

Research article

# An Agro-Ecological Assessment of Household Food Insecurity in Deme Catchment, South-western Ethiopia

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## Abstract

The study area is one of the most affected part of the Ethiopian mountain systems in terms of natural resources destruction, rain fall irregularity and the resultant drought and food shortage. The research attempts to examine situation of food insecurity and explore household food determinant variables in the watershed. In the analysis statistical methodologies such as Household Food Balance Sheet, Household Food Status and multiple regression models were utilized. In the study area, nearly 50% households those from highland and 39.3% households from midland Peasant Association are under the threat of food deficit compared to 85.2% households in lowland Peasant Association that attained optimal dietary per capita intake, suggesting that there is high degree of heterogeneity among the studied agro-ecologies. In addition, computed surplus/shortfall indices showed that food secure households attained 56% in excesses of the minimum per capita calorie requirement compared to 32% short fall per capita calorie requirement for food insecure households in the catchment. Moreover, the food data further revealed that in the studied year about 63.9 % of the households was found to be food insecure. The computed data showed that the relationship (R) between food availability (dependent variable) and sixteen independent household variables was found to be strong (0.913). Similarly, the percentage of variance of the predicted variable ( $R^2$ ) was computed to be 0.834. Hence, in the study, 83.4 percent of the variance of per capita food availability was explained by sixteen independent variables, while the remaining 16.6 percent of per capita food availability is due to other factors, which are not considered in the study. Generally, an analysis of this kind would help the local government to take timely intervention and help planners and donor agencies to include the problems as a priority area of intervention in their project. **Copyright © acascipub.com, all rights reserved.**

**Key words:** food security, agro-ecology, sustainable development, food availability and Deme Catchment.

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## INTRODUCTION

### Background to the problem

Based on elevation, Ethiopia is divided into five similar cropping and rainfall zones or what traditionally called as agro- ecology (Hurni, 1995). These are *wurch* (cold highland), *dega* (cool highland), *woinadega* (cool sub-humid highland), *kola* (semi-arid lowland) and *bereha* (desert). These spatial units have their own effect on the way of life of the people and food acquisition system, in addition to its impact on climatic and agricultural activities. In Ethiopia, subsistence mixed smallholders agriculture in the highlands and pastoral system in the semi-arid lowlands are the main source of food supply and means of livelihood for more than 85 percent of the population. Climatic variability, deteriorating soil conditions etc are blamed as the main threats of sufficient crop harvest in the country. As a result, similar to most sub-Saharan African countries food production (growing by 1.6 percent per annum) cannot feed fast growing population growth (2.7 percent per annum). Calories requirement, which measures the adequacy of diet, varies from an average 2199 calories in the Sub-Saharan Africa to 3300 calories per person per day in the USA. While the mean per capita daily dietary intake in Ethiopia is 1888 calories, where medically allowed minimum daily requirement is 2100 calories per adult per day. This figure gave a very high (44 percent) prevalence of under-nourishment for Ethiopia in 2003 compared to 33 percent under-nourishment of the whole Sub-Saharan Africa (Berhanu, 2004). Food insecurity both chronic and transitory (seasonal) is a persistent problem facing the majority of Ethiopians today. As observed from the Ethiopian Disaster Prevention and Preparedness Report reports, in Ethiopia domestic food production was able to cover only 68.8 % and 76.3% of the total national food requirement in 2002 and 2005, respectively.

According to Food and Agricultural Organization, (FAO) food security is the physical and economic access to basic foods for the people need. In a more realistic term, the availability of food to agricultural households largely depends on the extent of the seasonal harvest. In Ethiopia, historically food insecure areas coincide with areas of low and unreliable rainfall, high population density and low resource endowments. Population pressure declined soil nutrient content and pushes farming into remote vegetated lands and damaged the environment at large. The impact of erratic rainfall and hence recurrent drought has decreased the asset base of the rural households, leading to destitution. Regarding causation and severity of food insecurity in Ethiopia; various studies have revealed interesting empirical findings. For instance, Webb et al. 1994 (drought and war), Diriba 1995 (decline in physical resources), Kebede 1995 (marketing policy of the Marxist regime) and Dessalegn 1998 (tenure insecurity and insufficient land) are some of the outstanding causes of food insecurity in Ethiopia.

