European Commission

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Building sustainable resilience for food security and livelihood dynamics:

The case of rural farming households in Ethiopia

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2017

EUR 29111 EN

Joint Research Centre

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JRC Science Hub
https://ec.europa.eu/jrc

JRC110834

EUR 29111 EN

PDF ISBN 978-92-79-79830-6 ISSN 1831-9424 doi:10.2760/973096

Ispra: European Commission, 2017

How to cite this report: Tefera N, Demeke M, Kayitakire F, *Building sustainable resilience for food security and livelihood dynamics: the case of farming rural households in Ethiopia*, EUR 29111 EN, European Commission, Ispra, 2017, ISBN 978-92-79-79830-6, doi:10.2760/973096, JRC110834

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Abstract

Building sustainable resilience for food security and livelihood dynamics is explored using the Ethiopia Rural Household Survey panel data. Household resilience scores are derived from measures taken to protect against shocks. The impact of several demographic and socio-economic factors on resilience dynamics is then tested. The result shows that the experience of resilience in the past leads to a subsequent higher chance of continuing to be resilient ('true state-dependence'). It also demonstrates that measures that promote asset creation, diversified enterprises and access to improved technologies are positively and significantly correlated with dynamics of building resilience for food security.

1 Introduction

Over the last several decades, drought-induced famine has threatened lives and livelihoods of millions of rural people in Ethiopia. For instance, the 1958 and 1973 famines are reported to have claimed over 100,000 and 300,000 lives, respectively. During the 1984/85 famine, approximately 10 million people suffered from starvation and approximately one million are reported to have died (Alex, 1991). Millions were also affected by the 1999/00, 2002/03 and 2009/10 droughts. At present, the Southern and Eastern parts of the country are affected by a severe drought, which is ravaging much of the horn of Africa. Moreover, since 2005, about 8 million chronically food insecure people have been supported through the Productive safety Net Program (PSNP). Simultaneously, the government, along with development partners, are actively looking for strategies that would strengthen the resilience of households to manage and cope with shocks and upheavals.

In the context of food security, resilience[1] can be expressed as household's ability to maintain a certain level of well-being regardless of any disturbance/ shock (Alinovi et al., 2008). It also refers to capacity of individuals, households or communities function in ways that enable them not only to observe shocks and stresses but also learn from past events, and ensure food security at all times. Resilience strategies require reorganization and transition to a better form of livelihood. It encompasses anticipation of future shocks and making the necessary preparations to cope and manage shocks without suffering from food insecurity or losing production capacity. Resilience should not only involve bouncing back from shocks and stresses but also bouncing forward to a state where challenges

[1] Resilience is generally understood as 'the ability of a system to absorb shocks, to avoid crossing a threshold into an alternate and possibly irreversible new state, and to regenerate after disturbance' (Resilience Alliance, 2007). The concept of resilience – developed in ecology (Holling, 1973) and later applied to social systems (Adger, 1997), and/or human-environment systems (Carpenter *et al.,* 2004; Folke, 2006) – has been introduced into food security analysis very recently (Folke *et al.,* 2002; Hemrich and Alinovi, 2004; Ericksen, 2007; Alinovi *et al.,* 2008).

that constrain livelihoods are addressed and overall quality of human livelihoods improved (Dodman et al. 2009)

Studies applying the concept of resilience to the assessment of rural livelihoods strategies in Ethiopia are limited. Frankenberger et al. (2007), using qualitative information obtained through rapid rural appraisal, showed that households who were able to cope with shocks that regularly plague their communities are characterized by several factors, including diversification of income sources, savings and investment, good work ethic, access to food year round and place value on education, among others. However, the study is based on the perception of a few individuals and community elders at one particular period.

The objectives of this paper are three fold: (i) construct a multidimensional household resilience index, (ii) compare and contrast resilience scores across survey periods and villages, and (iii) investigate factors influencing household resilience dynamics.

2 Conceptual framework

Building sustainable resilience for food security at households level could be achieved either through investment in their own production and/or in-kind precautionary saving that could be liquidated for consumption smoothing. Moreover, resilient households could also be a forward looking and invest in children education and community based risk sharing arrangement. In an effort to understand the complex process of building resilience for food security of subsistence-oriented mixed farming system households in Ethiopia, we developed a simplified framework (Fig. 1).

The framework elucidates the role of productive assets such as land and livestock[2] , human and social capital formation as well as risk-sharing arrangement. It also integrates social resilience with asset based approaches to social risk management, as presented by Siegel and Alwang (1999), with the theoretical underpinnings of Sen's (1981) 'entitlement approach' as well as the sustainable livelihoods framework (e.g. Scoones, 1998; Devereux, 2003). Moreover, the approach complements the traditional consumption-based vulnerability analysis but shifts the focus to building sustainable resilience for food security. Thus, it is consistent with multidimensional nature of food security as defined by the World Food Summit (1996): food security exists 'when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life'.

As we briefly discussed above, for mixed farming system in Ethiopia, gross income is the sum of revenue obtained from crop and livestock production, non-farm activities, wage employment and transfers. Income is mainly

[2] Livestock is categorized into major productive assets; oxen, cow and transport animals and precautionary animal assets such as small stocks and cattle other than oxen and cow. In order to be resilient household should protect major productive assets as losing these stocks will results in poverty trap.

used for consumption and any surplus (in kind or cash) above immediate consumption needs is saved and invested in various forms to meet two critical objectives: (i) to augment productive assets in order to expand productive capacity (as an investment), and/or (ii) build resilience capacity (self-insurance) (Fig.1).

