant information.

Questionnaire - a type of survey where respondents write answers to questions posted by the researcher on a question form. The main reason why the researcher used this method of data collection is because to cover wider spread areas and to get the respondent's adequate and well thought out answers. The type of questions in the questionnaires used by the researcher were both close-ended and open-ended. And they were disseminated to all respondents of 135 HHs. The questionnaires were prepared in both English and Tigrigna languages so as to provide proper rapport and gain better responses for all respondents and especially for those who can't clearly read and understand the English language.

Field observation: also being made by the researcher to collect relevant and sufficient information about the research problem as a participant in the study area and it was helpful to identify the impact of climate variability on household food security and Observing the environment and lifestyle of the community.

Focus group discussion: The researcher was employed by two groups discussion that have something in common to gather information that have combined perspectives(opinions) and in depth interview between selected individuals (key informants) on a particular topic by choosing the experts and cluster coordinators of agrarian and DAs purposely to participate in detail on the study.

Sample Size and Sampling Technique

Both probability and non-probability sampling techniques was used to select the sample population. A probability, stratified random sampling was used to get information from three kebeles of the Asgede Tsimbla. This technique was preferred because it was used to help in minimizing bias when dealing with the population and due to the heterogeneity of farm lands in each kebeles of the study area. With this technique, the sampling frame was organized into relatively homogeneous strata, then the researcher uses simple random sampling selected respondents in the sample with respect to quota size. This step allows a fair representation of the various types of household size of the study area. The researcher was selected the sample size, based on a list of the farmer households formally registered in municipality of Asgede Tsimbla woreda. And the sample size that was selected here is considered as representative of total households. Non-probability sampling technique has help to select the study area from the total kebeles of Aseged Tsimbla woreda because the selected areas are more arable land than the other kebeles based on the statistical data of Asgede Tsimbla woreda and the DAs were selected in terms of purposive sampling.

The researchers were employed the following sample size determination formula developed by Kothari (2004), assuming 95% confidence level and e =.5.

$$n = \frac{Nz^2PQ}{E^2(N\text{-}1) + z^2PQ}$$

$$n = \frac{5345(1.96)^2(0.9)(0.1)}{(0.05)^2(5345\text{-}1) + (1.96)^2(0.9)(0.1)}$$

$$n = 135$$

The 135 household respondents were selected from the 5345 households using simple random sampling technique. Therefore, 135 households are the sample unit or sample size of the study, because the problem is common throughout the study area.

Data Analysis

Both qualitative and quantitative approaches were used to analyze the collected primary and secondary data.

A descriptive statistical analysis technique was carried through frequencies, means and standard deviation for the qualitative data. The meteorological data were computed by Microsoft XL gathered from SWAT, and presented by line and bar graph to show the trend of climate variability. In addition, climate variability of the study area was analysed by the precipitation concentration index (PCI); by its formula,

$$PCI = \frac{(\Sigma Pi^2)}{(\Sigma Pi)^2} * 100 \text{ (Woldeamlak, 2009)} \text{ ....}\ldots\ldots\text{Equation 1}$$

Quantitative research on the other hand explores traits and situations from which numerical data can be obtained. It makes use of measurement and statistics. The researcher used inferential or statistical techniques, such as one sample t-test were employed to compare food consumption in Kcal per person per day. Chi-square (x^2) was applied to evaluate variables of household food security and paired t-test was employed to evaluate the pass 10 years of cereal crops and numbers of livestock with cereal crops and numbers of livestock by now. Multiple regression model was also used to show the contribution of dependent and independent variables. Statistical package for Social Science (SPSS) version 20 Software was employed to analyze.

Result and discussion

Table 1.Computation of PCI in the study area

Months	Ten years mean monthly RF (pi)	Pi^2
Jan	0.1	0.01
Feb	0.0	0
Mar	3.1	9.61
Apr	25.0	625
May	32.5	1056.25
Jun	455.01	207034.1001
Jul	563.1	317081.61
Aug	655.4	429549.16
Sep	199.8	39920.04
Oct	30.9	954.81
Nov	6.2	38.44
Dec	0.13	0.0169
Total	$\sum pi=1971.24$	$\sum pi^2=996269.047$
	$(\sum pi)^2=3885787.1376$	

$$\mathrm{PCI} = \frac{(\Sigma \mathrm{Pi}^2)}{(\Sigma \mathrm{Pi})^2} * 100$$

$$\mathrm{PCI} = \frac{(996269.047\ )}{3885787.1376} * 100$$

$$\mathrm{PCI} = 25.64$$

Where *pi* = is the rainfall amount of the *i*th month of a year and Σ = summation over the 12 months.The rainfall variability was assessed by precipitation concentration index. As it is computed on Table 1, the precipitation concentration index (PCI) value of the study area is 25.64. As it indicates in (Weldeamlak, 2009) PCI values of less than 10 indicate uniform monthly distribution of rainfall, values between 11 and 20 indicate high temporal concentration and above

21 indicate very high temporal rainfall concentration. Thus, precipitation concentration index result indicates very high rainfall concentration because the value of PCI is greater than 21.