Similar to other part of Ethiopia, in Southern Nations, Nationalities and People Region (SNNPR from now on wards) where the study was conducted, poor performance of the agriculture may be attributed to cumulative causation of demographic and non-demographic factors (Shumeye, 1998). Poverty is one of the most important concerns of the SNNPR region where about 56.8 percent of the total population is living under poverty line (CSA, 2007). The same source further estimated that about 46.2 percent of the farmers in the region own 0.1-0.5 hectare of land per household whereas the proportion who have land size of more than 2 hectares per household are only 4.7 percent. About 53.9 percent of children are stunted, 12 percent are severely wasted and 52.5 percent are under weight (CSA, 2007). Due to increasing population size over the decades with small land size, there has been series of food shortages, which resulted in migration of household members.

Similar to other parts of Ethiopia, In Deme catchment due to unsustainable land use practices, erratic rainfall and demographic pressure pose a serious threat to the status households' food security and food shortage. For instance rainfall data collected from Kutcha district metrological station for twelve years (2001-2012) revealed significant annual rainfall variability with a coefficient of variation more than 13% and the variability is much more than the annual behavior the seasonal level. In a similar condition, collected food data showed yearly food production increase by 1.8%, where annual population growth would be nearly 4% (owns survey). Thus, as mentioned elsewhere in the study due to traditional farming practices, rainfall variability and other related factors annual food production didn't much with population growth. As a result there is a strong gap of food availability in the district. Kutcha District agriculture office revealed annual Relief beneficiary population would be nearly 11.2% of the total district population showing the magnitude affected population in the area. Therefore, it may be concluded that the problems of food shortage in the study area was emanated from three causes: (i) high population growth rate

(2.7 %) resulted in a meager holdings; (ii) poor crop performance; and (iii) lack of diversified income sources. When these factors are triggered by inconsistent rainfall, the households are at risk.

In the analysis of food security, various authors used different methodologies like general explanation approach (Markos, 1997), food availability decline and food entitlement decline models (Sen, 1981) to analyze the food security. In the study, the latter approach has been adapted for the analysis of household food shortage in Basso catchment. This is because the model tries to consider different variables of food security such as household food production, wage labor, transfer, gift, the attitude of people or coping strategies, etc. The study site, having a limited spatial coverage, but its diversified terrains has resulted in forming various geographic localities with contrasting climate, flora and livelihood strategies. An attempt has been made in the research to explore the determinants and situation of household food insecurity among sample Peasant Associations in Deme Catchment.

## Materials and Methods

### The study area

Deme catchment is located between  $6^{\circ} 20' N$  to  $6^{\circ} 40' N$  latitude and  $37^{\circ} 20' E$  to  $37^{\circ} 40' E$  longitude (Fig. 1). The three PAs selected for the study were belonged to three agro-ecologies, namely cool climate (Kulo), sub-tropical (Fango) and semi-arid climate (Dana). The three agro-ecologies accounts for about 20%, 30% and 50% of the total area of the catchment. The study area is characterized by hills, rugged terrain and rolling plains. The mean annual temperature and rainfall is about  $22^{\circ} C$  and 1100mm, respectively, but varies considerably throughout the agro ecologies and seasons.