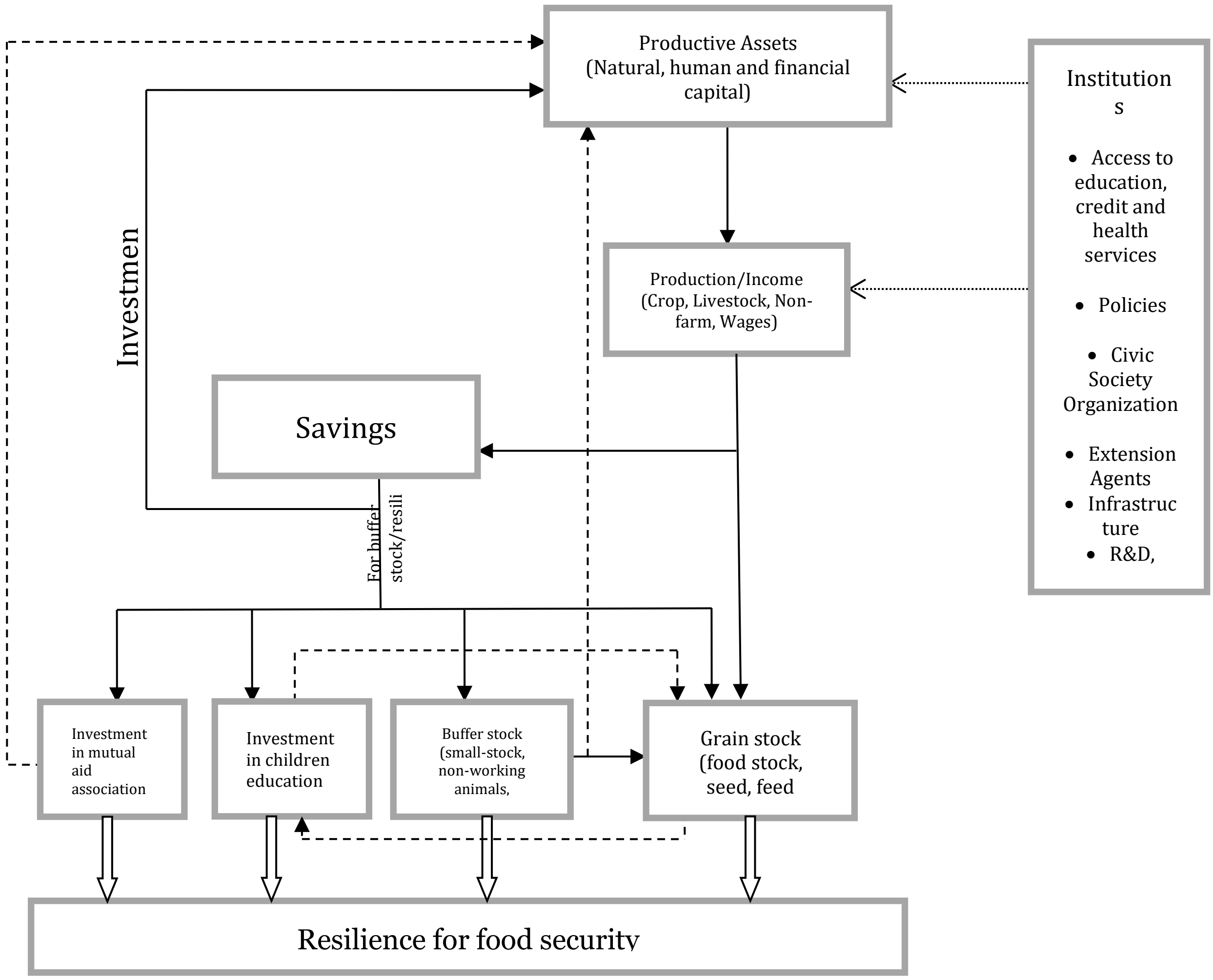

Figure1. Simplified Analytical Framework for Measuring Resilience for Food Security; Rural Households in Ethiopia. Source: Authors.

The direction of the arrows in Fig.1 envisage how resilience capacity for food security could be built through savings and investment in the form of: (a) grain in stock, (b) in-kind precautionary savings, (c) education of school-aged children and (d) social risk-sharing arrangements. Grain stock is mainly made up of their own production (minus sales plus purchase and received in the form of gift). Rural households in Ethiopia often smooth their consumption by keeping a stock of food grains to last them at least until the next harvest season (i.e., short term strategy). For subsistence producers, with underdeveloped and inefficient markets, buying food from the market is often more expensive than retaining and consuming their own production. Income in excess of consumption can be used to buy inputs and productive assets for intensification or expansion, hence increasing resilience to food insecurity.

In mixed farming systems, resilient families keep animals that serve as precautionary in-kind savings (as self-insurance). Such in-kind precautionary savings or buffer assets may take the form of small ruminants (sheep and goats) and cattle other than the principal ones (oxen and cows). These stocks are often used to smooth shortfalls in consumption following shocks and stresses that affect livelihoods. In the absence these buffer stocks, households could also be forced to deplete the principal assets (oxen and cows) whenever faced with unforeseen shocks. Thus, in-kind precautionary saving/assets help to protect major assets from being depleted. Moreover, protecting major productive assets such as oxen is crucial since households with no oxen often end up in poverty traps (see, for instance, Carter et al. 2007). Families lacking oxen may lease out their land for very low return (because rental markets are underdeveloped and the transaction often involves distress rent) or enter into labour-oxen sharing arrangements with terms and conditions that are very unfavourable[3] .

In the long term, investment in human and social development is crucial for a resilient livelihood. Educated children assist in fostering innovative ideas for transforming farming practices, improving consumption and general wellbeing, and/or promoting diversification into non-farm activities. In a traditional rural setting, investment in children education not only helps parents benefit from remittances (in the long-term) but also ensures the

[3] Labor-oxen sharing arrangement involves working two days for the owner of oxen in return for using the pair for a single day (Bevan and Pankhurst, 2007). Devoting two-third of their time on tilling for oxen owner is very costly and the least preferred option.

next generation is able to make a transition to a better livelihood in the non-farm sector (Rigg, 2006). It is also shown that risk-averse parents invest in children schooling as a substitute for an optimal amount of in-kind precautionary savings in order to benefit from higher returns from their children in the future (Cipollone, 2011).

Investment in informal risk-sharing schemes is used to manage risks and ensure resilience both in the short and medium or long-terms. Traditional social organizations such as *idir* (mutual aid association) are a form of indigenous social insurance systems whose main function is to help members undergoing bereavement or suffering from loss of major assets. Households invest in *idir* through regular monthly or weekly contributions in return for reciprocal payments (e.g., cash and in kind assistance) in time of needs.

Institutional environment in the form of government policies, programs and civil society organizations enhance resilience through improving productive capacity (e.g. investment in research & extension), augmenting income (e.g. income transfer), improving market access (e.g. building infrastructure) and improving basic services that contribute to the betterment of living standards and income (Fig. 1). Favourable government policies ensure resilience through increasing opportunities to gain and maintain secure access to production assets, especially land and other natural resources, and through improving access to health care and education that would assist households generate more income and savings.

3 Methodology

3.1 Constructing resilience index

Although there is a general understanding that resilience is a dynamic multidimensional and context specific concepts, there is no well-defined variables that can be used to measure resilience[4] (Gallopin, 2006) and the question of how to quantify resilience remains controversial (Chan *et al.*, 2007). The classical approach is to find 3-5 readily available key variables that can demonstrate the concept and its context very well (Walker and Salt, 2006) as a more complex variables likely obscure key patterns of resilience (Walker and Salt, 2006; Yorque *et al.*, 2002). In this study, resilience for food security is constructed as a composite index based on aggregation of grain stock, in-kind precautionary assets (small-stock and cattle other than oxen and cows), education of school-aged children and risk sharing strategies. Accordingly, the resilience index for household *i* at time *t* can be formulated as:

$$R_{it} = f(grainstock_{it}, bufferassets_{it}, avedu_{it}, network_{it}) \qquad (1)$$

Where R is latent variable representing household resilience index, *grainstock* is the stock of grain available for consumption, *bufferassets* is precautionary saving including number of small-stocks and cattle owned (other than oxen and cow), *avedu* is average education of school-aged children and *network* refers to participation in *idir* (risk sharing arrangement).

Estimating resilience through such proxy variables is not entirely a new idea. In measuring household resilience to food insecurity in Palestine,

[4] Resilience is less easily measured than vulnerability in part because the former included elements like adaptive capacity and institutional learning (Adger, 1997; 2000)

Alinovi *et al.* (2008), for instance, used four pillars: income and food access, assets, access to public service and social safety nets. Two additional dimensions (stability and adaptive capacity) cut across the four pillars and account for households' capacity to respond and adapt to shocks. In their framework, a resilience index is developed after constructing an index for each pillar involving use of decision matrices and multivariate methods. Similarly, Keil *et al.* (2008) has quantified household resilience towards ENSO-related drought in Indonesia by using the degree of drought-induced expenditure reductions for basic necessities and the absolute differences in the consumption of selected food items between the 'normal' and the drought situation as a basic indictor for resilience.