As far as the seasonal distribution of rainfall in the study area concerned, it is characterized by seasonal variation. There is one main rainy season: summer (June, July and August) season. During this season heavy rainfall is observed in the study area. Report (National Meteorological Agency of Ethiopia, 2012 and Livelihoods, Early Assessment and Protection, 2013) indicates that the annual rainfall is significantly changed across Ethiopia and suggesting a high inter-annual variability with a slight but statistically significant negative trend. This is in line with previous analyses, which highlight the importance of inter and intra-seasonal rainfall variability over total annual rainfall in determining livelihood and food security outcomes (Krishnamurthy, P. K, et al., 2013). According to (Woldeamlak B. 2009), PCI is classified into three: 21 very high concentration of rainfall. Therefore, the result showed high concentration rainfall variability, which is similar to the finding of (Hadgu G et al., 2013); this implies that food availability is in question, because high concentrations of rainfall exposes arable and non-arable land to severe soil erosion and environmental degradation.

Table 2. Food consumption in Kcal/person/day

	One-Sample Test			
	Test Value = 2300			
	Mean	T	Df	P -Value
Food consumption in Kcal/person/day	1840.66	-13.936	134	.000

According (FAO) 2017), the mean Food consumption in Kcal/person/day in the study area M = 1840.66 was significantly less than in the poorer regions of the world standard of Food consumption in Kcal/person/day M = 2300, t (134) = (13.936), P= .000. The food consumption in Kcal/person/day of the poorer regions of the world standard mean was higher than the mean of food consumption in Kcal/person/day in the study area.

Table 3. Variability occur in your locality in the past 10 years and vulnerable to climate change related problems

			variability occur in your locality in the past 10 years		Total
			Yes	No	
vulnerable to climate variability	Yes	Count	117	1	118
		Expected Count	109.3	8.7	118.0
		%	99.2%	0.8%	100.0%
	No	Count	8	9	17
		Expected Count	15.7	1.3	17.0
		%	47.1%	52.9%	100.0%
Total		Count	125	10	135
		Expected Count	125.0	10.0	135.0
		%	92.6%	7.4%	100.0%
X2 – value		58.793			
X^2 critical value		3.84			
Df		1			
P – value		.000			

As shows the above table 3 there was a significant association between variability occur in your locality in the past 10 years and vulnerable to climate variability $X^2(1, N=135) = 58.793, P< 0.05)$ since, x^2 value 58.793 is greater than the critical value 3.84 climate variability occur in your locality was vulnerable to climate change related problems this is more influential to food secure thus the researcher shows that one to other outcome were associated significant each other at df=1 p<0.05. In addition, his research finding was a significant association between variability occur in your locality and vulnerable to climate change related problems (weldeabzigi, 2018).

Table 4.Problems due to climate variability and Effects on livelihoods of the households

			Effects on livelihoods of the households						Total
			Drought	Shortage of animal feed	Food inadequacy	Migration	Price fluctuations for agricultural products	Shortage of water supply	
Problems faced due to climate variability	Fluctuation of rainfall	Count	12	0	0	0	0	13	25
		Expected Count	5.2	3.7	5.7	4.6	2.4	3.3	25.0
		%	48.0%	0.0%	0.0%	0.0%	0.0%	52.0%	100.0%
	Increased temperature	Count	15	16	3	0	0	0	34
		Expected Count	7.1	5.0	7.8	6.3	3.3	4.5	34.0
		%	44.1%	47.1%	8.8%	0.0%	0.0%	0.0%	100.0%
	Deforestation	Count	0	2	19	0	0	0	21
		Expected Count	4.4	3.1	4.8	3.9	2.0	2.8	21.0
		%	0.0%	9.5%	90.5%	0.0%	0.0%	0.0%	100.0%
	Flood	Count	0	2	7	12	0	0	21
		Expected Count	4.4	3.1	4.8	3.9	2.0	2.8	21.0
		%	0.0%	9.5%	33.3%	57.1%	0.0%	0.0%	100.0%
	Drought	Count	1	0	2	13	13	5	34
		Expected Count	7.1	5.0	7.8	6.3	3.3	4.5	34.0
		%	2.9%	0.0%	5.9%	38.2%	38.2%	14.7%	100.0%
Total		Count	28	20	31	25	13	18	135
		Expected Count	28.0	20.0	31.0	25.0	13.0	18.0	135.0
		%	20.7%	14.8%	23.0%	18.5%	9.6%	13.3%	100.0%
X^2 – value			236.605						
X^2 critical value			36.42						
Df			20						
P – value			.000						

