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Invited paper presented at the 5th International Conference of the African Association of Agricultural Economists, September 23-26, 2016, Addis Ababa, Ethiopia

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Abstract

Persistent hunger, widespread undernourishment and frequent famine affect the food security situations. The major objective of this research is to evaluate rural households' food security using resilience indicators. Households were classified into three wealth groups as poor (<1725Kcal), medium (1725kcal to 3250kcal) and rich (> 3250kcal). The classification produces reasonable comparisons based on measures of asset ownership and characteristics. Results indicate that the daily average kcal per day per AE for the poor is 1183.949kcal and for the rich is 4561.767 kcal. Sanitation facility of the poor is 25% less than that of the rich. The underlying factors to household food security system to sustain, seven components of resilience were taken into account to measure households' capability to absorb the negative effects of unpredictable shocks. Each building block was separately estimated using different multivariate techniques, which becomes covariates in estimation of resilience index. Except access to public services, which is negatively correlated with other variables, all are positively correlated to resilience. This can be imagined given that weak APS increases when households become poorer. In the second factor, APS 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. It 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 blocks. From all the building blocks under the third factor, stability and adaptive capacity are positive, which likely tells common story in terms of food security situations.

Introduction

The 2008 global food crises due to increase in global cereals prices and global rainfall variability show the most recent trend in food security challenges. For Ethiopia, there exists strong correlation between the overall gross domestic product (GDP), agriculture GDP and the rainfall pattern (FAO, 2006), showing how plentiful rain events associated with surplus food availability. During a growing rainfall season speaks to a bountiful agricultural production, while a “poor” or limited rains in amount and/or extent-meaning a poor agriculture harvest for most.

An estimated average of 4.5 million Ethiopians were left to emergency food handout from 2011 through 2015 due to drought induced calamites. Owing to the continued *El Nino* from June 2015 onwards; Ethiopia is facing one of the worst crises, with an estimated 10.2 million people dipping in need of food aid, which is best explained by the multifaceted indicators of the food insecurity and livelihoods of the households’ and which is dynamic and complex issue that has remained controversial. These demands for the shift in attention from the crises management to the risk management, which again needs the shift in mental model construct of the society itself and the key actors for building households resilience to such deep rooted chronic food insecurity. In this regard, the national government needs to have moral and political responsibilities to establish communities that withstand the challenge before it happens or quickly recover from the shocks. .

The government of Ethiopia has quite progressive programs like the productive safety net program (PSNP), agricultural growth program (AGP), household asset building (HAB) program, resettlement program (RP) and other policy oriented programs that aimed to lever households from food insecurity and even leading to economic and decent life. Albeit these endeavor, looking for sustainable solutions through resilience building remains crucial.

The concepts of resilience measure the capability of households to absorb the negative consequences of unpredictable shocks while a similar household does not (Alinovi et al., 2008) as vulnerability, in reverse, to predict the future occurrence of a crisis. Theoretically, resilience refers to the capacity of economic agents to sustain conscious from myriad shocks, avoid shocks and exploit benefits from it (Constas and Barrett, 2013). However, it 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, 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 place. Two basic facts according to Alinovi *et al* (2009) can be pointed out. The first reason is related to the fact that resilience has multidimensional nature and the second reason is associated with unpredictable nature of shocks households to which they are exposed makes a strong case for measuring extent of households' resilience in terms of food security.

This empirical household level resilience to food insecurity was conducted in five woredas of West Shoa zone of Ethiopia. Household level resilience was measured through developing asset based resilience indicators and evaluates their resilience status. Asset-based index is the underlying unobserved variable that can be determined through indicator variables associated with a household's relative wealth position and which needs to select and attach appropriate weight from the vexing problem using advanced statistics, like principal component analyses. In this study, resilience was defined according to five building blocks with additional two dimensions. These building blocks are agricultural input access, social safety nets, access to public services, access to food and income, access to asset and wealth, adaptive capacity and stability.