In order to derive the uni-dimensional resilience indicator, standard values of individual indicators can be summed up, but this assumes that all individual indicators are weighted equally. A better alternative is to use multivariate analysis, i.e. factor analysis (FA) or principal component analysis (PCA), which can give appropriate weight for each indicator[5]. This study has applied PCA in constructing the index as it has been used for aggregating food security indicators in the literature. PCA linearly transforms the indicator variables of resilience into smaller component which account for most of the information contained in the original indicators (Dunteman 1994). In mathematical terms, from an initial set of n correlated variables (X_1, X_2, X_3,…, X_n), PCA creates uncorrelated indices or components whereby each component is a linear weighted combination of the initial variables as follows:

$$pc_m = a_{m1}X_1 + a_{m2}X_2 + a_{m3}X_3 + ... + a_{mn}X_n \tag{2}$$

[5] Both FA and PCA are used to reduce a number of variables into a smaller number of 'dimensions'. However, while FA assumes that covariation in the observed variables is due to the presence of one or more latent (unmeasured) factors that exert causal influence on observed variables, PCA is computed without assuming any underlying structure caused by latent variables (Ford *at al*., 1986).

where a_{mn} represents the weighted for the m^{th} principal component and the n^{th} variable. The components are ordered so that the first component explains the largest amount of variables in the data subject to the constraint that the sum of the squared weight ($a_{m1} + a_{m2} + a_{m3} + \ldots + a_{mn}$) is equal to one. Each subsequent component explains additional but less proportion of variation among the variables. The higher degree of correlation among the original variables, the fewer the components required to capture common information (see also Vyas and Kumaranayake, 2006). Once the components are identified, we can derive the resilience index as follows:

$$y_i = \sum F_i[(x_{ji} - x_i)/s_i] \qquad (3)$$

where y_j is the estimated resilience index, which follows a normal distribution with mean of 0 and standard deviation of 1, F_i is the weight for the i^{th} variable in the PCA model, X_{ji} is the j^{th} household's value for the i^{th} variables, and X_i and S_i are the mean and standard deviation of the i^{th} variable for overall household.

3.2 Model specification: household resilience dynamics

The study uses the dynamic probit random-effect model for analysis of factors influencing household resilience dynamics[6]. The dynamic probit random-effects model[7] takes into account lags of the response variable and

[6] The model has been applied in many empirical discrete choice models, including welfare (Chay and Hyslop, 2000; Bane and Ellwood, 1983), labour participation (Chay and Hyslop, 2000; Heckman and Wills, 1977; Sousounis, 2008), poverty dynamics (Islam and Shimeles, 2005), and unemployment and low-wage employment (Auralampalam, 1999; Auralampalam *et al.,* 2000; Stewart, 2005; 2006; Auralampalam and Stewart, 2007), among others.

[7] The dynamic random- effects estimators are used under variety of specification if the stochastic restrictions of the error terms are appropriate., "..., the fixed effects approach can only be used if the errors have an i.i.d. logistic distribution." (Chay and Hyslop, 2000). And also,"... there [is no] sufficient statistic allowing the [probit] fixed effects to be conditioned out of the likelihood. Unconditional fixed-effects probit models may be fit with

unobserved individual-specific heterogeneity [8] effects, as explanatory variables. The inclusion of these variables help us to distinguish the effect of underlying dynamic process, 'true state dependence', from the propensity to experience a certain outcome in all periods, unobserved individual-specific heterogeneity, (Heckman, 1981). The 'true state dependence' arises from the fact that the experience of an event in the past influence the occurrence of the same event in the future. The unobserved individual-specific heterogeneity can be considered as "spurious" state dependence, as the current events don't structurally affect the future events (Chay and Hyslop, 2000).

Household resilience that accounts for 'true state dependence' and unobserved heterogeneity can be specified as:

$$y_{it}^{*} = x_{it}'\beta + \gamma y_{i,t-1} + \alpha_i + u_{it}; \qquad \text{i=1, ... ,N; t=2, ..., T} \qquad (4)$$

$$y_{it} = \begin{cases} 1 \text{ if } y_{it}^{*} \geq 0 \\ 0 \; otherwise \end{cases}$$

where y_{it}^{*} is the latent indicator of resilience score and y_{it} is the observed binary outcome of resilience score as derived from PCA procedure. The subscript *i* indexes individuals and *t* indexes time period (survey period); $y_{i,t-1}$ one period lagged resilience score used to measure dynamic process or state dependence; X_{it} is vector of explanatory variables; α_{i} is unobserved individuals-specific time-invariant heterogeneity effect; $u_{it} : iid \; \text{N}(0 \; \sigma_u^2)$ is the error term. The parameter γ represents true state dependence whereby household resilience in the past can influence the persistence of the present resilience; and β is a set of associated parameters to be estimated.

the probit command with indicator variables for the panels. However, unconditional fixed-effects estimates are biased." (StataCorp, 2009).

[8] The heterogeneity may be either permanent or serially correlated transitory differences.

Although the errors u_{it} are assumed to be serially independent, the composite error terms, $v_{it} = \alpha_i + u_{it}$, will be correlated over time due to the individual-specific time-invariant, α_i , terms (Stewart, 2006). The individual-specific random effect specification adopted implies the correlation between the two successive error terms, v_{it} and v_{it-1}, for the same individual is assumed to be constant:

$$\lambda = corr(v_{it}, v_{it-1}) = \frac{\sigma_\alpha^2}{\sigma_\alpha^2 + \sigma_u^2}; \qquad \text{t=2,...,T} \qquad (5)$$

The standard (uncorrelated) random effect model assumes that α_i is uncorrelated with observed variables (X_{it}). However, this assumption unlikely holds in most cases. For instance, unobserved heterogeneity may capture individual motivation or ability which is reasonably correlated with at least some of the explanatory variables. Following, Mundlak (1978) and Chamberlain (1984), the assumption of no correlation between α_i and observed variable are relaxed by expressing α_i as a linear function of either the means or the combinations of means with lags and leads of time varying covariates as follows:

$$\alpha_i = \lambda_0 + \bar{X}_i'\lambda_i + w_i \qquad (6)$$

where $\bar{X}_i$ is a vector of means of the time-varying covariates, $\text{w}_\text{i} : \text{iid N}(0, \delta_w^2)$ is uncorrelated with observed variables and u_{it} for all *i* and *t*. If we substitute equation [6] into equation [4], we obtain:

$$y_{it}^* = X_{it}'\beta + \gamma y_{it-1} + \bar{X}_i'\lambda_i + w_i + u_{it}; \qquad \text{i=1,...,N;} \quad \text{t=2,...,T} \qquad (7)$$

where the intercept λ_0 is observed in β . This model is similar with the random effects probit model which accounts for the dependence between unobserved household specific with additional vectors, $\bar{X}_i$. Various studies have applied these strategies to control for unobserved individual-specific heterogeneity effects (see, Chay and Hyslop, 2000, Sousounis, 2008; Islam and Shimeles, 2005, Auralampalam, 1999; Auralampalam *et al.*, 2000; Auralampalam and Stewart, 2007; Stewart, 2005; 2006).

In panel data with large observations (N) and short time dimensions (T), initial conditions/observations, y_{i1}, is likely to be correlated with, α_i, and affect y_{it}. The initial conditions problem arises due to the fact that the start of the dynamic process may not coincide with the start of the observation periods. For instance, resilient households in the first survey round, the 1994, may be resilient before the survey period. Misspecification of the initial conditions results in drastically overstated estimates of the state dependence while understating estimates of short and long-run effects (Chay and Hyslop, 2000).

In order to correct for the initial condition problem, three methods of estimations have been suggested: Heckman (1981), Orme (2001), and Wooldridge (2005). All the three estimators provide the same results (Auralampalam and Stewart, 2007; Sousounis, 2008). We apply Heckman (1981) approach that involves specifying a linearized reduced form equation for the initial value of the latent variable:

$$y_{i1}^{*} = z_{i1}'\pi + \eta_i; \qquad i=1,\dots, N \qquad (8)$$

where z_i is a vector of exogenous instrumental variables (and include, x_{i1}, which are relevant in period t_1, in 1994), pre-sample information influencing the probability of being resilient in period t_1; and η_i is correlated with α_i, but uncorrelated with u_{it}, for $t \geq 2$.

