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Econometric Analysis of Rural Households' Resilience to Food Insecurity in West Shoa, Ethiopia

Temesgen Kebede[1,*], Jema Haji[1], Belaineh Legesse[1], Girma Mammo[2]

[1]School of Agricultural Economics, Haramaya University, Dire Dawa, Ethiopia
[2]Ethiopian Institutes of Agricultural Research, Melkassa, Ethiopia
*Corresponding author: temesgenkebede@gmail.com

Abstract The major objective of this study is to analyze rural households' capability to absorb the negative consequences of unexpected shocks using seven resilience blocs based on the framework of resilience analysis. Resilience index was defined as a function of agricultural inputs and technology, social safety nets, access to public services, access to food and income, access to assets, stability and adaptive capacity. The estimation of each bloc was made separately using different multivariate techniques, where the result becomes covariates in the measurement of resilience index. The estimation of resilience index was done using factor analysis and three factors were retained. Under the first factor, all blocs, except access to public services, are positively correlated with resilience. The negative correlation between access to public services and resilience is because observed variables like health services and education qualities decreases as households become poorer. In terms of importance to rural household's resilience index, the result indicates that asset ownership play significant role followed by access to food and income, as well as social safety nets. These resilience blocs show the likelihood of recovering from any form of climatic shocks that a household experiences. In the second factor, access to public services becomes positive, which shows that it is a positive characteristic of resilience. Adaptive capacity is positive in the first factor and negative in the second factor. The third factor triggers hidden information of the resilience bloc as stability and adaptive capacity are positive, which likely tells common story in terms of food security situations. In conclusion, poor households have limited or no access to physical and financial assets, little education, and often suffer from human illness and livestock diseases/death. Poor households lack access to sufficient, high-quality land and other natural resources or to remunerative resources of income and agricultural production boosting activities. Therefore, it is recommended that households should have supplements with preconditions and options available to them in terms of capabilities and activities such as agricultural production boosting and income-generating activities, access to assets, improving the quality of public services, social safety nets and adaptive capacity.

Keywords: *resilience, food insecurity, smallholders, West Shoa, Ethiopia*

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1. Introduction

Climate is a key natural resource for sustenance of life. The change in climate is a complex biophysical process and difficult concept. It is slippery to empirically demonstrate the climatic events that are attributable outside the ideal world of computer models [1]. In fact, there is a scientific understanding that has been established on the significant rising of greenhouse gases (GHG) arising mainly from anthropogenic activities [2] results in the atmosphere and oceans to warmer, glaciers to melt, sea levels to increase and the climate continue to change [3].

The climate is continually changing regardless of human intervention for at least the next decades and beyond [4]. Consequently, there are observable global and regional temperature change; as well as hydrological cycle getting disrupted; including the change in the atmospheric water vapor, precipitation, stream flows; cryosphere changes, and changes in ocean properties. The effects of the change with the implication for nature and human lives have been observed scientifically [5]. This negative impact of climate change becomes a serious concern in particular in developing countries' agricultural production and the food systems [6,7].

Climate related shocks are the major causes of persistent hunger, frequent famine, [8] and widespread undernourishment and stifled rural households' food security in developing countries. The global unfavorable climate variability show the most recent trend in food security challenges. For Ethiopia, there exists strong correlation between the overall gross domestic product (GDP), agriculture contribution to GDP and the rainfall pattern, showing how plentiful rain events associated with bountiful agricultural production and food security, while a "poor" or limited rains in amount, distribution and duration means a poor harvest for most [9,10]. The amount of rainfall below the long run average by 10% in

Ethiopia, for instance, leads to a 4.4% reduction in the food production [11].

Rainfall distribution and pattern is correlated to agricultural production which remains crucial challenge [12] even after twenty five years of von Braun conclusion. The perdition of failed rainfall accompanied with ever exploding population growth, declining of soil fertility and rising erosion mainly arising from tilling of the steep slopes causes great damages to the life and livelihoods of rural smallholder farmers. The stride for livelihood from charcoal marketing and expanding farm land, and over-grazing has led to deforestation. These cumulative effects contribute negatively to agricultural production, which led to subsistence harvest.

Poor agricultural harvest due to drought induced calamites primarily owed to successive failed rains left a significant number of people in Ethiopia to emergency food handout. Owing to the continued ocean warming effect of El *Nino*, Ethiopia is facing one of the worst crises. From June 2015 onwards; the effect left an estimated 10.2 million people to emergency food aid [13] and hence, rural households are dipping into food insecurity.

These demands for the shift in attention from the crises management, shift in mental model construct of the society itself and identifying the key actors for building households resilience to such deep rooted chronic food insecurity. Some pioneer scholars [12,13] and international organization [16] have tried to examine household level food security issues through short term and long term strategic combinations from resilience perspective. Resilience is a broad concept of measurement of systems' ability to withstand unpredictable shocks. In this regard, the government needs to have moral and political responsibilities to establish communities that withstand the challenge before it happens or quickly recover from the shocks or exploit benefit from crisis.