Materials and methods

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. According to CSA (2013) population and housing survey projection, there is a population of 2,500,482. The zone has 18 districts and from the total, 4 districts are located in agro ecological of *dega* (highland), 8 districts are *woynadega* (mid altitude) and 6 of them are *kola* (lowland) with proportion of 22%, 44% and 33% respectively.

Zonal land covers of 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. Agriculture is the major means of livelihood making in the zone. Around 70 % of income of the rural households is generated from crop production, and about 20% from livestock rearing. Major crop grown in the zone constitutes cereals, legumes and oil crops. 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), poultry, donkey, mule and horses (more than 300,000 equines.); bee colonies; traditional, transitive and modern beehive.

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 18^0C to 30^0C with minimum temperature ranges from 7^0C to 22^0C. 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.

Data description

The survey was administered to samples taken by multistage sampling technique. In the first stage, the zone was clustered into three agro ecologies, which are lowland, midland and highland, and then the study districts were selected based on the frequent relief distribution. Accordingly, in 2012/13 there are six districts receiving relief. Three districts, Meta Robi, Gindeberet, and Jeldu were selected randomly. In terms of the total number of beneficiaries around 60% were found in these districts. To account for diversity two additional districts from non beneficiaries namely Ambo and Bako Tibe were also included randomly. In the second stage, each district was clustered based on agro-ecologies. From the selected districts, representative kebeles were selected using simple random sampling technique.

Finally, sample respondents were randomly selected based on probability proportion to size. The total sample size determined using Kothari (2004) as:

$$n = \frac{Z^2 pqN}{e^2(N-1) + Z^2 pq} \Rightarrow n = \left[\frac{(1.96^2)(0.5)(0.5)(330{,}772)}{(0.05^2)(330{,}771) + (1.96)^2(0.5)(0.5)}\right] \Leftrightarrow = \frac{317673.4288}{827.8879}$$
$$= 383.72 \approx 384$$

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. According to the information from West Shoa zone Office of Agriculture there are 330,772 rural households in the zone, and around 50% of the total kebeles are exposed to rainfall variability. N is the total number of rural households found in the zone. Therefore, the sample size was determined to be 384 farming households. Structured questionnaire was formulated at household level and conducted face to face to obtain firsthand information.

Asset based index construction: key household resilience indicators to food security

There are various ways of asset based index construction, but here we have used principal components analysis (PCA) to assign weight for each asset. The methods of generating the weights according to Filmer and Pritchett (2001) of the variables included in the asset indices are discussed below. Let us assume we have N variety of assets by each household, a_{j1} to a_{jN}. The principal component normalizes each variable to its mean and variance by finding the linear combination of the variables with maximum variance. Technically, $(Y-\lambda_n I)v_n = 0$ needs to be solved where Y is the matrix of correlations between the scaled variables, v_n is the vector of coefficients on the nth component for each variable - it is the eigenvectors or the components or the factors and λ_n is the Eigenvalues. The aim is to maximize the variance explained by the first q PCs is given by $\psi = \frac{\lambda_1 + \ldots + \lambda_q}{\sum \lambda_j}$

Score estimation and household classification

Scores for each household were calculated using the following equation

$$A_j = f_1 * (a_{j1} - a_1)/s_1 + f_2 * (a_{j2} - a_2)/s_2 + \ldots + f_N * (a_{jN} - a_N)/s_N$$

Where A_j is the socioeconomic status score for household j; f_1 the component loading generated by the respective method for the first variable, a_{j1} household's value for the first variable; a_1 and s_1 are the mean and standard deviation, respectively, of the first variable over all the households.

Estimation of resilience of farm households

As we already stated above, resilience is the positive capacity of households bounces back from the negative effects of adverse shocks. To estimate resilience, it is therefore, necessary to estimate separately each building block which are themselves latent variables because they cannot be directly observed in a given survey, but it is possible to estimate them through multivariate techniques (Alinovi *et al.,* 2008; 2010).

Access to agricultural inputs and technology

Observable variables that are expected to generate the agricultural inputs and access to technology variables (fertilizer, herbicide and pesticide) and average number of extension contacts per week and factor analysis was employed to estimate latent variables.

