Increasing Resilience in Changing Climate among Rural Households: Evidence from West Shewa, Ethiopia

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

[1] PhD, School of Agricultural Economics, Haramaya University

[2] Agro-meteorologist, Ethiopian Institutes of Agricultural Research (EIAR)

* E mail of corresponding author: temesgenkebede@gmail.com

Abstract

Shared ranges of complex risks, including climate change, environmental degradation, and conflict are exacerbating the challenges faced by farm households. This research aimed to measure measn to increase farm households resilience to changing climate using seven blocs of the resilience 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 blocs. The estimation was made separately using principal component analysis. Three components were retained to estimate resilience. Under the first component, all blocs, except social safety nets and adaptive capacity, were positively correlated with resilience. The negative correlation between social safety nets and resilience, for instance, is because social prominence decreases as households becomes poorer. In terms of importance to rural household's resilience index, the result indicates that asset ownership and access to food and income play significant role followed by access to inputs and technology and access to public services. These resilience blocs show the likely that when a household experiences any form of climatic shocks, pooled out from the difficult situation and enables them to acquire resources that they did not have acquainted before. In the second component assets and stability were negative but weak, which shows that these blocs make deteriorate resilience capacity of rural farm households. The third component triggers hidden information of the resilience bloc. From all the resilience blocs under the third component, stability is strong and positive, which likely tells common story in terms of food security situations.

Key Words: Resilience, Food Insecurity, Smallholders, West Shewa, Ethiopia

1. INTRODUCTION

1.1. Background

Shared ranges of complex risks, including climate change, environmental degradation, and conflict are exacerbating the challenges faced by farm households. The climate system recurrently varies (IPCC, 2014), and unpredictable and the environment degrade persistently (Béné et al., 2015). These calamities threatens the poorest and most vulnerable segments of the farm households (Arndt et al., 2012; Brown, 2014) and left many to food insecure and hunger.

The tipping point lies on resilience in the fight against food insecurity, hunger and malnutrition, economic and social disruptions. The Food and Agriculture Organization (FAO) of the United

Nations were the first organization championing the concept of resilience in a complex food system (Pingali, et al., 2005). To this effect, Alinovi et al. (2008) proposed econometric foundation of Resilience Index Measurement and Analysis (RIMA), for measuring resilience. Frankenberger et al. (2012) measure resilience to enhance food security shocks in Africa and Vaitla et al. (2012) examined the resilience and livelihoods change in Ethiopia. Building resilience creates and strengthen the capacities of vulnerable farm households to adapt to changing circumstances, manage to escape to increasingly complex risk environment, and cope with shocks of the farm households who are unable to prevent.

Efforts to assist vulnerable groups to manage risks and build resilient farm households must be developed through diversified efforts. Government role has an obligation to bring more holistic approach that transcends any barriers of the farm households would have been felt. Resilience building increases the likelihood that activities will be relevant to farm households' needs and deliver sustained gains. It must be a joint effort to an end of food insecurity, hunger and malnutrition.

This study was conducted at household level in West Shoa zone. In the zone, on average, there were 69,530 relief beneficiaries of grains, food, oil and pulses from 2007/2008 to 2012/2013. The most frequent relief receipt districts were Ilfeta, Ada'a Berga, Gindeberet, Abuna Gindeberet and Jeldu. Moreover, on average, half of the total kebeles were exposed to rainfall variability, flooding and land degradation, which put households to be more food insecure, affects their resilience capacity. Therefore, determinants of food security and factors affecting' resilience capacity to climate variability and shocks was also examined.

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 at a distant of 114 km west of Addis Ababa. Its capital city is Ambo and has 528 rural and 43 urban kebeles. 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 has maximum temperature ranges of 180C to 300C with minimum temperature ranges from

70C to 220C. Rainfall distribution is also varying from minimum 250 mm in Meta Robi to a maximum of 2610 mm in Ilfeta. Almost half of the soil type of the zone is red, 29 % of the soil is grey, 27.52 % of the total soil type is categorized under red brown and the remaining 6.32 % constitutes other soil types.