Using an orthogonal projection, it can be specified as:

$$\eta_i = \theta\alpha_i + u_{i1} \tag{9}$$

Given the fact that α_i and u_{i1} are orthogonal to one another; and $\theta = \rho\frac{\sigma_n}{\sigma_\alpha}$, after simplification and substitution, we can obtain $\mathrm{var}(u_{i1}) = \sigma_\eta^2(1-\rho^2)$. Furthermore, we assume that $corr(y_{i1}, u_{it}) = 0$ and $corr(X_{it}, u_{i1}) = 0$ for all *i* and *t*. After substituting equation [9] into equation [8], the 'initial conditions' equations becomes

$$y_{i1}^* = z_{i1}\pi + \theta\alpha_i + u_{i1} \tag{10}$$

Finally, since y_{it} is a binary variable, normalization is required (Stewart, 2006). A convenient one is $\sigma_u^2 = 1$. Moreover, since u_{it} is normally distributed, the joint probability of the observed normalized binary sequence of individual *i*, given α_i, in the Heckman approach is given by

$$\Phi[(z'_{i1} + \theta\alpha_i)(2y_{i1} - 1)]\prod_{t=2}^{T}\Phi[(\gamma y_{i,t-1} + x'_{it}\beta + \alpha_i)(2y_{it} - 1)] \tag{11}$$

Hence for a random sample of individuals that likelihood to be maximized is given by

$$\prod_i \int_{\alpha^*} \left\{ \Phi[(z'_{i1} + \theta\alpha_i)(2y_{i1} - 1)]\prod_{t=2}^{T}\Phi[(\gamma y_{i,t-1} + x'_{it}\beta + \alpha_i)(2y_{it} - 1)] \right\} dF(\alpha^*) \tag{12}$$

where F is the distribution function of $\alpha^* = \alpha / \sigma_\alpha$. Under the normalization used, $\sigma_\alpha = \sqrt{\lambda/(1-\lambda)}$. With α taken to be normally distributed, the integral over α^* can be evaluated using Gaussian-Hermite quadrature (Stewart, 2005; 2006).

3.3 Estimation strategies

Equation [12] is estimated using "redprob" Stata program written by Stewart (2005) through two-step procedures. The first step involves estimating the reduced form model, using simple probit model, for the initial observation, y_{i1} , and then predicts a generalized residual. The estimated residual will be included as regressor in the random effect dynamic probit models in the second step. In addition to the lagged dependent variable and generalized residual from the first step, the model used includes a set of household demographics, major assets, agricultural inputs, access to information and marketing, off-farm activities as well as coping strategies. It also includes villages and survey dummies.

4 Data and descriptive statistics

The Ethiopia Rural Household Survey (ERHS) panel data is used for analysis. The data has been collected by the Economics Department of Addis Ababa University (AAU) in collaboration with the Centre for the Study of African Economies (CSAE) at Oxford University and the International Food Policy Research Institute (IFPRI)[9]. The United States Agency for International Development (USAID) and the Ethiopia Development Research Institute (EDRI) have also been involved in most recent surveys[10]. The survey started in 1989 when the IFPRI team visited 450 households in seven farming villages in Central and Southern Ethiopia (see Dercon and Hoddinott, 2004).

In 1994 the survey was expanded to cover the main agro-climatic zones and main farming systems in the country. In total, 1,477 households from 15 villages across four regional states, Tigray, Amhara, Oromia and Southern Nations, Nationalities and People (SNNP. Households were randomly selected within each Peasant Association (PA). Stratification was used to include a sufficient coverage of the farming systems (Dercon and Hoddinott, 2004). These households were surveyed again in late 1994, 1995[11] and 1997. In 1999, the sample frame was further expanded to cover 1681 households in 18 villages[12]. In 2004, however, the additional (three)

[9] The survey has conducted with various institutions individually or collectively as follows; the 1994-1995 surveys with the CSAE, the 1997 survey with IFPRI and CSAE, the 1999 survey with USAID and CSAE, the 2004 survey with IFPRI and CSAE and the 2009 survey with IFPRI and EDRI.

[10] These data have been made available by the Economics Department, Addis Ababa University, the Centre for the Study of African Economies, University of Oxford and the International Food Policy Research Institute. Funding for data collection was provided by the Economic and Social Research Council (ESRC), the Swedish International Development Agency (SIDA) and the United States Agency for International Development (USAID); the preparation of the public release version of these data was supported, in part, by the World Bank. AAU, CSAE, IFPRI, ESRC, SIDA, USAID and the World Bank are not responsible for any errors in these data or for their use or interpretation.

[11] Round one, two and three were conducted within 18 months of each other in the 1994/5 periods

[12] The three additional villages were to cover the potential cereals and cash crops producing areas.

villages were excluded although independently surveyed in 2005. In 2009, the 7th round survey was conducted for the 1681 households. This study uses the 1994a, 1995, 1997, 1999 and 2004 surveys. Moreover, only households observed in each of these survey waves are used. This gives a balanced panel with 1,240 households and 6,200 observations. The dataset provides detailed information on production, consumption, purchase, sales, land holding and livestock ownership as well as basic household demographics. Information on market prices, access to health and education and other infrastructure facilities were also collected at community level.

4.1 Descriptive statistics: indicators and resilience scores

Household resilience to food insecurity indicators are constructed based on amount of grain in stock (potentially used for consumption purposes), precautionary savings (animals kept for sale or replacement that can also be easily liquidated), investment in children's education and participation in traditional risk sharing arrangement (locally known as *idir*). Table 1 provides a descriptive statistics for these indicators. Grain stock (in wheat-equivalent) per household increased from 6.94 quintal (696 kg)[13] in 1994 to 10.38qt in 1995 and further to 12.7qt in 1997. However, it slightly dropped to 11.81qt in 1999 but increased to 12.11 qt in 2004. Precautionary savings, on average, increased from 1.52 TLU in 1944 to 1.8 in 1995 but decreased to 0.98 in 1997 and to 0.77 in 1999 but slightly improved to 0.91 in 2004. The average education of school-aged children improved from about 1 year of schooling in 1994 to about 2 years in 2004. Average annual contribution to *idir* was less than 50 ETB although it eventually increased from about 21 ETB in 1994 and 1995 to about 30 ETB in 1997 and 1999 and further to 41 ETB in 2004 (Table 1).

[13] A quintal is 100 kg

Table 1: Descriptive statistics of resilience indicators or variables

	1994	1995	1997	1999	2004
Average grain in stock in wheat equivalent (in quintals)	6.94	10.34	12.70	11.81	12.18
Average precautionary saving (in TLU)	1.52	1.79	0.97	0.77	0.90
Average education level of children (in years)	0.48	0.59	0.94	1.08	2.16
Average contributions to *idir* (in ETB)	24.35	21.00	29.31	33.21	41.09

Source: Authors' calculation from ERHS data

The resilience score/index is computed through principal component analysis (PCA) using the four indicators. The PCA is estimated for the pooled data from all rounds and the resulting weight is then applied to the variable values for each round of the data. Since the variable used to construct the index and their respective weights remain the same in all rounds, we can use it to compare changes over time (Vyas and Kumaranayke, 2006). Using eigenvalues greater or equal to 1, as a critical point, we can retains the first two factor loadings that explains about 61.4% of the total variation in the data (Table 2). Moreover, almost all indictors have loading factors (either first or second factor loadings) greater or equal to 0.4, critical value suggested by Stevens (2002) (Table 3). While the first component has the maximum loading on food grains and precautionary saving (accounts for 33.7%), the second component has maximum loading on child education and contribution to *iddir* (accounts for 27.7%). The first component tends to measure the short-term pillars of building resilience and the second components more likely resembles of building resilience from the long-term perspective (more on investment building capacity). These two pillars should be interpreted separately in building resilience capacity at household level and this analysis give more weight to the first component. Note that child education and contribution to *iddir* have some loading on the first component.