Social safety nets

Social safety net included in our study was one of the crucial components for sustenance of life particularly for the poor. The component included in the social safety nets are amount of cash and in kind assistance received by individual PRINCALS algorithm was used to estimate each variable.

Access to public service (APS)

Access to public services encompassed key responses provided by the public that is expected to enhance household's resilience, included are access to information (dummy 1 if the household access information through television, radio or any other means of accessing information), access to credit (dummy variable, 1 if the household member has borrowed credit over the observation period), access to irrigation, infrastructure like roads, hospitals and schools. Ordinal scale was used to categorize the service provisions, a case where principal component and factor analyses failed to address the intended purposes because observed variables are not continuous. To this, optimal scaling is the most appropriate technique.

Access to food and income (AFI)

Income and food access directly related to households capacity to resilience to shocks were employed. 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 , categorized into per capita income of the household computed from total household's income to the family size; per capita calorie intake which is the household's average food calorie intake per person per day. To estimate income and food access at household, factor analysis was employed; given that the variables are significant can serve as a latent variable for estimating resilience.

Access to asset

Here we classified into two: agricultural assets and non agricultural assets. Agricultural assets like land size, livestock and non agricultural assets included nonfarm income estimated amount of income earned in *Birr* and value of asset in *Birr* like the estimated value of house.

Stability

It is an important dimension of household's resilience that captures the options available over time. To estimate the value of these latent variables, the value of loss due to shocks was employed. Variables like livestock loss due to theft or dead, crop loss due to drought, water shortages, outbreak of diseases and fall in price in the market, other shocks like member of household death, illness, and losses of job.

Adaptive capacity

Adaptive capacity refers to the extent of access to and use of resources in order to deal with disturbance and long term trend results in the ability to 'bounce back' from shocks and successfully adapt or changing conditions in the future (Frankenberg *et al.*, 2012).

Adaptive capacity measures household's ability to adapt and react to shocks. This latent variable was estimated from diversified sources of income. It is based on the premises that a higher diversified sources of income leads to a higher adaptive capacity. Employment ratio between the number of household member to the household size, and education average which is the average of years of education completed by household members.

In a mathematical notation, resilience is represented as:

$$\begin{aligned}\text{Resilience} = f(&\text{Agricultural input access, Social safetynet, Access to public services,}\\ &\text{access to food and income, access to asset, adaptive capacity, stability})\end{aligned}$$

$$Ri = f(Agri, SS, APS, AInco, Ast, AC, S)$$

Where R – Resilience, Agri – agricultural inputs, SS – Social safety nets, APS – Access to Public Services, AIco – Access to income, Ast – Asset, AC – Adaptive capacity, S – stability. Hence, resilience index is the weight sum of the factors generated:

$$R_i = \sum_{i=1} W_j F_j$$

Where W_j is the weight of variable j and F_j is the factor under consideration of the variable j.

After identifying important factors that explained resilience, the next step was forecasting. It is the most important part in the analysis of resilience towards food security analysis, which actually requires time series data. As time series data is barely found in Ethiopia, and to make forecasting feasible OLS regression model was employed using resilience index as dependent variable.

$$R = \alpha + \beta_1 Agri + \beta_2 SS + \beta_3 APS + \beta_4 AInco + \beta_5 Ast \beta_6 + \beta_7 AC + \beta_8 S + \varepsilon \qquad (20)$$

ε is the error term, which captures the information of the variables used to estimate resilience but excluded from the regression model specified.

Results and Discussions

Asset indicators included in this study were household ownership of consumer durables like ownership of radio, the characteristics associated with assets like toilet facilities, sources of drinking water, and main source of lighting and household landownership, livestock ownership measured in terms of TLU and total income.

Households were categorized based on their daily kilo calorie intake per AE. The groupings was based on three strata as poor for those households whose kilocalorie intake per day per AE less than 1725Kcal; middle category as those households whose kilo calorie intake per day per AE fall between 1725kcal to 3250kcal and the last group termed as rich kilo calorie intake whose per day per AE kilo calorie intake exceeds 3250 kcal.