The total land covers 14349.29 square kilometer of which mainly leveled field constitute of 47.7 % of the total area makes it an ideal place for agriculture. Gorges (4.6 %), mountainous area (16.8 %) other (30.9 %) take the topography share of the zone. From the total area, 8195.976 square kilometers used for cultivation, 1734.935 square kilometers covered with forests and bushes, 682.157 square kilometers are grass lands and the remaining are bare land. Agriculture is the major means of livelihood in the zone. The common agricultural practices are mixed farming involving both crop-livestock system. Around 70 % of income is generated from crop production, and about 20% from livestock.

2.2. Modelling resilience to food insecurity

Resilience of rural households depends on options available to them to lead a decent life (Alinovi *et al.,* 2009). Those options are preconditions for the household response mechanisms to the negative effects of unforeseen climate related shocks. 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 (Alinovi *et al.,* 2009).

The SEM is an extension of general linear modeling procedure like analysis of variance (ANOVA) and multiple regression analysis. 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 (Lei and Wu, 2007). 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.

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 (Alinovi *et al.*, 2008). In this paper, principal component analysis was used to estimate these latent variables developed by Alinovi *et al.* (2008) resilience analysis framework.

As it was stated earlier, resilience is the positive capacity of households to bounces back from the negative effects of adverse shocks. 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 principal component analysis (Alinovi *et al.*, 2008; 2010). 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.

Access to agricultural inputs and technology

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. Principal component analysis was run to estimate the latent variable.

Social safety nets

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 Shewa 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.

Access to public service (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 enhances 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.

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. This 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) (Coates *et al.*, 2006). 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 (Hoddinott and Yohannes, 2002). To estimate income and food access latent variable, principal component analysis was used.

Access to assets

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.

Stability

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 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 undesirable 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.

Adaptive capacity

Adaptive capacity refers to the level of access to and exploits benefit therein from resources in order to deal with shocks (Frankenberg *et al.,* 2012). 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 one of the member of the households are healthy, otherwise zero.

2.3. Resilience estimation

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:

$$\text{Resilience} = f(\text{Agricultural input and technology}, \text{Social safety net}, \text{Access to public services}, \text{access to food and income}, \text{access to asset}, \text{adaptive capacity}, \text{stability})$$

$$Ri = f(AIT, SSN, APS, AFI, A, S, AC) \qquad \text{[EQ 3]}$$

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:

$$R_i = \sum_{i=1} W_j F_j \qquad \text{[EQ 4]}$$

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.

3. Results and Discussion

In this section, we present summary of the results of the observed variables that 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.

Access to agricultural inputs and technology

A critical building component to the success of resilience to climate variability is the provisions of agricultural service packages that constitute agricultural input supplies and scientific knowledge sharing through extension workers.

Table 1 depicts principal component analysis and based on Kaiser Criterion to retain component 1 with eigen-values greater than 1. Component 1 explains around 42% of the variation. The second table (Table 2) shows the eign-vector for the original variables. The three indicators play important role in estimating access to agricultural input and technology (AIT).

Table 1: Eigen values for each factor

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	1.265	0.327	0.422	0.422
Comp 2	0.937	0.139	0.313	0.734
Comp 3	0.798	.	0.266	1

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

Table 2: Principal components (eigenvectors) and unique variances

Variable	Comp1	Unexplained	AIT
Access to fertilizer	0.654	0.459	0.581
Herbicides	0.469	0.721	0.417
Extension frequency	0.593	0.555	0.528

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	Cumulative
Comp1	4.524	4.318	0.905	0.905
Comp2	0.206	0.046	0.041	0.946
Comp3	0.160	0.086	0.032	0.978
Comp4	0.074	0.037	0.015	0.993
Comp5	0.037	.	0.007	1.000

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.