The government of Ethiopia has quite progressive programs that enable rural households to withstand climate related shocks like the productive safety net program (PSNP), household asset building (HAB) and other policy oriented programs. The major aim of these programs is to lever households from food insecurity and even leading to economic and decent life. Conversely, as in [17] document reports that the support for livelihoods due to crises affected rural households has been insufficient. This reveals albeit endeavor for making rural households to lead a decent life, looking for sustainable solutions through resilience building remains crucial.

The notion of resilience is a complex process more often than not requiring people to adapt completely new orientation of life and to transform existing social and institutional structures. In such cases, those well established and institutionalized patterns of social agency will have to be discarded and new organizational settings beyond the framework of familiar strategies will have to be developed and put in practice. Two basic facts as in [15] can be coined. The first is related to the fact that resilience has multidimensional nature and the second fact is associated with the unpredictable nature of shocks to households to which they are exposed.

This empirical household level study on resilience to food insecurity was conducted in five woredas of West Shoa zone of Ethiopia. In this study, resilience was defined as the current states of affairs and its ability to withstand shocks. Accordingly, five resilience blocs with two additional capability dimensions were used. These resilience blocs are access to agricultural input and technology, social safety nets, access to public services, access to food and income, access to asset, stability and adaptive capacity.

2. Research Methodology

2.1. Description of the Study Area

This study was carried out in West Shoa zone, one of the 18 zones located at the center of Oromia National Regional States. Its capital is Ambo and has 528 rural and 43 urban kebeles. As in [18] population and housing survey projection, it has a population of 2,500,482. The zone has 18 districts and among these, four districts are located in highland agro ecology, eight districts are located in mid altitude and six of them are located in lowland.

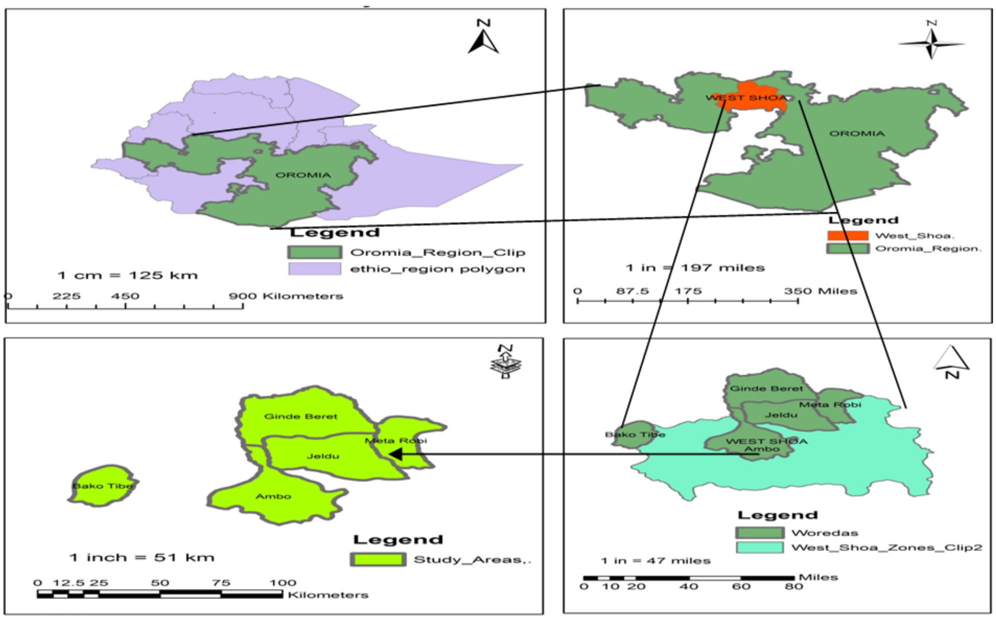

Figure 1. Map of the study area

The zone has area of 14,349.29 square kilometers. The zone consists of 47.7% of the total area as leveled field which is an ideal place for agriculture. Gorges (4.6%), mountainous area (16.8%) and other (30.9%) take the topography share of the zone. Agriculture is the major means of the livelihood. Around 70% of income of the rural households is generated from crop production, and about 20% from livestock rearing. The major crops produced are wheat, *teff*, barley, maize, sorghum, bean, pea, *noug* and sesame. In addition, there are a large number of livestock (1.86 million cattle), small ruminants (1.55 million goats and sheep), donkey, mule and horses (more than 300,000 equines); poultry, bee colonies: - traditional, transitive and modern beehive.

The altitude of West Shoa zone ranges from 1000 to 3288 meters above sea level, where the largest area lies above 2000 meters above sea level. The zone experiences maximum temperature ranging from 18°C to 30°C with minimum temperature ranging from 7°C to 22°C. Rainfall distribution also varies from minimum of 250 mm to a maximum of 2610 mm. Almost half of the soil type of the zone is red, 29% of the soil is grey, 27% of the soil type is categorized under red brown and the remaining 6% constitutes other soil types.