Table 1 reports the scoring factors from the principal components analysis and summary statistics of the 11 variables. The weights have an easy interpretation captured from the changes of the index by $f_{1i}*/s_i*$. A household that owns a radio has an asset index higher by 0.612 than one that does not; owning a land size in hectare raises a household's asset index by 0.151 units.

The asset index performs well on three classifications of households as poor, middle and rich kilo calorie intake per day per AE households differs markedly. Moreover, it produces reasonable comparisons with measures of asset ownership and characteristics. It is found that the daily average kcal per AE for the poor is 1183.949 and for the rich is 4561.767. Sanitation facility of the poor is 24.68% less than for the rich. Phone access of the poor (20%) is less than the middle (38%). This reveals that there is large difference between the poor, middle and the rich.

Table 1: scoring factors and summary statistics for variables entering the computation of the first principal component

Variables	Scoring	Mean	Standard deviation	**Scoring/SD**	**Poor** (<=1725 kilocalorie intake hh (40% of hh)	**Middle** kilocalorie intake hh (1725<Kcal<=3250) (40% of hh)	**Rich** >3250 kilocalorie intake hh (20% of hh)
Kilocal per day per AE	0.2316	2354.297	1430.215	0.000	1183.949	2421.344	4561.767
TLU	0.196	4.15593	3.98012	0.049	2.432974	5.058497	5.808468
Owns radio	0.2927	0.35156	0.47808	0.612	0.363636	0.352941	0.324675
landholding	0.2195	1.55466	1.4538	0.151	1.000864	1.766895	2.240584
Total income	0.1776	6675.39	5032.30	0.000	5546.968	7411.66	7469.273
Phone network access	0.4832	0.30729	0.46197	1.046	0.201299	0.379085	0.376623
Access to drinking water	0.5025	0.25781	0.4380	1.147	0.149351	0.313726	0.363636
Sanitation facility	0.1943	0.42447	0.4949	0.393	0.311688	0.470588	0.558442
Security	0.0181	1.20312	0.5215	0.035	1.201299	1.20915	1.194805
Mobility	-0.0664	2.38281	0.853	-0.078	2.396104	2.431373	2.25974
Access to electricity	0.4626	0.1875	0.391	1.183	0.11039	0.20915	0.298701

The percentage of the covariance explained by the first principal component is 28.49%. The first eigenvalue is 3.13; the second eigenvalue is 2.06.

The estimation of farm level resilience based on how the observed variables contribute to assessing the value of the latent variables representing the resilience components are dealt in the following subsections.

Access to agricultural inputs and technology

A critical building component to the success of resilience to climate variability is the provisions agricultural service packages that constitute agricultural input supplies and scientific knowledge sharing through extension workers. Factor analysis was run using principal factor method and the outcome was presented in the following table over agro ecology.

The following table (Table 2) depicts factor analysis using principal component factors and Kaiser Criterion suggests to retain Factor1 with eigenvalues higher than 1. Factor 1 explains more than 42% of the variation. The table presents eigen values for each factor and the second table (Table 16) shows the factor loadings for the original variables. The three indicators play important role in estimating access to agricultural input and technology (AIT).

Table 2: 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

Table 3: Factor loadings (pattern matrix) and uniquevariances

Variable	Factor1	Uniqueness	AIT
Access to fertilizer	0.7353	0.4593	0.58144
Herbicides	0.5279	0.7213	0.41743
Extension frequency	0.6673	0.5547	0.52768

Social safety nets (SSN)

Social safety nets as social protections component has been an essential ingredient in the fight against food insecurity and vulnerability, and increasing household's resilience to climate variability. In West Shoa zone, social protection, in the form of relief that consists of grain, oil and pulses, in cash and in kind assistance rendered, and hence, quality of assistance, job assistance, frequency of assistance and overall attitude on targeting assistance to the needy was asked. The observed variables to generate the unobserved (latent) variables were diverse indicators ranging from continuous (cash and in kind assistance) to discrete values (like job assistance). Therefore, for estimating social safety nets, PRINCALS algorithm is essential, which enables to separately specify a number of measurement levels for each variable and treat missing values by setting weights in the gradient of loss function equal to 0. Missing values are imputed from other categories.