Table 2: Eigenvalue of the correlation matrix

Component	Comp.1	Comp.2	Comp.3	Comp.4
Eigenvalue	1.35	1.11	0.85	0.69
Proportion (in %)	33.7	27.7	21.4	17.2
Cumulative (in %)	33.7	61.4	8.28	100.0

Source: Authors' calculation from ERHS data

Table 3: Principal components factor loadings

Variables	Comp1	Comp2	Comp3	Comp4
Food grain stock per adult equivalent (in '000)	0.67	-0.11	0.22	-0.70
Precautionary saving per adult equivalent	0.56	-0.49	0.12	0.66
Average education level of school-age children	0.20	0.73	0.59	0.26
Total contribution to *idir* (social network)	0.44	0.46	-0.77	0.11

Source: Authors' calculation from ERHS data

The resilience score has mean value of zero and standard deviation of 1. It is re-scaled to have values that lie between 0 (less resilient) and 1(highest resilient). Accordingly, average household resilience scores increased from 0.47 in 1994 to 0.52 in 1995 and 1997 but dropped to 0.51 in 1999 and increased 0.53 in 2004 (Annex 1).

Using the original resilience scores, households are re-classified into relatively resilient (with score ≥ 0) and less resilient (with score <0) for food security. The index performed well in categorizing households into resilient and less resilient groups; using the base year survey (1994) as a reference, we observed that resilient households owned significantly more livestock (oxen, cow and transport animals) and cultivate a larger size of land, and have less dependent household members (see next section for discussion of these variables). The proportion of households using fertilizer and manure is significantly greater for resilient households than otherwise. Moreover, resilient households have better access to information and markets as measured by whether households have a radio or not, whether any family member has been in a leadership position or not, and/or whether any family member has received extension advice or not. Non-resilient households, on the other hand, are more likely to participate in low return casual wage employment (Annex 2).

Further comparisons over the surveyed years have indicated that only 22% of the households are resilient over the 10 year period, while the majority (47%) are non-resilient throughout the entire period (Annex 3). The status of other households changed over time: about 12% were resilient only four times, 9% three times, 7% twice and 3.6% only once. About 90% in Imdibir, more than 60% of households in Haresaw, Geblen and Dinki and about 75% in Gara Godo and Doma are consistently non-resilient during the 10 year period while 50% from Yetmen and more than 70% from D/Brihan villages are consistently resilient.

4.2 Descriptive statistics: factors explaining household resilience dynamics

Household resilience dynamics are influenced by a number of factors, including physical assets (stock of physical and human capital), income diversification and access to agricultural inputs as well as information. Physical capital consists of land, livestock, farm tools and equipment. Land is an important household assets - for growing crops and raising livestock, among others. With limited practice of intensive agriculture, increasing farm size is expected to be a major factor in determining whether a household has the capacity to produce more (for consumption) and save or invest into in-kind precautionary assets. Sample households cultivated, on average, 1.34 ha of land in 1994. It increased slightly to 1.49 ha in 1997, but contracted to 1.2ha in 1999 and further to 1.06ha in 2004 (Table 4). The average cultivated land declined by nearly 20% over the 10 year period.

Ownership of livestock assets (oxen, milking cows, and transport animals) induces households to invest in insurance or resilient farming practices. These animal are also important in farm production and income generation, leading to increased savings and investment in self-insurance.

Table 4: Descriptive statistics; determinants of dynamic resilience to food insecurity

	1994	1995	1997	1999	2004	All
Physical assets						
Total cultivated land (in ha.)	1.34	1.45	1.49	1.20	1.06	1.31
Number of oxen owned (in TLU)	1.01	1.02	1.24	1.32	1.22	1.16
Number of cows owned (in TLU)	0.37	0.40	0.83	0.81	0.82	0.65
Number of transport animals owned (in TLU)	0.52	0.55	0.35	0.35	0.36	0.43
Agricultural inputs						
Fertilizer use; 1 if yes	0.13	0.38	0.50	0.50	0.41	0.38
Manure use; 1 if yes	0.48	0.61	0.61	0.46	0.72	0.58
Irrigation use; 1 if yes	0.03	0.03	0.03	0.10	0.22	0.08
Access to information						
Advised by extension agents; 1 if yes	0.35	0.36	0.37	0.40	0.51	0.40
Radio ownership; 1 if yes	0.12	0.08	0.10	0.10	0.14	0.11
Non-agricultural income diversification						
Participated in causal wage employment scheme; 1 if yes	0.23	0.33	0.16	0.18	0.24	0.23
Participated in casual self-employment scheme ; 1 if yes	0.68	0.75	0.66	0.29	0.34	0.54
Household demographics						
Sex of household head; 1 if male	0.79	0.79	0.77	0.73	0.70	0.76
Adult family members (in number)	2.04	2.11	2.26	1.99	1.93	2.07
Age of household head (in years)	46.48	47.54	48.95	49.41	50.78	48.63
Age of household head squared (/100)	24.04	24.97	26.22	26.71	28.09	26.01
Household head education level; 1 if primary school	0.14	0.14	0.10	0.10	0.08	0.11
Household head education level; 1 if secondary school	0.05	0.05	0.02	0.02	0.04	0.04
Any family member is/was in any leadership position (index)	0.51	0.51	0.51	0.51	0.51	0.51
Village characteristics						
Obtained income from chat growing; 1 if yes	0.07	0.08	0.13	0.06	0.11	0.09
Obtained income from coffee growing; 1 if yes	0.14	0.17	0.23	0.22	0.21	0.19
Risk management tools or coping strategies						
Received remittance from any sources; 1 if yes	0.17	0.46	0.28	0.22	0.38	0.30
Received food assistance from gov't, NGO's and relatives	0.30	0.08	0.15	0.19	0.07	0.16
Received credit from informal/formal credit scheme; 1 if yes	0.50	0.36	0.54	0.53	0.54	0.49
Lent to others through informal credit scheme; 1 if yes	0.04	0.05	0.08	0.07	0.08	0.07
Members in local saving scheme (*Iquib*); 1 if yes	0.19	0.15	0.15	0.14	0.17	0.16
Involved in labor groups (*debo or wenfel*) 1 if yes	0.34	0.44	0.12	0.55	0.43	0.38

Source: Authors calculation from ERHS data

The number of oxen, milking cows and transport animals owned are expected to be positively correlated with resilience for food security, mainly through their positive impact on production. For sample households, average number of oxen owned increased, from 1.01 TLU in 1994 to 1.32

in 1999 but dropped to 1.22 in 2004 (Table 4). Similarly, number of milking cows owned increased from 0.37 TLU in 1994 to about 0.80 between 1997 and 2004. Average number of transport animals owned was 0.52 TLU in 1995 but declined to 0.35 in the later years.

Use of chemical fertilizer, manure and irrigation has been used as a measure of access to inputs. The proportions of households using chemical fertilizer have increased from about 13% in 1994 to about 50% in 1997 and 1999 but slightly declined to about 41% in 2004. Households using manure and irrigation have increased from 48% and 3% in 1994 to about 72% and 22% in 2004, respectively. One-third of households have received remittance from relatives and about 16% have received food assistance from either government, NGO's or relatives. Furthermore, about 40% of households were advised by extension workers and about 10% have reported ownership of radio (Table 4).

Income diversification activities in the survey areas include non-farm business activities, wage employment and earning remittances. Households participating in wage employment account for nearly 23% during the course of the survey periods. However, participation in self-employment declined from about 70% between 1994 and 1997 to 30% between 1997 and 2004.

Due to the absence of formal insurance and financial markets, informal risk management such as access to informal credit schemes are important for rural farming households. Two groups of households are identified in this regard: those who borrowed (borrower) and those who gave out loans. Borrowers are expected to be less resilient than lenders, as the reason for resorting to a high cost informal loan is likely to be poverty, limited precautionary savings or no grain stock. About 49% of households are reported to have borrowed during the survey period, mainly from informal sources. On the other hand, lenders are more likely to be relatively richer with adequate saving; the proportion of lending households is very small (7%).