2.2. Sampling and Data Description

In this study, both primary and secondary data were collected. Primary data collection was mainly based on a survey, which was formulated at household level and conducted face to face to obtain firsthand information.

To administer the survey, multistage sampling techniques was used. First, districts in the zone were clustered based on agro-ecology into three as highland, mid-altitude and lowland. Again, each district was classified into two based on relief recipient and non relief recipient districts. Accordingly, from the four districts located in the highland agro ecology, two of them are more frequent relief receivers (in thirteen years juncture, the districts receive relief more than 7 times) and the remaining two districts are less frequent relief receivers (received relief less than 3 times) for the time period ranging from 2003 to 2015. Similarly, among the eight districts which are located in the mid-altitude, three of them are more frequent relief receivers and the remaining five districts are less relief receiver districts. Likewise, out of the six districts located in lowland agro-ecology, one district is a more frequent relief receiver and the remaining five districts are less relief receivers.

Therefore, there are six clusters of more relief and less relief receiver districts. Two round of non-repetitive selection procedure were taken from each cluster to give second chance of selecting every district. In each cluster, a value of one and zero was assigned, with the name of the district having a value of 1 to be included and otherwise to be rejected. Then, using lottery method, picking up one at a time from each cluster was made. Accordingly, from the cluster of relief receiver highland agro-ecology districts, Jaldu district was selected randomly. From mid-altitude agro-ecology, Gindeberet and Meta Robi districts were more frequent relief receivers and Ambo from less frequent relief receiver clusters were selected. The three districts, Meta Robi, Gindeberet, and Jaldu make around 60% the total number of beneficiaries. From less relief receiver lowland agro-ecology districts, Bako Tibe was also included randomly. The total districts sum up to five, one district from highland agro-ecology, three districts from midlands and one district from low land agro-ecology.

Kebeles in each randomly selected district was again clustered based on agro-ecologies. Then, one representative kebele from each agro-ecology in the district was selected using simple random sampling technique. Kebeles in Gindeberet are either lowland or midland while other districts have three agro-ecologies. Therefore, the total kebeles selected sum up to fourteen.

There are 330,772 rural households in the zone. From the total kebeles in the zone, each year 50% of them are experiencing shocks associated with rainfall variability. Finally, the sample size is determined following [19] formula as:

$$n = \frac{Z^2 pqN}{e^2(N-1) + Z^2 pq} \quad (1)$$

Where n is the required sample size, Z is the inverse of the standard cumulative distribution that correspond to the level of confidence, e is the desired level of precision, p is the estimated proportion of kebeles exposed to rainfall variability. N is the total number of rural households inhabiting in the zone.

$$= \left[\frac{(1.96^2)(0.5)(0.5)(330{,}772\ )}{(0.05^2)(330{,}771) + (1.96)^2(0.5)(0.5)}\right]$$

$$= \frac{317673.4288}{827.8879}$$

$$= 383.72 \approx 384.$$

Therefore, the total sample size is determined to be 384 rural households. Finally, sample respondents were selected from each kebele randomly based on probability proportion to size.

Secondary data were also collected from zonal office of agriculture, zonal risk prevention and preparedness office, and each respective district office of agriculture. Data on climatic variables were collected from National Meteorological Agency Stations at different locations.

3. Modeling Resilience to Food Insecurity

Resilience of rural households depends on options available to them to lead a decent life [15]. Those options are preconditions for the households' response mechanisms to the negative effects of unforeseen climate related shocks [20]. For instance, agricultural inputs and technology constitutes of the provisions of agricultural service packages, agricultural input supplies and scientific knowledge. These aggregate forms of agricultural inputs and technology play significant role in increasing agricultural production henceforth enhance their resilience to food insecurity. Social safety nets as social protections component has also been an essential mechanism that enables households' recovering capability and increase household's resilience to food insecurity.

Resilience is a latent variable defined indirectly, using seven resilience blocs. To measure household resilience, two options are available: measure all dimensions simultaneously through structural equation modeling (SEM) or measure each bloc separately using different multivariate techniques [15].

The SEM is an extension of general linear modeling procedure like analysis of variance (ANOVA) and multiple regression analysis [15,20]. The model measures all the components simultaneously and assumes that residuals are distributed normally. Hence, it is limited to the normally distributed observed variables in continuous form [21]. However, data collected at household level is either ordinal or categorical, which inhibit the use of SEM to measure resilience. Measurement of latent variable with the help of multivariate techniques is advantageous [15].

Multivariate statistical techniques to generate these latent variables depend on the scale of observed variables where, household level survey data are qualitative in nature, non-continuous type variables. Hence, a separate multivariate technique is relevant to employ for the analysis like factorial analysis, and principal component analysis. This is because, it is related to the assumptions that variables may not be normally distributed and measuring different component separately enables the model to be more flexible [15,20]. In this paper both principal component analysis and factor analyses were used to estimate unobserved variables of the resilience bloc [20].