Transformed variables	SSN
Do you get cash and in kind assistance	.500
Frequency of assistance	.598
Amount of cash and in-kind assistance	.889
Quality of assistance	.811
Assistance targeted to the needy	.664

Access to public services (APS)

Physical access to human and livestock health plays important role in the process of resilience. Perceptions of sentiment of being secure increases the confidence to bounce back in case any shock happens because it has the potential capability to increase social harmony and cooperation. Information through phone and updating farmers with current meteorological facts that elapse local and regional rainfall distribution to natural calamities; to marketing information about products' prices and quantities demanded in the market; to agricultural input prices like the market price of fertilizers, insecticide and pesticides among others that help encourage farmers to makes them ready for bounce back and shed from any form of shocks that will happen in the life and livelihoods formulations. Access to credit enables in the formulation of assets that minimizes vulnerability to food insecurity which can be provided by government and/or private sector to smallholder farmers. Moreover, irrigation access and use plays a crucial role in smallholder famer's livelihoods accumulations and in enhancing their resilience by enabling them to plough more than once in a year. This increases the stock of grains in their store. Infrastructure development like constructions of roads that links rural kebeles to the neighboring markets has the probability of increasing the competitiveness of smallholders' output in the market at a fairly better price.

Hence, the observed variables to generate the unobserved (latent) variables were diverse indicators ranging from "Yes/ No" to ordinal likert scale of 6 (Excellent, very good, good, bad, worse, the worst). Therefore, PRINCALS algorithm is also used to generate latent variables. Table below shows that all the original variables (transformed using optimal scaling) 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 APS are seen. This may be due to the fact that physical access to health services filled with few numbers of well educated physicians, to physical equipments in the process of health service provisions.

Transformed variables	APS
Physical access to health services to you and your family	.023
Physical access to health services to your livestock?	.093
How do you see the quality of health services to you and your family?	.219
Access of education	.235
How do you see the quality of educational system	.182
Perception of security	.094
Mobility and transport constraints	.016
Do you have access to drinking water	.443
Do you have access to electricity	.398

Do you have access to phone networks	.412
Do you have access to sanitation	.120

Access to food and income (AFI)

The income and food access categorized into per capita income of the household computed from total household's income to the family size; per capita calorie intake which is the household's average food calorie intake per person per day. The dietary diversity as a nutritional indicator; and the household food insecurity access scale (HFIAS) as an indicator of the household's perception of food security were also inculcated.

per capita income: This is an aggregated value of the different sources of income divided by family size.

per capita calorie:

Dietary diversity: this is computed using specific for food security assessments applied to the two weeks consumption of different food items. It can also be used as a proxy indicator for food access

HFIAS:

To estimate AFI latent indicator, a factor analysis was run using the principal factor method.

Table 4: Eigenvalue

Factor analysis/correlation		Number of obs = 384		
Method: principal factors		Retained factors = 2		
Rotation: (unrotated)		Number of params = 6		
Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	0.968	0.964	1.509	1.509
Factor2	0.004	0.095	0.006	1.516
Factor3	-0.091	0.148	-0.142	1.373
Factor4	-0.240	.	-0.373	1.000
LR test: independent vs. saturated: chi2(6) = 148.84 Prob>chi2 = 0.000				

Table 5: Factor loadings (pattern matrix) and unique variances

Variable	Factor1	Factor2	Uniqueness
HFIAS	-0.4216	0.0404	0.8206
Kcal_day_AE	0.6288	0.0063	0.6046
HDDS	0.4257	-0.0182	0.8184
per_capita~e	0.4627	0.045	0.7839

Table 16 above shows the eigen-values for each factor, while Table 17 shows the factor loading. 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. HFIAS has a negative correlation because it increases as food security decreases.

Access to asset (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. The veritable galaxy of such assets improves quality of life by supporting and enabling to generate from diversified sources of income, encourage productions of both crop and livestock, improves mechanism to access nutritious food, make light of vulnerability and enhances resilience of smallholder farmers.