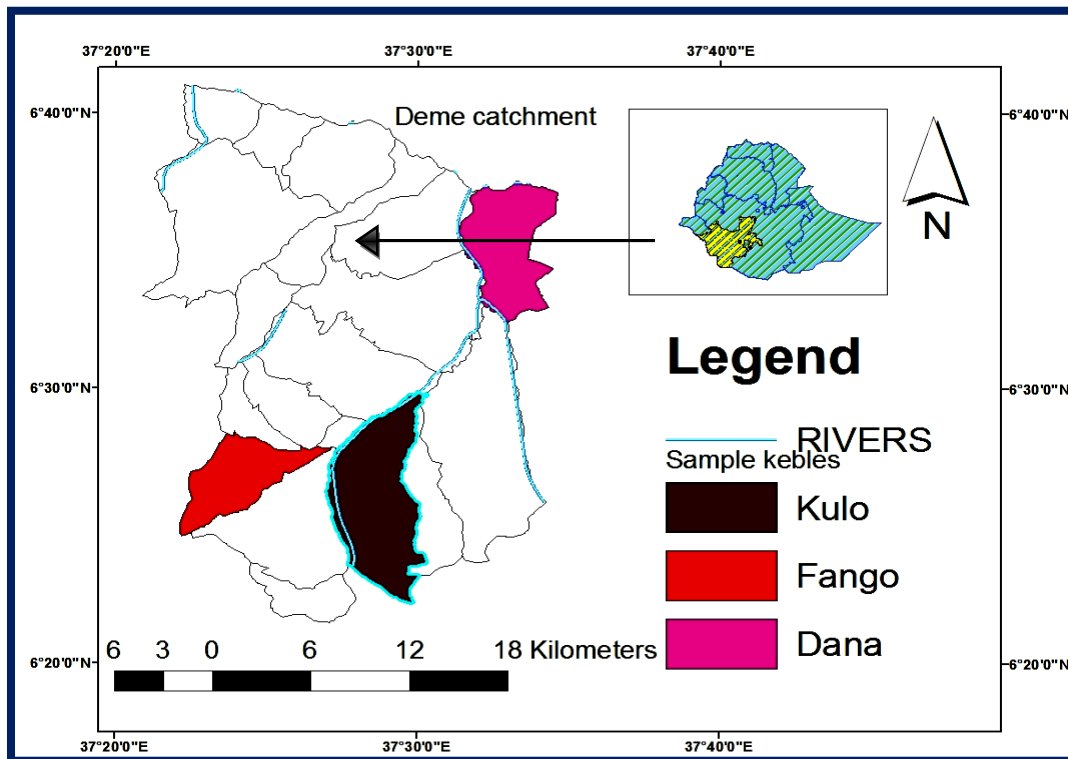


Figure 1: location of the study area

The livelihood of the people in the study area is basically agricultural but off farm activities are also carried out during spring season. The agricultural activities carried out in the area include both crop production and animal husbandry. In the catchment, perennial crops covered a significant size (23.7 %) of the total cultivated land. Thus, of perennial crop, *ensete ventricosum* in the upland, and *Musa Mesta* and *Mangifera indica* in the lowland are an important source of food and cash income. Perennials (*ensete ventricosum*) and cereal crops (barley, maize and wheat) dominated the cropping pattern and subsistence in nature, and meant only for home consumption. In responses to the degraded natural environment and erratic rainfall, the rural population in the area is vulnerable to food shortage.

## Data acquisition and Analysis method

**Data collection techniques:** in this study, both primary and secondary data were utilized. The primary data were generated through household survey, key informant interviews and focus group discussion. Secondary data were obtained from meteorological station and Kutcha district agriculture and Rural Development office. Three sample Peasant associations were selected from 19 PAs in catchment using stratified random sampling technique in order to represent one sample PA from each agro-ecology. Then from the three sample PAs, 10% sample household heads were selected using stratified and systematic random sampling techniques. The selected sample households were proportional to the sample size. Household survey was conducted in the period between Nov.2011 and Nov 2012 from three sample PAs. During data collection, all sample household heads were interviewed using a structured survey questionnaire. In addition, Key informant interview and focus group discussion were held with household heads in the PAs. Further, discussion were also held with village officials, heads of women and youth associations, and development agents on key issues such as climatic and environmental change and situation of household food insecurity.