Sample households have access to a few traditional associations: *debbo* and *wonfel*- labor sharing arrangements, and *Iquib* (a Rotating Saving and Credit Association (ROSCA). *Iquib* is an association established by a small group of people in order to provide substantial rotating funds for members. About 16% of households participated in *Iquib* and about 38% were involved in labor groups (*debo and wonfel*).

Human capital includes family labor as well as education and experience of the household head. An adult family member determines the family's capacity to work. Educational level of the household head is thought to influence the return to family labor. Literate household heads are thus expected to have better resilience score because of their better management know-how. Age of household head and participation of the head or the spouse in management position of a community based organization is used as a proxy for experience. Male-headed households are also expected to have higher resilience score than female headed ones. The proportion of household heads with primary and secondary school level of education is 11% and 4%, respectively. On average adult family members are limited to about 2 persons (economically inactive family members account for more than half of the family) and about 25% of the sample households are headed by females.

5 Empirical results

Table 5 presents estimation results for pooled as well as dynamic random-effects probit models. Column (A) presents estimation from a simple pooled probit model (without random effects) while columns (B) and (C) report the random-effect dynamic probit models with initial conditions to be exogenous and endogenous, respectively. The Heckman's estimator is used for endogeniety of the initial conditions. Column (D) reports the Heckman estimators as in column (C) but include additional explanatory variables. The panel-level variance component and exogeneity of the initial condition in the random effects probit model can be tested by simple significance test under the null of $\rho=0$ and $\theta=0$, respectively[14].

The coefficient of the lagged resilience is positive and highly significant indicating strong feedback from the past resilience that could help household learn more about how to ensure present and future resilience. However, assuming unobserved heterogeneity and initial conditions as exogenous overstates the effects of state dependence as obvious from rather inflated pooled probit model (column A) and dynamic probit model without controlling for initial condition (column B). Once controlling for both effects, the coefficient(s) is (are) almost halved for the rest of estimations. Moreover, inclusion of additional explanatory variables will not lead to a significant change in the coefficient of the state dependence, once both unobserved heterogeneity and initial conditions are controlled (see column C and D).

[14] It is worth to note that random-effect probit model and pooled probit model use different normalization (Stewart, 2006; Arulampalm, 1998). The random effects model use a normalization of $\sigma_u^2=1$ while the pooled probit estimator used $\sigma_v^2=1$. Therefore, when comparing them with probit estimates, random effect model estimates need to be multiplied by an estimate of.

$$\sigma_u / \sigma_v = \sqrt{1-\lambda}$$

Furthermore, sustainable resilience for food security dynamics increases with households' physical capital: total size of cultivated land has positive and significant impact on resilience to food security at 1% level of significance (Table 5). Given the present low rate of technology application, expanding land under cultivation seem to be the main option to ensure resilience for food insecurity. Nevertheless, high population pressure and the restrictive land markets (farmers have only use right over their land) do not allow consolidation.

The number of oxen owned has positive and significant impact on household resilience at 1% level of significance. Households who own oxen are more likely to invest in resilience-enhancing portfolios. Milking cow ownership contributes positively and significantly to the likelihood of being resilient (Table 5). Milking cows provide milk and offspring that serve as precautionary assets and/or replacement of major stock (oxen and cows). Moreover, Aune *et al.* (2006) found that milking animals earn more profit than oxen in the highlands of Ethiopia. The contribution of cows to income and resilience would have been much higher had farmers used cross breeds which give higher milk yield.

The number of transport animals owned increase household resilience at 5% level of significance. Given that motorized transport services are underdeveloped in rural areas, pack animals play a critical role in transporting outputs and inputs to and from the markets. Households with pack animals incur less transportation costs and hence earn greater earnings and savings.

Fertilizer use has positive and significant impact on household resilience at 1% level of significance (Table 5). Although appropriate packages such as fertilizer, improved seeds and pesticides are crucial for increasing crop productivity, fertilizer is the only modern input widely used by rural households in Ethiopia[15]. Fertilizer is used to overcome the decline in soil fertility associated with continuous cultivation of the same plot of land every year. Most farmers have no chance of fallowing the land (traditional method of maintaining fertility) because of their small land sizes. Manure use has also a positive but insignificant impact being resilient to food insecurity at 10% level of significance. The coefficient of irrigation is not significant and also unexpectedly negative in the pooled and random effect probit regressions (Table 5). This unexpected result could be attributed to inadequate marketing environment to grow high value crops and make efficient use of irrigation to earn sufficiently higher income (that allows investment in resilience-enhancing activities).

Human capital can be improved with education or experience as a community leader. Experience from serving in a leadership position (in a local administration or farmer organization) has a positive and significant impact on resilience; it may provide the opportunity to observe and learn from better off and more resilient farmers. Education of the head has a positive but insignificant impacts. Resilience capacity increases with age; older household heads may have more resources and capacity of coping with shocks than younger heads.

Labor availability, as measured by adult population of the households, has positive and significant impact on resilience; the higher the proportion of economically active members, the greater the possibility of investment in grain stock, precautionary savings or child education.

Male-headed households have greater probability of being resilient than female-headed households (the coefficient of gender is positive and significant in the dynamic model). The results suggest that female-headed

[15] Only 3-4% of the total cultivated land in Ethiopia is covered by improved seeds

households likely face cultural and social barriers in managing their resources and building their resilience capacity.

The variables used to measure accessing basic information are found to have a positive impact on household resilience for food security. The coefficient of radio ownership is positive and significant in to two (out of four) cases (Table 5), implying that access to national and local news and other information is likely to help in creating awareness and building resilience capacity. The positive (although insignificant) coefficient of extension agents shows the favorable role of advice on production and marketing.

Access to markets with better facilities has positive and significant impact in both static and dynamic models. Better markets may improve the way households plan their work and their investment decisions. Residing nearby markets may also mean improved access to health and education facilities and favorable input and output prices. Diversifying income sources to wage and self-employment activities was not found to have a significant impact (although the coefficient is positive). These could be attributed to low return or low productivity of wage and self-employment in Ethiopia (Demeke, *et al.*, 2003). The World Bank (2008) study has also shown that the average profit earned from running a nonfarm enterprise is low and less than a dollar a day. It appears that poorer households diversify into wage employment and off-farm activities to meet immediate subsistence needs, but are unlikely to have the income needed to make investment in activities enhancing long lasting resilience to food insecurity.

Households in predominantly cereal growing areas are more resilient than coffee or *chat*[16] areas. Although *chat* production is generally considered more lucrative than coffee or cereal production (Belwal and Teshome,

[16] Chat (Catha edulis) is a shrub whose leaves are chewed to get a mild stimulant effect.

2011), its impact on resilience is not significant probably due to the fact that households producing the plant are also unduly chewing it with adverse impact on their mental and physical wellbeing. Habitual use of *chat* is known to lead to problems like depression, anxiety and reduced productivity[17] (Reda, *et al.*, 2012), deterring investment in productive assets or precautionary savings. Coffee growers, on the other hand, are affected by high levels of price volatility (Bellemare, *et al.*, 2012) and limited opportunity to increase productivity and expand production (Gebreselassies and Ludit, 2008). Moreover, specializing in *chat* or coffee production and commercialization is not a preferred option for many farmers as relying on the market for food can be risky due high price volatility caused by underdeveloped markets and recurrent weather problems in many parts of the country (IFPRI, 2010). The production, productivity and other challenges and uncertainties in the agricultural markets need to be addressed for *chat* and coffee farmers to invest in activities that would make them resilient to food insecurity.