Transformed variable	A
Landholding	.524
TLU	.511
Non farm income	.303
House structure	.334
Number of rooms owned	.358

Stability (S)

Stability refers to 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 and continue their livelihoods operations indifferently. To estimate the value of these latent variables, the loss due to shocks was employed, variables like livestock loss due to theft or dead, crop loss due to drought, water shortages, outbreak of diseases and fall in price in the market, other shocks like member of household death, illness, and losses of job. To analyze the correlation using the iterated principal factor method, which re-estimates the communalities iteratively, a factor analysis was run. Then, the Bartlett technique was applied to generate the S indicator.

Factor	Eigenvalue
Factor1	1.64088
Factor2	1.34818
Factor3	1.11414
Factor4	0.5539
Factor5	0.53204
Factor6	0.35456
Factor7	0.23565
Factor8	0.05232
Factor9	0.0183

Rotated factor loadings (pattern matrix) and unique variances

Variable	Factor1	Factor2	Factor3	Uniqueness
Drought	-0.8302	0.1408	-0.1002	0.215
Rainfall variability	-0.0442	0.1304	0.4602	0.5287
Livestock diseases/ death	-0.158	0.0436	-0.0985	0.445

Crop disease/failure	0.2189	0.4169	-0.0904	0.3894
Fall in price of output	-0.1081	0.9015	-0.0666	0.1541
Severe shortage of water	0.5061	0.1243	-0.0929	0.5866
Chronic illness	0.3556	-0.0529	-0.0599	0.3668
Violent crime	0.1477	-0.0773	0.2383	0.5078
Death of household member	0.1403	-0.2112	0.6631	0.4448
Snow fall	0.0531	0.3186	0.0294	0.5118

Adaptive capacity (AC)

Adaptive capacity is the ability to adapt and react to shocks, which ranges from institutional framework that enables to learn, generate experience and store knowledge to power structure to solve *ex ante* and *ex post* problems through creating conducive situations in learning process. This latent variable was estimated from diversified sources of income based on the premises that a higher diversified sources of income leads to a higher adaptive capacity. Moreover, the existence of institutional framework like being a member of idir or equib enhances households' trust among themselves. Stock of knowledge made through average education of years completed by household members increase adaptive capacity of that particular household. 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 total family size. Health matters for adaptive capacity, which was captured as it is a dummy taking value equal to one if member of the households are healthy, otherwise zero.

Different measurement scale of observed variables necessitates PRINCALS algorithm to estimate adaptive capacity. The following table shows the correlation of AC to transformed variables.

Transformed variable	A C
diversified income sources	0.333
labor force participations	0.521

household members' health	0.213
average education of members	0.304
membership in the community	0.103

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.

Estimation of resilience

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

The following table summarizes results obtained after factor analysis is run using principal factor method. The table shows that factor 1 explains 50.9% of the variations. Factor 2 and factor 3 explains 29.6% and 9.4%, respectively.

Table 6: Eigenvalues and variance explained

Factor analysis/correlation — Number of obs = 384

Method: principal-component factors — Retained factors = 3

Rotation: (unrotated) — Number of params = 18

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	1.768	0.483	0.253	0.253
Factor2	1.286	0.256	0.184	0.436
Factor3	1.030	0.076	0.147	0.583
Factor4	0.954	0.097	0.136	0.720
Factor5	0.857	0.263	0.122	0.842
Factor6	0.594	0.083	0.085	0.927

Factor7	0.511	.	0.073	1.000

The first factor represents resilience building blocks 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 blocks. From all the building blocks 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 26 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 building blocks 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 7: Factor loadings (pattern matrix) and uniquevariances