To estimate resilience, two stages were followed. In the first stage each resilience bloc was estimated separately. Nonetheless, each bloc is latent variable, not observed directly, in a given survey but possible to estimate them through multivariate techniques [20,22]. In the second stage, resilience index was computed from the result of the first stage. The blocs that enable to estimate resilience are agricultural input access and technology, social safety nets, access to public services, access to food and income, access to assets, stability and adaptive capacity.

3.1. Access to Agricultural Inputs and Technology (AIT)

This resilience bloc is directly related to the household's degree of production capacity. Observable variables that are expected to define access to agricultural inputs and technology include fertilizer, herbicide and extension contacts. Farmers that are using fertilizer as one form of agricultural input enable them to improve their farm productivity through increasing crop per unit area, which would improve total production per household and more food to be available for the household, and hence enhance their resilience.

Herbicide use has likely control plant diseases and hence increase household level of food production thereby enhances resilience to food insecurity. Extension contacts are the average number of contacts that the household head received during the last 12 months. Access to agricultural inputs and technology is a critical resilience bloc for the success of resilience to climate variability. Factor analysis was run using principal factor method.

3.2. Social Safety Net (SSN)

Social safety nets are crucial aspect for the poor to make life simple and lessen the impact of climate related shocks to them. In West Shoa zone, social safety nets as social protection, in the form of relief that consists of grain, oil and pulses, assistances in cash and in kind was given to households affected with climate related shocks. Households that receive assistance were asked about the quality of assistance, job assistance, frequency of assistance and overall attitude on targeting assistance to the needy. The observed variables to generate the unobserved (latent) variables were diverse indicators ranging from discrete values (like job assistance) to categorical (assistance targeted to the needy; including some not needy; and targeted without distinction) to continuous (cash assistance). In order to estimate social safety nets latent variable principal component analysis was used.

3.3. Access to Public Services (APS)

Access to public services encompasses key responses provided by the public that is expected to enhance household's resilience. The provisions of public services are exogenous to households, but it remains fundamental to manage risk and respond accordingly and enhancing household's resilience.

Observed variables to estimate the latent variable (in this case access to public services) included are access to information (dummy variable: 1 if the household head access to information through television, radio or any other means of accessing information), access to credit (dummy variable: 1 if the household head has borrowed credit over the last 12 months period), access to irrigation, infrastructure like roads, hospitals and schools. Access to drinking water, electricity and telecommunications networks and mobility and transport constraints (ordinal scale from 1 (less constraints) to 3 (more constraints) were also included in estimation of this latent variable.

3.4. Access to Food and Income (AFI)

Income and food access are directly related to households capacity to absorb shocks. Food access is the economic capacity of a household to afford food, which requires a household to have income for food consumption expenditure; therefore, we have calculated it as the per capita income of the household computed from total household's income to the family size. Average dietary energy consumption is included to take caloric adequacy at household level, which is calculated from average kilo calorie intake per AE per day. To account for perception of food access, household heads were asked nine generic questions of the Household Food Insecurity Access Scale (HFIAS) developed by Food and Nutrition Technical Assistance (FANTA) [23]. Household dietary diversity score (HDDS) was also included as an indicator of the household's nutritional proxies applied to the two weeks consumption of different food items. The consumption of 12 food groups for dietary diversity score, which can also be used as a proxy indicator for food access [24,25,26]. To estimate income and food access latent variable, factor analysis was used.

3.5. Access to Assets (A)

Smallholder farmers possess agricultural assets like land, livestock and non agricultural assets like estimated amount of nonfarm income earned in *Birr*, house structure and number of rooms. Land holding and livestock ownership are veritable assets that improve quality of life by supporting and enabling to generate diversified sources of income, encourage productions of both crop and livestock, improves mechanism to access nutritious food, and enhances resilience of smallholder farmers.

3.6. Stability (S)

Stability refers to household's options and capacity to withstand as a whole to external shocks and stressors during shock prevalence time. It is one bloc of resilience responds to perturbation, confront climate related shocks and recovering quickly. Household's survival depends on the interaction components that enable them to react to such external stimuli and continue their life and livelihoods operations indifferently. Stability is an important dimension of household's resilience.

The bedeviled nature of notoriously unpredictable climate variability causes instability. It progressively worsens resilience of smallholder farmers' and severely hamstrung their life and livelihoods. Even smaller external event can bring nefarious outcome like catastrophe destruction. Households with high stability have likely illustrates high resilience to food insecurity, while those showing low stability will have low resilience.

Socio-economic and ecological variables were captured to estimate this latent variable like perceptions to drought over the last two to three decades, the rainfall variability that elapsed similar period of time, livestock diseases and crop failure due to climate variability causes, output price volatility, water shortages. Moreover, human related disturbances like chronic illness, violence, death were also taken into account.

To estimate stability, observed variables are, indeed, an indicator of instability. Thus, we multiplied each of the observed variables by negative 1 in order to make them consistent with the meaning of the latent variable S.