Table 5 also presents the impact of some traditional risk sharing management tools (in addition to income or crop diversification) and traditional financial arrangements on resilience for food security. With no formal insurance and inadequate credit market, farmers rely on remittances (transfer income), food assistance (mostly from relatives), informal credit schemes (extending or receiving loans), local saving and traditional labor sharing groups. We also included lagged values of the variables (risk-sharing) so as to control for long term impacts[18]. Among traditional risk sharing management options, households who received remittance, lent out to others, participated in local saving scheme (*Iquib*) and joined labor sharing groups are found to be more resilient at 1% and 5% level of significance.

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[17] Reduced productivity could also be attributed to the long hours spent on chewing.
[18] There may be some correlation between the lagged and current values of regressors, but the pair-wise correlation matrix shows there is no significant correlation among those variables

Table 5: Household Resilience dynamics; Dynamic Probit estimation results

	Pooled Probit (A)	RE dynamic Probit (B)	RE dynamic probit (Heckman) (C)	RE dynamic (Heckman approach) (D)
Lagged resilience index (first lag)	1.20***	1.16***	0.75***	0.75***
	(26.54)	(16.67)	(9.79)	(9.72)
Physical Assets				
Number of oxen household owned	0.04**	0.04**	0.045*	0.045**
	(2.05)	(2.09)	(1.95)	(2.00)
Number of milking cows owned	0.09***	0.09***	0.09***	0.09***
	(3.29)	(3.29)	(2.96)	(2.78)
Number of transport animals owned (in TLU)	0.08**	0.09**	0.09**	0.08*
	(2.17)	(2.18)	(2.10)	(1.75)
Total size of land cultivated (in ha)	0.07***	0.07***	0.08***	0.07***
	(3.15)	(3.11)	(3.25)	(3.00)
Agricultural inputs				
Use of fertilizer; 1 if yes	0.20***	0.21***	0.22***	0.22***
	(4.03)	(4.00)	(3.76)	(3.65)
Use of manure; 1 if yes	0.07	0.07	0.10*	0.09*
	(1.38)	(1.41)	(1.77)	(1.65)
Use of irrigation; 1 if yes	-0.04	-0.06	0.02	0.01
	(0.57)	(0.79)	(0.26)	(0.15)
Access to information				
Advised by extension agent; 1 if yes	0.06	0.06	0.05	0.05
	(1.25)	(1.28)	(0.82)	(0.81)
Radio ownership; 1 if yes	0.12*	0.12*	0.12	0.10
	(1.73)	(1.72)	(1.50)	(1.24)
Have access to market with better facilities; 1 if yes	0.32***	0.34***	0.57***	0.59***
	(6.56)	(5.93)	(7.61)	(7.64)
Non-agricultural income diversification				
Participation in wage employment; 1 if yes	0.04	0.04	0.03	0.02
	(0.88)	(0.81)	(0.48)	(0.39)
Participation in self-employment; 1 if yes	0.01	0.01	0.01	-0.02
	(0.22)	(0.17)	(0.19)	(0.31)
Household demographics				
Household head sex; 1 if male	0.08	0.08	0.12*	0.13**
	(1.52)	(1.55)	(1.96)	(2.01)
Family labor (number of active member)	0.07***	0.07***	0.08***	0.08***
	(3.75)	(3.73)	(3.55)	(3.53)
Age of head	-0.00	-0.00	-0.01	-0.00
	(0.10)	(0.20)	(0.63)	(0.49)
Age of head squared	0.00	0.00	0.00	0.00
	(0.21)	(0.30)	(0.65)	(0.58)
Head education; 1 if completed primary	0.06	0.06	0.06	0.04
	(0.90)	(0.90)	(0.71)	(0.53)
Head education; 1 if completed secondary	0.12	0.12	0.12	0.11
	(1.01)	(0.99)	(0.84)	(0.78)
Head/wife or parents leadership position	0.12*	0.12*	0.16**	0.16*
	(1.87)	(1.85)	(1.97)	(1.93)
Village characteristics				
Obtain income from chat growing; 1 if yes	-0.03	0.18	-0.05	-0.09
	(0.41)	(1.55)	(0.61)	(0.97)
Obtained income from coffee growing; 1 if yes	0.09*	-0.01	0.08	0.09
	(1.88)	(0.05)	(1.19)	(1.37)
Risk management tools or coping strategies				
Received remittance; 1 if yes				0.10*
				(1.86)
Food assistance from gov't, NGO's ; 1 if yes				0.13*
				(1.76)
Received informal credit; 1 if yes				-0.04
				(0.91)
Lent to others; 1 if yes				0.38***
				(3.91)
Member in '*equb*', local saving; 1 if yes				0.16**
				(2.02)
Involved in; *debo &/ wonful* 1 if yes				0.09*
				(1.73)

Table 5 (ctd): Household Resilience dynamics; Dynamic Probit estimation results

	Pooled Probit (A)	RE dynamic Probit (B)	RE dynamic probit (Heckman) (C)	RE dynamic (Heckman approach) (D)
Received remittance in period t-1; 1 if yes				0.04
				(0.68)
Received food assistance in period t-1; 1 if yes				-0.11*
				(1.80)
Received informal credit in period t-1; 1 if yes				-0.05
				(0.96)
Lend out (informal lender) in period t-1; 1 if yes				0.02
				(0.18)
Member in "*equb*" in period t-1; 1 if yes				0.04
				(0.50)
Involved in "*debo &/wenful*" in period t-1, 1 if yes				0.06
				(1.05)
Constant	-0.82***	-0.79***	-1.28***	-1.30***
	(3.84)	(3.54)	(4.89)	(4.84)
ρ		0.04**	0.26**	0.27**
		(2.73)	(2.01)	(2.65)
θ			0.37*	0.35*
			(1.67)	(1.61)
Log likelihood	-2,494.41	-2,494.03	-3,022.26	-3,001.63
Number of observations	4,960	4,960	6,200	6,200
Wald Chi-square	1,879.13	1,380.69	876.07	884.38

* $p<0.1$; ** $p<0.05$; *** $p<0.01$
Note: Figures under parentheses are t-values. The regression is controlled for villages and round interaction term but not reported

Lending money to others can generate an attractive income as lenders benefit from charging high interest rates, often 10% per month or 120% per year (Bevan and Pankhurst, 1996). Borrowers may also provide labor to lenders. *Iquib* is a forced saving mechanism and participants may use their savings to invest in resilience-enhancing activities. Households involved in labor sharing groups are more likely to earn more income for investment in resilience because such arrangements[19] allow efficient and effective use of labor during peak farming seasons (e.g. planting and harvesting).

The coefficient of lagged value of food assistance is negative and significant, implying receiving only food assistance could have an adverse impact on household resilience dynamics. Food assistance should

[19] Debo and/wonfel is often called by better-off household as who call for such labor sharing often prepare lunch and dinner including drinks for participants which the poor couldn't afford.

complement with long-term investment on productive assets such as the newly introduced Productive Safety Net program (PSNP). For instance, Siyoum, *et al.* (2012) found that the amount of food distributed is not only insufficient to meet even basic consumption needs but there is also little or no complementary measure to address the structural problems of poor soil fertility, environmental degradation, population pressure, fragmented landholdings, and lack of income-generating opportunities outside of agriculture which led to dependence on food aid in the first place. It is thus important for national and international organizations to collaborate and mobilize sufficient resources to meet the immediate food needs and long-term investment requirements of chronically food-insecure households. Moreover, transfers should be designed in a manner that beneficiaries do not run the risk of losing benefits once their situation starts to improve[20] or assistance does not result in dependency syndrome (Sharp and Devereux, 2004)

Borrowing from informal credit schemes seems to have a negative impact in the long-run. This is understandable given the fact that borrowing from the informal market often involves payment of exorbitant interest rates (Bevan and Pankhurst, 1996). On the other hand, remittances have a positive and significant impact on household resilience in the short as well as in the long-run. Remittances, which are largely obtained from educated family members working in urban areas, can be associated with greater human development outcomes (support younger siblings to stay in school) and better protection (insurance) of productive assets at times of drought or other shocks.