As display the above table there was a significant association between problems you have faced due to climate variability and affects your life X^2((20, N=135 = 236.605, P< 0.05)) since, x^2value 236.605 is greater than the critical value 36.42 problems you have faced due to climate variability and affects your life were associated significant each other at df=20, P<0.05.

Table 5. Paired comparisons of productivity of cereal crops and livestock in the last 10 years

Paired Samples T-test									
		Paired Differences					T	Df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	teff before-teff now	-2.3859	1.34696	.12615	2.13603	2.63590	-18.913	134	.000
Pair 2	maize before - maize now	-4.1315	1.10920	.10389	3.92576	4.33740	-39.770	134	.000
Pair 3	sorghum in before - sorghum now	-4.5526	.83180	.07791	4.39829	4.70698	-58.438	134	.000
Pair 4	millet before - millet now	-4.184	.78217	.07326	4.03908	4.32935	-57.117	134	.000
Pair 5	Cattle before–cattle now	-9.719	5.43588	.50912	-10.72795	-8.71065	-19.090	134	.000
Pair 6	Goats before–goats now	-9.833	6.44777	.60389	-11.02975	-8.63692	-16.283	134	.000
Pair 7	Sheep before–sheep now	-9.464	5.38628	.50447	-10.46436	-8.46546	-18.762	134	.000
Pair 8	donkeys before–donkeys now	-9.973	5.44069	.50957	-10.98323	-8.96414	-19.573	134	.000
Pair 9	Camels before–camels now	-11.07	6.73407	.63070	-12.32848	-9.82941	-17.566	134	.000
Pair 10	horses before – horses now	-10.19	5.77280	.54067	-11.26415	-9.12181	-18.852	134	.000

As defined by the pair of variables, there are 10 consecutive years to illustrate the average teff before and teff now was 2.38596 and standard deviation of teff before and teff now was 1.34696. Since, it was statistically significantly associated between teff before and teff now ((t=18.91) degree of freedom was 134, p< 0.05)), .000 less than .05, the average maize before - maize now was 4.13158 and standard deviation of maize before and maize now was 1.10920. Since, it was statistically significantly associated between maize before and maize now ((t= 39.77) degree of freedom was 134, p< 0.05)), .000 less than .05, the average sorghum in before and sorghum now was 4.55263 and standard deviation of sorghum in before and sorghum now was .83180. Since, it was statistically significantly associated between sorghum in before and sorghum now ((t= 58.43) degree of freedom was 134, p< 0.05)), .000 less than .05, the average millet before and millet now was 4.18421 and standard deviation of millet before and millet now was .78217. Since, it was statistically significantly associated between millet before and millet now ((t= 57.117) degree of freedom was 134, p< 0.05)), .000 less than .05, the average cattle before and cattle now was -9.71930 and standard deviation of cattle before and cattle now was 5.43588. Since, it was statistically significantly associated between cattle before and cattle now ((t= 19.09) degree of freedom was 134, p< 0.05)), .000 less than .05, the average goats before and goats now was -9.83333and standard deviation of goats before and goats now was 6.44777. Since, it was statistically significantly associated between cattle before and cattle now ((t= 16.283) degree of freedom was 134, p< 0.05)), .000 less than .05, the average sheep before and sheep now was -9.46491and standard deviation of sheep before and sheep now was 5.38628. Since, it was statistically significantly associated between sheep before and sheep now ((t= 18.762) degree of freedom was 134, p< 0.05)), .000 less than .05, the average donkeys before– donkeys now was 9.97368 and standard deviation of donkeys before and donkeys now was 5.44069. Since, it was statistically significantly associated between donkeys before and donkeys now ((t= 19.573) degree of freedom was 134, p< 0.05)), .000 less than .05, the average camels before and camels now was 11.07895 and standard deviation of camels before and camels now was 6.73407. Since, it was statistically significantly associated between donkeys before and donkeys now ((t= 17.566) degree of freedom was 134, p< 0.05)), .000 less than .05, the average horses before and horses now was 10.19298 and standard deviation of horses before and horses now was 10.19298. Since, it was statistically significantly associated between horses before and horses now ((t= 18.852) degree of freedom was 134, p< 0.05)), .000 less than .05. Therefore, the researcher can conclude that both the cereal crops and the numbers of livestock were decreased year to year.