**Methods of Analysis:** to determine house hold food insecurity, models such as household food status and Household Food Balance sheet were used in the analysis (Haile et al 2005, Shiferaw et al 2004). Household Food Balance Model, HFBM was used to quantify the net available food by each of the 194 sampled rural households in Deme catchment in the study period covering between November 2011 to November 2012. All variables required for the HFBM model were then converted from the local grain measurement units into the corresponding kilo gram grain equivalent. The HFBM model was expressed as:  $Q_i = (P_i + B_i + F_i + R_i) - (L_i + S_i)$ . In the model, the index  $i$  runs from 1, 2, ..., 194 and  $Q_i$  represents net grain food available for household  $i$ ;  $P_i$  total grain produced by household  $i$ ;  $B_i$  is total grain purchased by household  $i$ ;  $F_i$  is total grain obtained through food-for-work by household  $i$ ;  $R_i$  is total relief grain food received by household  $i$ ;  $L_i$  is post-harvest crop losses to household  $i$ ;  $S_i$  total crop utilized for seed by household  $i$ ; With the exception of post-harvest losses, all the data needed for HFBM model were obtained from the primary data gathered for the period November 2011 to November 2012. According to the report of Woreda Agriculture Office, post-harvest crop loss and seed utilized for farming during the year under investigation was estimated at an average value of 15% and 6 % respectively of the total own crop production. Finally, following Alem(2007), the response variable was determined in four steps. First, net grain available for each household in kilogram ( $P_i$ ) was converted into equivalent total kilo calories using conversion factors used for Ethiopia (Agren et al, 1968). Second, the food supply at the household level calculated in step (i) was used to calculate calories available per person per day for each household.

Third, following Federal Democratic Republic of Ethiopia Food Security Strategy (2002), 2,100 kilo calories per person per day was used as a measure of calories required (i.e., demand) to enable an adult to live a healthy and moderately active life. Then a comparison between the available (supply) and required (i.e., demand) grain food was made. Finally, comparison between calories available and calories demanded by a household was used to determine the food security status of a household. A household whose daily per capita caloric available (supply) is less than his/her demand was regarded as food insecure, and coded as 2, while a household who did not experience a calorie deficit during the year under study was regarded as food secure and was assigned a code of 1. In view of this, the response variable, food security status of the  $i^{\text{th}}$  household,  $HFS_i$  was measured as a dichotomous variable:

$$HFS_i = \begin{cases} 1 = Y_i > 2100 \text{ kilocalorie (food secure)} \\ 2 = Y_i < 2100 \text{ kilo calorie (food insecure)} \end{cases}$$

where  $Y_i$  daily per capita calorie available;  $R$  is the minimum recommended national standard rate of calories per person per day, which is 2,100 kilo calorie and  $HFS_i$  food security status of the  $i^{th}$  household,  $i = 1, 2, 3 \dots 194$ . Head count ratio expressed as  $H = m/n$ , where  $m$  = number of food insecure households and “ $n$ ” equal to number of households in the sample was calculated to measure the extent of undernourishment. Besides, a shortfall/surplus index ( $P$ ) defined as  $P = \sum_{i=1}^m \left( \frac{Y_i - R}{mR} \right)$  calculated where  $Y_i$  daily per capita calorie intake of  $i^{th}$  household and  $R$  is the recommended per capita daily calorie intake, which is 2,100 kilo calorie. The index “ $P$ ” measures the proportion of shortfall/surplus of the average daily dietary energy intake of the undernourished from the average national nutritional requirements, expressing the depth of undernourishment. In addition, to examine the statistical association of sixteen independent household variables with household food availability (dependent variable) a multiple regression model was used. Multiple regressions ( $y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_i x_i + \epsilon$ ) was used. Where,  $y$  is the value of the dependent variable  $\beta_0$  is the regression constant  $\beta_1, \beta_2, \dots, \beta_i$  is the partial regression coefficient for the independent variables, 1, 2, ...,  $i$  respectively. ‘ $i$ ’ is the number of independent variables.