3.7. Adaptive Capacity (AC)

Adaptive capacity refers to the level of access to and exploits benefit therein from resources in order to deal with shocks [27]. Adaptive capacity is the ability to react to shocks, which ranges from institutional framework that enables to learn, generate experience and store knowledge to create power structure to solve *ex ante* and *ex post* problems through learning processes. One basic mechanism to create knowledge and power structure is the existence of institutional framework like being a member of idir or equib by increasing households' trust among themselves. Education average was also used in the estimation of adaptive capacity, which is the average of years of education completed by household members, is sources for accumulating knowledge. Stock of knowledge made through average education of years completed by household members increase adaptive capacity of that particular household.

The other variable included to estimate this latent variable is diversified sources of income. It was based on the premises that a diversified sources of income leads to a greater adaptive capacity. Engagement in economic activities also enhances household's adaptive capacity, which was taken into account using the ratio of the number of households aged 15 to 60 to the total family size.

Health matters for adaptive capacity, which was captured as it is a dummy variable taking value equal to one if member of the households are healthy, otherwise zero.

3.8. Assessment Procedure of Resilience to Food Insecurity

In the second stage, resilience index is estimated from resilience blocs anticipated in the previous sub-sections. In mathematical notation, resilience index is represented as a function of the blocs as:

$$Ri = f(AIT, SSN, APS, AFI, A, S, AC) \quad (2)$$

Where Ri – Resilience index, AIT – Agricultural Inputs and Technology, SSN – Social Safety Nets, APS – Access to Public Services, AFI – Access to Food and Income, A – Assets, S – Stability, AC – Adaptive capacity. Hence, resilience index is the weighted sum of the factors generated and specified as:

$$R_i = \sum_{i=1} W_j F_j \quad (3)$$

Where W_j is the weight of variable j and F_j is the factor under consideration of the variable j. The weights are the proportions of variance explained by each factor.

4. Results and Discussion

In this section, we present summary of the results of the observed variables contribute to assessing the value of the latent variables representing the resilience blocs under the first stage. Under the second stage resilience index estimation result is made from the resilience blocs.

4.1. Access to Agricultural Inputs and Technology (AIT)

Table 1 presents eigen values for each factor and Table 2 shows the factor loadings for the original variables. The three variables play important role in estimation of access to agricultural inputs and technology (AIT). Table 1 depicts factor analysis using principal component factors and Kaiser Criterion suggests to retain Factor1 with eigenvalues higher than 1. Here, one factor is retained and it explains more than 42% of the variation.

Table 1. Eigen values for each factor

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	1.2646	0.32725	0.4215	0.4215
Factor2	0.93736	0.13932	0.3125	0.734
Factor3	0.79804	.	0.266	1

LR test: independent vs. saturated: chi2(3) =21.22 Prob>chi2=0.0001

Access to fertilizer and the number of extension services play significant role in estimation of AIT. The correlations between each variable and AIT is higher whereas herbicide is less important. These variables are the most import inputs boosting agricultural production where food access, one dimension of food security, depends on production. The more the agriculture performs well the greater is the households have the options and the capability to escape from food insecurity. Therefore, we can conclude that fertilizer use, herbicide use and extension contacts enhances agricultural production, ensure food security and thereby households become more resilient to food insecurity.

Table 2. Factor loadings (pattern matrix) and unique variances

Variable	Factor1	Uniqueness	AIT
Fertilizer use	0.7353	0.4593	0.58144
Herbicide use	0.5279	0.7213	0.41743
Extension frequency	0.6673	0.5547	0.52768

4.2. Social Safety Nets (SSN)

The first component obtained explains 91% of the variation and it is acceptable for estimating the latent variable SSN.

Table 3. Eigen value for SSN

Component	Eigenvalue	Difference	Proportion
Comp1	4.524	4.318	0.905
Comp2	0.206	0.046	0.041
Comp3	0.160	0.086	0.032
Comp4	0.074	0.037	0.015
Comp5	0.037	.	0.007

Table 4 below illuminates the correlation between observed variables and the latent variable (SSN). In the first component, all the observed variables are positively correlated with SSN and play important role in the estimation.

Table 4. Principal components (eigenvectors) for SSN

Variable	Comp1	Unexplained	SSN
Job assistance	0.463	0.032	0.984
Frequency of assisted	0.451	0.079	0.960
Cash and in kind assistance	0.445	0.105	0.946
Quality of assistance	0.434	0.150	0.922
Assistance target the needy	0.443	0.111	0.943

Each indicator of SSN has similar importance in the estimation. SSN as the social protection scheme constitutes job assistance and its frequency, amount in cash and in-kind and the quality associated with service as well as assistance targeting the needy are important variables. Job assistance is the major among the generated variables to estimate SSN.

4.3. Access to Public Services (APS)

The following table (Table 5) shows the eigen values for running principal component analysis. Four components are retained. The four components explain 58.6% of the variation.