Determinates of local households heads for food security

To identify factors that influence food security in the study area, multiple regression analysis was carried out. **Table 6** presents the selected variables that influence household of food security across the three kebelles. Among 7 variables considered in the model, only 6 variables were found to have significant influence on food security of households. These variables together explained 94.30 percent of the variance in food security.

Table 6. The Results of multiple regression (only significant predictors are included)

Variables selection							
Dependent	Independent	Adjusted R Square	R Square	F Change	df1	df2	Sig. F Change
food insecurity	Age	.901	.912	83.202	1	8	.000
	Family size	.627	.669	16.133	1	8	.004
	Land size	.775	.800	32.029	1	8	.000
	Crop production	.840	.857	48.077	1	8	.000
	Livestock size	.719	.750	24.045	1	8	.001
	Annual income	.795	.818	36.000	1	8	.000

In the step wise multiple regression, that age significantly affected for food security in R Square (.912), df (8) and p=.000, family size significantly affected for food security in R Square (.669), df (8) and p=.004, land size significantly affected for food security in R Square (.800), df (8) and p=.000, crop production per quintal significantly affected for food security in R Square (.857), df (8) and p=.000, livestock size significantly affected for food security in R Square (.750), df (8) and p=.001 and annual income significantly affected for food security in R Square (.818), df (8) and p=.000. The variables left out of the analysis at the last step all have significant values smaller than 0.05 and Pearson's correlation analysis indicted strong and positive association between food security of households and independent variables (r=+.971, p<0.013). In addition, findings of (Tibesigwa B. and Ahmed UJ, et al., 2016 – 2017) in Pakistan, South Africa and Ethiopia showed female-headed households are food more insecure than male-headed households. This is mainly related to lack of access to finance, social, human, natural and physical assets.

Households' opinion on short term adaptive mechanisms

During food insecurity in the short term the households use a wide range of mechanisms to cope with the situation. The questioners, FGD and KIs stated that they adapt or cope the climate variability by excavation of gold, asset sell, daily labor, borrowing and wood and charcoal selling. In addition to this, farmers were found an immediate solution such as ask support from relatives and friends, seasonal migration, reducing food consumption and call aid from different organizations. Therefore, the survey found that the dominant short term adoption and coping mechanism in the study area was the extraction of gold followed by asset sell.

Households opinion on long term adaptive mechanisms

As KIs and FGD reported, the local communities used a variety of strategies to cope with climate variability and adapt to climate change. These coping and adaptation strategies broadly included adjustments in crop and livestock production, wise use of natural resources, and adjustments to new household food and income sources. Specific important strategies in crop production included changes in the types and varieties of crops produced, increased diversification of crop production, and soil and water conservation. Important strategies for livestock production included increased use of crop residues as animal feed; diversifying animal feed for goats and camels, cactus for camels, elephant grass and changes in herd composition through reducing number of cattle while increasing camels and goats associated with better feeding habits; migration over long distances in search of feed and water resources; and development of fodder banks for the dry season or drought period. Other adaptation responses included investments in natural resources management. These include soil and water conservation with physical and biological measures, water harvesting, a forestation and reforestation, and area enclosure and rehabilitation of degraded lands.

CONCLUSION

Food insecurity and drought are the most challenging problems in the study area. The research investigated the impacts of climate variability on food security and to examine and adaptive and coping mechanisms of the households.

According to the research findings, the dominant climate elements where rainfall and temperature fluctuation that was posed major impact on food insecurity in the study area. And, also the study assesses the rainfall and temperature trend in the study area, as long- term meteorological data indicates the PCI shows very high variation in concentration of rainfall that is erratic in nature and there is high fluctuation of temperature.

The research finding also indicated strong and positive association between food security of households and independent variables ($r=+.971$, $p<0.013$) and 94.30 percent of the variance in food security.

Recommendation

- The government and any concerning bodies have to appreciate and support local adoptions and coping mechanisms that is very important to solve climate variability problems and to sustain the food security status of the households.
- The Wereda is highly vulnerable to drought because of this there is low production and productivity this lead to food insecurity of households to solve this the government with NGOS and organizations should dig deep wells for irrigation.
- To strengthen the coping strategies of farmers, local administrative organs have to arrange and organize work experience sharing program among very poor and poor with wealthy at community level as well as zonal and regional level to encourage and initiate vulnerable segment of population to involve in all income generating activities within hazard.
- It needs a further investigation to fill the knowledge and skill gap that revealed in the study area and to initiate and to empower the communities and all stakeholders in Wereda.

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