## RESULT AND DISCUSSION

### Food security status of the household

The major food types used in the study area are cereal, enset and root crops, while animal products and vegetables are rarely consumed. As shown in Table 1, farmers in the study area have access to food from four sources, namely own farm production, food purchased from market, grains obtained from Food for Work Program (FFW) and relief aid. In the study period, of the total food availability, own production contributed the highest proportion (51.2 percent) followed by purchased food from market (21.6 %). While the contribution of relief and food for work program also accounts a significant portion of food acquisition in the area.

**Table 1:** Source of Food Available for Consumption (Percent), 2011/2012

sample	Sample household	Source of food available%				Total net food availability in kilogram
		Own production	purchase	Food For work	Relief	
peasant Association						
Kulo	788	57	18.2	11.4	13.4	98000
Fango	437	54	17.5	12.9	15.6	59900
Dana	304	42.6	29	13.5	14.9	58950
Aggregate level	1529	51.2	21.6	12.6	14.6	216850

Sources: household survey, 2012

At Peasant Association level, the contribution of own production to the total households’ food availability was found to be the highest in all PAs (57 percent, 54 percent and 42.6 percent in Kulo, Fango and Dana peasant Association

respectively). But the contribution of purchased food to the household food source was found to be relatively large (29%) in Dana PA. This shows that in semi-arid lowlands, households show preference to cultivate cash crops and purchased food crop from market. This finding confirmed with the findings of Teshome, 2010 that was conducted in central Rift valley Lake region of Ethiopia. In the Lake region, with the promising fruit demand at the national markets, in this region farmers have shown their preference to cultivate value added cash crops, such as Banana and Mangoes instead of low value cereal crops.

By using Household Food Balance Model HFBM, household food availability was calculated. Thus, HFBM equals (own production plus purchased food plus Food for work plus Relief food) minus (15% post-harvest loss plus (6% utilized for seed)). That is  $HFBM = (143,441.4 \text{ kg} + 45,414 \text{ kg} + 26,857.4 \text{ kg} + 31,260 \text{ kg}) - (21,516 \text{ kg} + 8606 \text{ kg}) = 216850 \text{ kg}$ . Thus by using the short fall formula the surplus/shortfall indices of the household food security and insecurity status was calculated. Therefore the computed surplus/shortfall indices (P) for 70 food secure households were 0.56 and for 124 food insecure households were 0.32. This result indicates that food secure households exceeded the minimum calorie requirement by 56% and the food insecure households felt short of the calorie requirement by 32% respectively. The analysis further depicted that out of 194 sample household heads, the food secure and food insecure households' accounts for 36% and 64% respectively. This situation shows that the depth of undernourishment in the study area is acute and food insecurity situation is also severe.

In addition, Food Balance Sheet for the year 2011/12 was computed as presented in Table 2. As can be seen from the table that all sample PAs received daily per capita food of 55% lower than the medically recommended calories intake). The foregoing analysis further revealed that food energy deficiency showed a great disparity throughout the agro ecologies. For instance food deficiency was more acute in Kulo PA (45%) as compared to Dana PA (14%). At the aggregate level, the estimated average daily per capita food available was found to be 1411 calories, which is 32.8 percent lower than the minimum daily recommended dietary allowance compared to 46 percent undernourishment for Ethiopia in 2007/08 (UNDP, 2008). Further investigation of the data depicts that variation of food availability among the households with in the agro-ecologies seems to be very wide as shown by the variability statistics. Thus the coefficient of variation for Fango and Kulo PAs was found to be enormous (72% and 40% respectively). Households in the study area are on poverty line of 0.5 kg daily food per capita consumption requirement. Therefore, taking consumption of less than 0.62 kg cereal food daily per capita as an indicator of food insecurity, daily food per capita requirement 0.5 kg makes the study area in a severe situation of food insecurity.