Table 5. Eigen value for APS

Component	Eigenvalue	Difference	Proportion
Comp1	2.711	1.261	0.246
Comp2	1.450	0.285	0.132
Comp3	1.165	0.046	0.106
Comp4	1.118	0.119	0.102
Comp5	0.999	0.126	0.091
Comp6	0.873	0.058	0.079
Comp7	0.815	0.052	0.074
Comp8	0.763	0.061	0.069
Comp9	0.703	0.422	0.064
Comp10	0.281	0.159	0.026
Comp11	0.122	.	0.011

Access to phone networks, access to drinking water and access to electricity are correlated with component one. Access to education is correlated negatively with component two. Physical access to human health, physical access to livestock health, sanitation facilities, quality of education and access to education are correlated with the third component. Physical access to livestock health, perception to security and mobility and transport constraints variables are correlated with the fourth component (Table 6).

Table 6. Eigen vector for access to public services

Variable	Comp1	Comp2	Comp3	Comp4	Unexplained	APS
Physical access to human health	0.040	-0.030	0.626	0.191	0.497	0.067
Physical access to livestock health	0.080	-0.205	0.327	0.336	0.671	0.132
Quality of human health services	-0.047	0.550	0.274	-0.034	0.468	-0.078
Access to education	0.150	-0.442	0.321	-0.146	0.512	0.247
Quality of education	-0.056	0.557	0.307	-0.108	0.420	-0.093
Perception to security	-0.038	0.225	0.068	0.515	0.621	-0.063
Mobility and transport constraints	-0.057	-0.073	-0.198	0.730	0.342	-0.094
Access to drinking water	0.571	0.096	-0.114	0.035	0.086	0.941
Access to electricity	0.535	0.135	-0.070	0.112	0.177	0.882
Access to phone networks	0.546	0.126	-0.115	-0.047	0.152	0.898
Sanitation facilities	0.220	-0.225	0.393	-0.061	0.612	0.362

Access to phone network by household head or any members in the household enable them to obtain updated information on local and regional climate statistics, on agricultural input prices such as price of fertilizer, insecticides and pesticides. This helps farmers to make precautious and alert them to bounce back from potential future shocks.

The table above (Table 6) shows that the original variables like access to drinking water, electricity and phone networks are, as expected, positively correlated with the estimated APS. Weak correlation of the observed variables like physical access to health service to both human and livestock, and perceptions to security, mobility and transport with the first component are observed. This can be explained by the fact that physical access to health services and the quality therein are characterized by few numbers of well educated physicians, and physical equipments in the process of health service provisions to both human and livestock.

Under the second component in the estimation of APS, access to education is negatively correlated. This is because the school location is far consuming their time and efforts. Conversely, the quality of education is positively correlated APS. The more the school is equipped with professionals the more the quality is increasing.

4.4. Access to Food and Income (AFI)

Table 7 below shows the eigen-values for each factor and the subsequent table (Table 8) show the factor loading for the original variables. Factor one is retained which explains 49% of the variations. The factor produced is quite meaningful and it is possible to consider it the underlying latent variable for food and income access.

Table 7. Eigen value of food and income

Factor	Eigenvalue	Difference	Proportion
Factor1	1.96072	1.09563	0.4902
Factor2	0.86509	0.12919	0.2163
Factor3	0.7359	0.2976	0.184
Factor4	0.4383	.	0.1096

The factor loadings presented for the original variables that consists of HFIAS, kilo calorie available per day per adult equivalent, HDDS and per capita income per day. All these variables aim to measure food access. HFIAS has a negative correlation with AFI because it increases as food security decreases. HDDS and per capita income of the household remains less important than HFIAS and kilo calorie intake per AE per day. This involves that the high correlation of HFIAS and Kcal per day per AE with the IFA blocs, but even the HDDS, and per capita income have a meaningful correlation.

Table 8. Factor loadings (pattern matrix) and unique variances

Variable	Factor1	Uniqueness	AFI
HDDS	0.6212	0.6141	0.546
Per capita income	0.5815	0.6619	0.512
HFIAS	-0.7459	0.4436	-0.757
Kcal day AE	0.8248	0.3197	0.892

4.5. Access to Asset (A)

Table 9 shows the eigen values of the assets and two components are retained in the estimation of this latent variable. The retained components explain 62% of the variation.

Table 9. Eigen value for assets

Component	Eigenvalue	Difference	Proportion
Comp1	1.642	0.204	0.328
Comp2	1.438	0.536	0.288
Comp3	0.902	0.272	0.180
Comp4	0.630	0.242	0.126
Comp5	0.388	.	0.078

Table 10 below shows the eigen vector for estimation of the latent variable, which is access to assets. Landholding and livestock ownership measured in terms of TLU play significant role and their signs are positive as expected. Land holding and livestock ownership measured in TLU are strongly related to the first component of assets of smallholder farmers. Number of rooms is negatively related to the second component whereas house structure related positively to access to assets.