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	Cumulative
Comp1	2.711	1.261	0.246	0.246
Comp2	1.450	0.285	0.132	0.378
Comp3	1.165	0.046	0.106	0.484
Comp4	1.118	0.119	0.102	0.586
Comp5	0.999	0.126	0.091	0.677
Comp6	0.873	0.058	0.079	0.756
Comp7	0.815	0.052	0.074	0.830
Comp8	0.763	0.061	0.069	0.900
Comp9	0.703	0.422	0.064	0.963
Comp10	0.281	0.159	0.026	0.989
Comp11	0.122	.	0.011	1

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			0.626		0.497	0.067
Physical access to livestock health			0.327	0.336	0.671	0.132
Quality of human health services		0.550			0.468	-0.078
Access to education		-0.442	0.321		0.512	0.247
Quality of education		0.557	0.307		0.420	-0.093
Perception to security				0.515	0.621	-0.063
Mobility and transport constraints				0.730	0.342	-0.094
Access to drinking water	0.571				0.086	0.941

Access to electricity	0.535				0.177	0.882
Access to phone networks	0.546				0.152	0.898
Sanitation facilities			0.393		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.

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.

Access to food and income (AFI)

Table 7 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

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	1.96072	1.09563	0.4902	0.4902
Comp2	0.86509	0.12919	0.2163	0.7065
Comp3	0.7359	0.2976	0.184	0.8904
Comp4	0.4383	.	0.1096	1

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: Principal components (eigenvectors) 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

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	Cumulative
Comp1	1.642	0.204	0.328	0.328
Comp2	1.438	0.536	0.288	0.616
Comp3	0.902	0.272	0.180	0.796

Comp4	0.630	0.242	0.126	0.922
Comp5	0.388	.	0.078	1.000

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.

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.

Table 10: Eigen vector for assets

Variable	Comp1	Comp2	Comp3	Comp4	Comp5
Landholding	0.652	0.275	0.021	-0.012	0.707
TLU	0.662	0.227	0.127	0.014	-0.703
Nonfarm income	-0.242	0.389	0.833	-0.307	0.041
House structure	-0.230	0.624	-0.084	0.742	-0.016
Number of rooms	0.159	-0.577	0.532	0.595	0.072

Stability (S)

The following table (Table 11) shows the eigen values and the subsequent table (Table 12) depicts the factor loadings.

Table 11: Eigenvalue

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	1.956	0.200	0.196	0.196
Comp2	1.756	0.166	0.176	0.371

Comp3	1.590	0.575	0.159	0.530
Comp4	1.016	0.115	0.102	0.632
Comp5	0.900	0.057	0.090	0.722
Comp6	0.844	0.174	0.084	0.806
Comp7	0.670	0.128	0.067	0.873
Comp8	0.542	0.127	0.054	0.928
Comp9	0.415	0.105	0.042	0.969
Comp10	0.310	.	0.031	1

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 are instable.

Table 12: Principal components (eigenvectors) for stability

Variable	Comp1	Comp2	Comp3	Comp4	Unexplained
Drought	0.547				0.286
Excessive rainfall			0.446		0.599
Snow fall		0.309	0.455		0.491
Livestock diseases/death	0.415				0.475
Crop failure		0.472		0.568	0.234
Output price fall	0.372	0.442			0.277
Water short		0.339	0.366	-0.398	0.321
Illness in the household	-0.454	0.323			0.352
Crime			0.549		0.414
Death of household member/head	-0.313	-0.339		0.540	0.234

Adaptive capacity (AC)

Table 13: **Eigenvalue of the 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.

Table 14: Eigen vector

Variable	Comp1	Comp2	Unexplained	AC
Diversified income sources		0.648	0.448	-0.307
Household education average	0.574		0.572	0.640
Employment ratio		0.666	0.462	-0.235
Health situations	0.542		0.604	0.605
Institutions participations	0.507	0.302	0.581	0.565

Table 14 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.

Estimation of resilience

Under the section above emphasis was given to estimate each resilience bloc separately using principal component analysis. 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 principal component analysis.

Table 15 shows that component 1 explains 27.1% of the variations. Component 2 and component 3 explains 18.5% and 14.8%, respectively.