**Table 2:** Mean Net Food Available for Consumption in Kilocalories, 2012

PA	Mean total kg per household Per year	Mean total Kcal per household	Daily per capita food available in calories per individual						
			Mean	% of the mean	min	max	SD	CV	

		Per year.						
Kulo	970.3	2170	1156	55	567	4650	458.5	40
Fango	1222.4	5638	1274	61	450	4300	914.4	72
Dana	1339.7	6881.2	1802	86	540	2480	488.8	27
Aggregate level	1177.5	4896.4	1411	67	519	3810	620.6	46

Source: survey data, 2012

### Determinants of Household Food Security

To examine the statistical association of sixteen household variables with food availability and to measure how far the variation of the per capita food available (dependent variable) is predicted or explained by the fifteen factors (independent variables) multiple regressions was computed using the formula  $y = \beta_0 + \beta_1x_1 + \beta_2x_2 + \dots + \beta_ix_i + \epsilon$ . Where,  $y$  is the value of the dependent variable  $\beta_0$  is the regression constant  $\beta_1, \beta_2, \dots, \beta_i$  is the partial regression coefficient for the independent variables, 1, 2, ..., i respectively. 'i' is the number of independent variables. Multiple correlation ( $R^2$ ) is the most useful technique for determining the percentage of the variance of the predicted variable that can be explained by the predictors.

The  $R^2$  in this model indicates the proportion of variation in the dependent variables (food availability) that is explained by the sixteen different independent variables as stated in table 3. The "R" value indicates the correlation between per capita food availability and sixteen independent variables. The r-value of 0.913 suggests that there is a strong positive relationship among the independent variables and dependent variable considered in the study. The percentage of sixteen independent variables that is due to a combination of factors such as farm size, fertilizer use, crop harvest, etc is then  $R^2 = 0.834$ . Hence, in the study, 83.4 percent of the variance of per capita food availability was explained by sixteen independent variables. Because  $1 - R^2$  is 0.166, 16.6 percent of per capita food availability is due to other factors such as infrastructural development, government policy, land tenure, market situation, and measurement errors, which were not considered in the study.

Beta coefficients, also known as standardized regression coefficients are used to compare the strength of a given coefficient to the coefficient of another variable, say land sizes. The Beta coefficients are used to compare the relative strength of the various predictors within the model. Because the Beta coefficients are measured in standard deviation, instead of the unit of the variables, they can be compared to one another. In table 3, size of farm land has the largest Beta coefficient which is 0.600, and use of improved seed has the smallest Beta which is 0.020. Thus, a one standard deviation increase in land size leads to a 0.600 standard deviation increase in predicted per capita food availability, when the other variables held constant. And, a one standard deviation increase in application of improved seed leads to a 0.020 standard deviation increase in per capita food availability when the other variables in the model held constant. In addition, to determine whether the means of more than two samples are too different to attribute to sample error, the analysis of variance (ANOVA) was computed. The food availability variation with an ANOVA of F-ratio of 82.93 was also statistically significant.

In order to analyze these variables, the following hypothesis was stated. These are per capita food availability increases with the increase of use of technological inputs, use of farm oxen, possession of livestock, farm size, and age of household head and educational level of the head. Contrarily, per capita food available in calorie decreases with an increase in family size and female headed households. When we observe the effect of independent variables in terms of sign, among sixteen independent variables, seven independent variables have positive effects on per capita food availability. These independent variables are use of irrigation, application of fertilizers, house hold heads education level, fertility of farmland, marital status, use of off farm activity and support of extension agent. Among

these, irrigation use, fertility of farmland, support of extension agent and application of fertilizer has positive and significant effect on food availability in the study area. This implies that these four variables are important in determining food availability positively in the study area. Marital status, use of off farm activity and educational level has positive but insignificant effects on food availability. Other nine independent variables like gender, land size, family size, number of oxen, and age of house hold head, farm credit, size of crop harvest, total livestock and use of improved seed have negative effects on food availability in Deme catchment. This implies that there is negative relationship between the aforementioned independent variables and dependent variable (food availability) indicating that as the independent variable increase, per capita food availability decreases.