Table 10. Eigen vector for assets

Variable	Comp1	Comp2	Comp3	Comp4
landholding	0.652	0.275	0.021	-0.012
TLU	0.662	0.227	0.127	0.014
Nonfarm income	-0.242	0.389	0.833	-0.307
House structure	-0.230	0.624	-0.084	0.742
Number of rooms	0.159	-0.577	0.532	0.595

Under the component two, nonfarm income and house structure contribute in the estimation of resilience and the sign is positive as expected but the sign of the number of rooms turned negative. This is due to the fact that smallholder farmers do not tell the exact number of rooms they have in their compound.

4.6. Stability (S)

Table 11 shows the eigen values and the subsequent table (Table 12) depicts the coefficient loadings. To estimate the value of these latent variables, the loss due to shocks like livestock loss due to theft or dead, crop loss due to drought, water shortages, and outbreak of diseases and fall in price in the market, other shocks like member of household death, illness, and losses of job. It is the capacity as a whole to external shocks and stressors, where the household's survival depends on the interaction components that enable them to react to such external stimuli.

Table 11. Eigenvalue of stability

Factor	Eigenvalue	Difference	Proportion
Factor1	1.956	0.200	0.196
Factor2	1.756	0.166	0.176
Factor3	1.590	0.575	0.159
Factor4	1.016	0.115	0.102
Factor5	0.900	0.057	0.090
Factor6	0.844	0.174	0.084
Factor7	0.670	0.128	0.067
Factor8	0.542	0.127	0.054
Factor9	0.415	0.105	0.042
Factor10	0.310	.	0.031

Table 12 shows that the most variables like drought, rainfall and livestock disease are more common and stable. On the other hand, illness and water availability is instable. The table (Table 12) shows that the most variables like drought, rainfall and livestock disease are more common and stable. On the other hand, illness and water availability is instable.

Table 12. Rotated factor loadings (pattern matrix) and unique variances

Variable	Factor1	Factor2	Factor3	Factor4	Uniqueness
Drought	0.802	-0.130	-0.044	-0.229	0.286
Rainfall variability	0.247	0.324	-0.096	0.476	0.599
Snow	0.023	0.616	0.350	0.085	0.491
Livestock diseases	0.620	0.356	0.004	-0.116	0.475
Crop failure	-0.134	-0.112	0.856	-0.053	0.234
Output price volatility	0.235	0.259	0.759	-0.156	0.277
Water short	-0.371	0.727	-0.032	-0.110	0.321
Illness	-0.741	0.216	-0.091	-0.209	0.352
Crime	0.144	0.416	-0.142	0.611	0.414
Death	-0.187	-0.183	-0.098	0.829	0.234

4.7. Adaptive capacity (AC)

Table 13. Eigenvalue for adaptive capacity

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	1.244	0.155	0.249	0.249
Comp2	1.090	0.166	0.218	0.467
Comp3	0.923	0.045	0.185	0.652
Comp4	0.878	0.013	0.176	0.827
Comp5	0.865	.	0.173	1

Two components are retained. The first two components explain 47% of the variation.

Table 14. Eigen vector of adaptive capacity

Variable	Factor1	Factor2	Factor3
Diversified income sources	-0.2728	0.6495	0.4498
Household education average	0.5721	0.1311	-0.0112
Employment ratio	-0.2088	0.667	-0.5544
Health situations	-0.5423	-0.1643	0.4667
Institutions participations	0.5105	0.2985	0.5219

The table above shows the correlation of the estimated AC with transformed variables. Labor force participation is the most important variable followed by diversified income sources and average education of members in the household.

4.8. Estimation Result of Resilience

Under the section above emphasis was given to estimate each resilience bloc separately using different multivariate techniques mainly principal component and factor analyses. Now, it is necessary to pool each bloc to estimate resilience of smallholder farmers. The resilience blocs estimated above become covariates in the estimation of resilience index. Assuming all the blocs are normally distributed with mean zero and variance one, it is possible to run factor analysis using principal component factor method.

The following table summarizes results obtained after factor analysis is run using principal component factor method. The table shows that factor 1 explains 25% of the variations. Factor 2 and factor 3 explains 18% and 14%, respectively.

Table 15. Eigenvalues and variance explained

Factor	Eigenvalue	Difference	Proportion
Factor1	1.768	0.483	0.253
Factor2	1.286	0.256	0.184
Factor3	1.030	0.076	0.147
Factor4	0.954	0.097	0.136
Factor5	0.857	0.263	0.122
Factor6	0.594	0.083	0.085
Factor7	0.511	.	0.073

The first factor represents resilience bloc except access to public services (APS), which is negatively correlated with other variables. This can be imagined given that weak APS increases when households becomes poorer. In the second factor, APS becomes positive, which shows that it is a positive characteristic of resilience. Adaptive capacity (AC) is positive in the first factor and negative in the second factor. AC shows the likely that when a household becomes poor, put the poor in difficulty to acquire resources that they did not have before. The third factor triggers hidden information of the resilience bloc s. From all the building bloc s under the third factor, stability (S) and adaptive capacity (AC) are positive. This is likely tells common story in terms of food security and vulnerability situations.