Table 15: Eigenvalues and variance explained

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	1.894	0.599	0.271	0.271
Comp2	1.295	0.257	0.185	0.456
Comp3	1.038	0.170	0.148	0.604
Comp4	0.868	0.082	0.124	0.728
Comp5	0.786	0.145	0.112	0.840
Comp6	0.641	0.163	0.092	0.932
Comp7	0.4781	.	0.068	1

Table 16 shows the component loadings taking into consideration three components. Access to food and income, and asset are the most important component in resilience of smallholder farmers under component1, which represent household's level of wellbeing. Among the building resilience blocs, social safety nets and stability are negatively related to the first component. In component 2 assets and stability are negatively correlated to component 2. Under the third component (Component 3) access to food and income, asset and adaptive capacity are related negatively to the component

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

Variable	Comp1	Comp2	Comp3	Unexplained
AIT	0.473	0.348	0.063	0.415
SSN	-0.107	0.646	0.293	0.348
AFI	0.571	0.149	-0.071	0.348
APS	0.364	0.034	0.038	0.746
A	0.514	-0.245	-0.304	0.327
S	0.188	-0.089	0.838	0.195
AC	-0.083	0.608	-0.331	0.394

Forecasting resilience

Resilience is the most important regressor and the variance explained by the model (74.76%) is quite satisfactory. The OLS estimator produces consistent estimates and there is no collinearity problem. Agricultural input and technology like fertilizer use and herbicide use, sanitation facilities, average extension contacts, land holding enhance household level of resilience. Age of household head, family size, drought, excessive rainfall, fall of output price, livestock disease contribute negatively to resilience of households.

Table 17: OLS regression model outcome

	Coef.	Std. Err.
Sex of household head	0.093	0.116
Age of household head	-0.015***	0.003
Family size	-0.097***	0.020
Land holding	0.537***	0.030
Fertilizer use	0.991***	0.109
Herbicide use	0.754***	0.099
Average extension contacts	0.013***	0.002
Access to irrigation	0.132	0.099
Sanitation facilities	0.397***	0.076
Drought	-0.267***	0.090
Excessive rainfall	-0.178**	0.080
Livestock disease	-0.165 **	0.079
Crop failure	0.020	0.087
Fall of output price	-0.187 *	0.101
Water shortages	-0.076	0.085
Snow fall	-0.015	0.183
Constants	-1.099	0.233

F(16, 367) = 67.94	
R-squared = 0.7476	

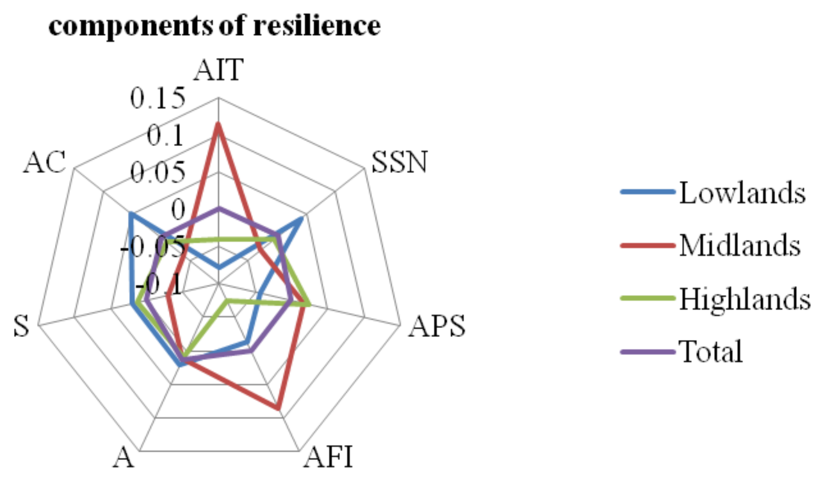

Figure 1: Radar graph for resilience components

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.

4. 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.

The fundamental question is how to design resilience capacity to maintain food secure and more resilient households and avoid the descending into undesirable domains. 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 principal component analysis. 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. 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,

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