Among the independent variables gender, size of crop harvest, size of farm land, number of oxen, total livestock have negative and significant influence on food availability in the Deme catchment but others have negative and insignificant effect on food availability. Generally, in the study area among the independent variables, the size of harvest, size of livestock population, farm oxen, use of improved seed, provision of extension service, fertility of the farmland, use of irrigation, farm size and gender of the household were found to be the major determinants of food availability at household level (the significance of 't' in table 3). As can be observed from Table 3, per capita food availability has revealed an increase with an increase in fertility of the farm. The impact of the fertility of farm on household food availability is the expected occurrence, because with good management if the farm is fertile one can automatically expect increasing agricultural productivity with increasing fertility of the soil. The possession of farm oxen and the use of extension services were found to enhance household food security. Farm oxen are the major farm labor in traditional farming system that is expected to increase farm output at the household level. This is because with the help of oxen drawn plough it is possible to plough six to eight times more land than hoe plough (elders view from the study area). In addition, the use of extension service can enhance farm productivity through the application of the introduced agronomic innovations. The increase in crop production and the presence of large number of livestock in a given household simultaneously raises the household food security through increasing per capita food availability. This is because in traditional communities livestock are a source of asset and a means security during the time of production deficit. Therefore, the positive relationship that had happened between food availability and nine independent variables are the expected variables.

**Table 3:** Results of Multiple Regression Analysis

<i>Independent Variables</i>	Beta (B)	T	significance
Gender of the HH head	-0.077	-2.326	0.021
Marital status	0.045	1.154	0.250
Educational level	-0.076	1.636	0.104
Land size	-0.600	-12.318	0.000
Family size	-0.029	-0.901	0.369
Number of oxen	-0.146	-4.150	0.000
Age of the HH head	-0.063	-1.299	0.196
Size of Livestock	-0.148	-3.185	0.002
Size of crop harvest	-0.658	-8.005	0.000
Off farm activity	0.40	0.678	0.499
Farm credit	-0.22	-0.467	0.641



Use of fertilizer	0.094	2.074	0.040
Support of extension agent	0.110	2.262	0.025
Use of improved seed	-0.020	-0.479	0.633
Use of irrigation	0.141	3.775	0.000
Fertility of farmland	0.164	3.406	0.001
Constant	2.570		
R	0.913		
R square	0.834		
Adjusted R square	0.824		
F change	82.93		

Source: computation from survey data, 2012.

In the analysis an increase in family size and female headed households resulted in a simultaneous decrease in food availability of the household. The increase of family size with decrease in production is in support to the notion that large family size has more implication on food consumption than on labor supply to boost agricultural production. In the same way, the inverse relationship between independent variables (such as farm size, use of credit, use of improved seed, size of crop harvest, total livestock, age of household head, number of oxen and gender of household head) and food availability was also beyond our expectation.

## CONCLUSION

Vulnerability to food insecurity is a common phenomenon along the semi-arid lowlands and degraded highlands of Ethiopia where rural households rely on rain-fed agriculture. The study has assessed the possible causation and severity of food insecurity in three randomly selected Peasant Associations in Deme catchment of South-western Ethiopia. It tries to show agro-ecology as a topographic element has influenced the level of food production and households' livelihood strategies through environmental factors. As revealed in the study that household factors played an immense role in determining food security status of the catchment.

The analysis of food shortage showed that the household food production during the survey period, especially in the two highland PAs is lower than annual food requirement as revealed in the food balance sheet, implying that there is a considerable stress of food insecurity in those localities. From the analysis given, so far, it is possible to suggest that problems associated with inappropriate land-use, soil degradation, rainfall variability, landlessness, and food insecurity are considered as the major development challenges and problems threatening agricultural development and food security in the study area. The argument made in the study is that if sustainable policy measures are not taken in areas such as population pressure, environmental protection and household income diversification, food insecurity in the catchment will persist.

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