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 8: 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,

components of resilience

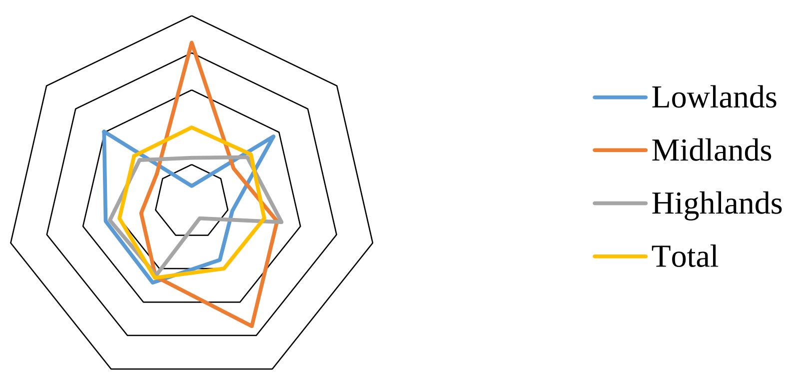

Figure 1: Radar graph for resilience components

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.

Conclusions

Household classification was made based on daily kilo calorie intake per AE. Households were classified as poor kcal intake per AE, middle kcal intake per AE and rich kcal intake per AE. The scoring factors from the principal components analysis indicates that household that owns a radio has an asset index higher the one that does not; owning a land size in hectare raises a household's asset index. The asset index performs well on three classifications of households as poor, middle and rich kilo calorie intake per day per AE households differs markedly. Moreover, it produces reasonable comparisons with measures of asset ownership and characteristics. It is found that the daily average kcal per AE for the poor is lower than for the rich. Sanitation facility of the poor is much less than for the rich. Phone access of is less than the middle. This reveals that there is large difference between the poor, middle and the rich.

Asset holding is the most important component in resilience of smallholder farmers, which represent household's level of wellbeing. Among the building blocks 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 need to be made, such as livestock related initiatives and water-related interventions. Building the resilience of smallholder farmers are the ultimate goal of interventions, a longer-term approach is imperative.

References

Alinovi, L., M. D'Errico, E. Mane, and D. Romano, 2010. Livelihoods Strategies and Household Resilience to Food Insecurity: An Empirical Analysis to Kenya. Paper Prepared for the Conference on "Promoting Resilience through Social Protection in Sub-Saharan Africa", organized by the European Report of Development in Dakar, Senegal, 28-30 June, 2010.

Alinovi, L., Mane, E., and D. Romano, 2008. Towards the Measurement of Household Resilience to Food Insecurity: Applying a Model to Palestinian Household Data. In Sibrian, R., (ed.). Deriving Food Security Information From National Household Budget Surveys. Experiences, Achievement, Challenges. FAO. Rome: 137-52. Available on: ftp://ftp.fao.org/docrep/fao/011/i0430e/i0430e.pdf.

Alinovi, L., Mane, E., and D. Romano, 2009. Measuring Household Resilience to Food Insecurity: Application to Palestinian Households. *EC – FAO, Food Security Program.*

Constas, M. and C. Barrett, 2013. Principles of Resilience Measurement for Food Insecurity: Metrics, Mechanisms, and Implementation Plans. Expert Consultation on Resilience

CSA (Central Statistical Agency), 2013. Population Projection of Ethiopia for All Regions At Wereda Level from 2014 – 2017. Federal Demographic Republic of Ethiopia, Addis Ababa, Ethiopia.

Filmer, D. and Pritchett, L.H. 2001. Estimating wealth effects without expenditure data – or tears: An application to educational enrolments in states of India. *Demography* 38 (1):115–132.

Frankenberger, Timothy, Mark Langworthy, and Thomas Spangler. 2012. “Enhancing Resilience to Food Security Shocks.” White Paper (Draft). TANGO International, Tucson.

Appendix : Principal component analysis (PCA) results

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	3.13423	1.06996	0.2849	0.2849
Comp2	2.06428	0.958571	0.1877	0.4726
Comp3	1.10571	0.057383	0.1005	0.5731
Comp4	1.04832	0.162499	0.0953	0.6684
Comp5	0.885824	0.124946	0.0805	0.7489
Comp6	0.760878	0.102925	0.0692	0.8181
Comp7	0.657953	0.072537	0.0598	0.8779
Comp8	0.585416	0.209505	0.0532	0.9311
Comp9	0.375911	0.110943	0.0342	0.9653
Comp10	0.264968	0.148454	0.0241	0.9894
Comp11	0.116514	.	0.0106	1