Resilience estimation cannot be a one dimension and Table 16 below shows the factor loadings taking into consideration three factors. Asset holding is the most important component in resilience of smallholder farmers, which represent household's level of wellbeing. Among the blocs of resilience, APS is negatively related to the first factor. This is evident that poor accesses to public services increases household's vulnerability to shocks and exacerbate their food insecurity situations.

Table 16. Factor loadings (pattern matrix) and unique variances

Variable	Factor1	Factor2	Factor3	Uniqueness
AIT	0.467	0.703	-0.030	0.287
SSN	0.470	-0.558	-0.044	0.466
APS	-0.378	0.319	-0.089	0.748
AFI	0.652	0.504	-0.171	0.292
A	0.740	-0.298	-0.210	0.319
S	0.107	0.116	0.894	0.175
AC	0.450	-0.146	0.382	0.630

Table 17. Means and standard deviations for resilience and its components in different agro ecology

Variable	Lowlands		Midlands		Highlands		Total	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
AIT	-0.079	0.993	0.114	0.997	-0.041	1.007	0.000	1
SSN	0.041	0.536	-0.028	0.730	-0.004	0.825	0.002	0.709
APS	-0.044	0.355	0.018	0.337	0.024	0.349	0.000	0.347
AFI	-0.013	0.790	0.086	0.838	-0.075	0.700	0.000	0.779
A	0.021	0.826	0.012	0.777	0.010	0.634	0.014	0.747
S	0.019	0.816	-0.030	0.903	0.013	0.872	0.000	0.863
AC	0.051	0.698	-0.040	0.535	-0.010	0.860	-0.001	0.708
R	0.033	1.303	-0.035	1.333	0.005	1.205	0.000	1.278

Among the three agro ecology classification,

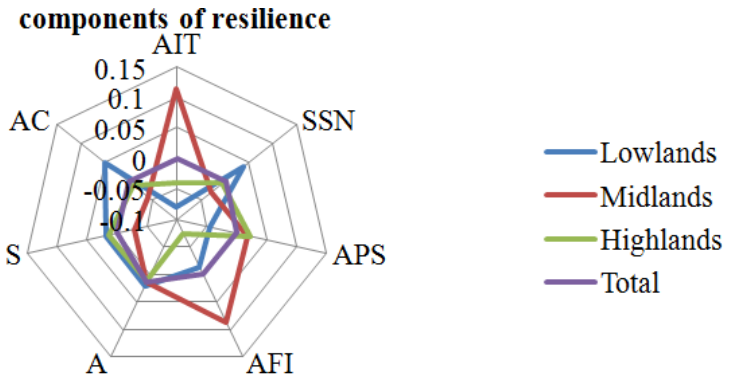

Figure 2. Radar graph for resilience components

Components of resilience is presented as shown in the figure above, where midland agro ecology is better resilient, which depends on access to inputs and technology and, income and food. Adaptive capacity and social safety nets seem to be weak in midland unlike lowlands agro ecology.

5. Conclusions

Food insecurity in Ethiopia, like most developing countries, is a dominant problem. Climate related shocks are the major causes and stifled rural households' food security. The way a household withstands climate related shocks depends on the preconditions and options available to them in terms of capabilities and activities. The best option to withstand the effects of climate related shocks is through resilience.

Using resilience analysis framework, resilience index was defined as a function of agricultural inputs and technology, social safety nets, access to public services, access to food and income, access to assets, stability and adaptive capacity. Each bloc was a latent variable; unobserved per se. Therefore the estimation was made separately using different multivariate techniques. The result of the estimation of each bloc becomes covariates in the measurement of resilience index. In the estimation of resilience each resilience bloc was pooled based on the fact that all the blocs were normally distributed.

Hence, factor analysis was run using principal component factor method and three factors were retained. Under the first factor, all blocs, except access to public services, are positively correlated with resilience. The negative correlation between access to public services and resilience is because access to public services like health services and education qualities decreases as households becomes poorer. In terms of importance to rural household's resilience index, the result indicates that asset ownership play significant role followed by access to food and income, as well as social safety nets. These resilience blocs show the likelihood of recovering from any form of climatic shocks that a household experiences. In the second factor, access to public services becomes positive, which shows that it is a positive characteristic of resilience. Adaptive capacity is positive in the first factor and negative in the second factor. The third factor triggers hidden information of the resilience bloc as stability and adaptive capacity are positive, which likely tells common story in terms of food security situations.

Asset holding is the most important component in resilience of smallholder farmers, which represent household's level of wellbeing. Among the building blocs of resilience, APS is negatively related to the first factor. This is evident that poor accesses to public services increases household's vulnerability to shocks and exacerbate their food insecurity situations. This means, in the specific case of smallholders found in lowlands agro ecology of the West Shoa zone need to be made, such as livestock related initiatives and water-related interventions.

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