[20]There may be disincentive effects if social transfers are provided based on the condition that beneficiaries remain poor. Beneficiaries who use the assistance they receive for investment and improvement of their livelihood situation should not be excluded from the program (Norad, 2008).

6 Conclusions and policy implications

This study has developed household resilience score for food security based on self-insurance options: (i) amount of grain in stock; (ii) level of in-kind precautionary investment (non-principal animals); (iii) investment in children education (proxied by average educational level of school-age children); and (iv) investment in social capital or mutual aid association (*idir*). The principle of self-insurance essentially is based on whether households anticipate shocks and develop their own short and long-term plans for mitigating shocks and enhancing resilience for food security.

We constructed resilience scores and identified factors influencing the scores using the Ethiopia Rural Household Survey (ERHS) panel data in five waves. The analysis is based on a balanced panel with 1,240 households and a total of 6,200 observations. The resilience scores at household level is generated using the principal component analysis. On average, the scores were found to be higher in samples drawn from Oromia and Amhara regions and lower in SNNP and Tigray regions; the results is consistent with the agricultural potential of the regions.

Factors influencing the dynamic of household resilience is assessed using dynamic probit random-effect model. The results show the level of resilience score in the past has significant impact on the current resilience. In other words, there is a '*true state-dependence*' on the dynamics of resilience for food security. Household resilience is also influenced by physical, human and financial capital as well as access to basic services, information, input, markets and income diversification.

Assets such as land as well as improved technologies are positively related to building household resilience for food security. Expanding farm size (or larger farm size) improves. However, the current land policies restrict consolidation of holdings by prohibiting the sale or purchase of land. Land lease is also restricted by a number of provisions, limitations and rights attenuations (Crewett, *et al.*, 2008). Revisiting the existing land policy has the potential of contributing to the emergence of a more dynamic and resilient farming sector.

Intensification through use of improved technologies such as fertilizer can improve resilience. Users of fertilizer are probably more productive and market-oriented and are more likely to be aware of the need for investing in self-insurance portfolios. Since fertilizer is often used along with traditional seeds and the optimum rate of fertilizer application is constrained by high cost and limited access to credit, improving the profitability of fertilizer and promoting widespread use of a package of improved inputs can contribute to greater degree of resilience.

Ownership of principal assets such as oxen and milking cows has a positive and significant contribution to building resilience. Asset owners are more concerned about shocks and thus take in-kind precautionary savings and investment more seriously. Moreover, the return from oxen, milking cows and transport animals enables owners to make the necessary investment in grain stock, farm animals, education of children and social capital. As diseconomies of scale of scale may render crop production on very small farms unsustainable, keeping milking cows can be a better option to ensure resilience for food security for smallholders with no interest or chance to relocate in the non-agricultural sector.

Income diversification into wage employment and non-farm activities were found to have an insignificant impact on building sustainable resilience for food security. The lack of significance may demonstrate the low level of income generated from off-farm employment. A positive and significant contribution of wage and non-farm employment to resilience and sustainable growth would be achieved only if there are productive activities within and outside agriculture that offer remunerative opportunities. A broad and sustainable growth of the overall economy needs to be an important part of the strategy to build resilient rural communities.

Participation in cash crop (coffee and *chat*) production would improve resilience provided the current production, marketing and other challenges were overcome to ensure a more sustainable growth and better return to land and labor resources. In particular, addressing price volatilities in both cash and food crops should be given particular attention to stimulate investment in resilient livelihoods. Given the negative impact of *chat* on health and productivity of labor, efforts to find an alternative livelihood option should be accorded immediate considerations.

Short-term loans from informal sources seem to have a negative impact on resilience (because they are probably very expensive). A corollary to this finding is that the role of a more affordable and longer-term formal credit (including micro credit) in assisting poor households to build their resilience capacity and asset base cannot be overemphasized.

Some traditional risk management and financial tools were found to influence resilience. Membership in savings and credit associations and labor sharing groups were found to have a significant positive impact. Measures aimed at supporting traditional saving and credit groups and community organizations need to be given adequate attention. On the other hand, the evidence shows that families receiving only food aid are less resilient in the long-run. This can be expected because the level of assistance is too small and development interventions aimed at addressing poor soil fertility, diminishing farm sizes and recurrent droughts are inadequate for the most part. The focus in marginal areas needs to be on safety net programs that adequately meet food consumption requirements accompanied by complimentary measures to support asset build up and intensification of production to achieve sustainable resilience to food insecurity. It should also be added that safety net programs and insurance schemes cannot be sustained if farming systems are not resilient, dynamic and on a growth trajectory[21].

Sustainable resilience for food security in an environment of predominantly subsistence farming requires an integrated approach. Education, experience (participation in community activities), and improved access to information, community organizations, transport services, irrigation and package of improved inputs and animal breeds (dairy animals) can help but the impact will remain limited until the markets for land, credit, insurance, output, input and capital goods are sufficiently developed and expanded. A focus on institutional measures to address market failures and missing markets would go a long way in building sustainable resilience to hunger and breaking the cycle of subsistence and vulnerable farming systems.

[21] According to Katharine Vincent of the Regional Hunger and Vulnerability Programme, "Insurance companies are not answerable to any public sector organizations or governments, and thus are entitled to (and do) withdraw their products should they no longer become financially viable, … [Insurance] may discourage farmers from engaging in their traditional self-reliance, preparedness, and risk-spreading activities. If this happens and then the insurance product is removed, they will arguably be in a more precarious situation – both worse off economically and more vulnerable to risk - than they were before the insurance was available," http://www.wahenga.net/node/1919.

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Annexes

Annex 1. Sustainable resilience scores by villages and survey period; First components

	1994	1995	1997	1999	2004	Pooled data
All	0.47	0.52	0.52	0.51	0.53	0.51
Haresaw	0.37	0.50	0.50	0.47	0.50	0.47
Geblen	0.39	0.46	0.49	0.48	0.50	0.46
Dinki	0.45	0.40	0.49	0.47	0.53	0.47
Yetmen	0.56	0.61	0.56	0.58	0.56	0.57
Shumsha	0.47	0.55	0.50	0.46	0.50	0.50
Sirbana Godeti	0.60	0.59	0.51	0.53	0.53	0.55
Adele Keke	0.47	0.49	0.52	0.51	0.54	0.51
Korodegaga	0.50	0.61	0.59	0.51	0.54	0.55
Trirufe Ketchema	0.51	0.59	0.56	0.55	0.53	0.55
Imdibir	0.34	0.32	0.40	0.33	0.42	0.36
Aze Deboa	0.44	0.47	0.47	0.48	0.48	0.47
Adado	0.39	0.43	0.48	0.48	0.46	0.45
Gara Godo	0.34	0.41	0.47	0.50	0.49	0.44
Doma	0.39	0.49	0.49	0.48	0.53	0.48
D/Brihan – Milki	0.60	0.63	0.64	0.65	0.64	0.63
- Kormargefia	0.63	0.64	0.65	0.65	0.64	0.64
- Karafino	0.61	0.64	0.62	0.61	0.64	0.63
- Bokafia	0.64	0.66	0.66	0.64	0.66	0.65

Source: Authors' calculation from ERHS data

Annex 2. Difference-of-Means Tests between resilient and non-resilient households; 1994

	Non-resilient (B)	Resilient (A)	Difference (B-A)
	Means (S.D)	Means (S.D)	In Means[22] (t-test)[23]
Household assets			
Number of oxen owned (in TLU)	0.83 (1.27)	1.41 (1.73)	-0.58*** (-5.66)
Number of cows owned (in TLU)	0.27 (0.61)	0.61 (0.99)	-0.33*** (-6.09)
Number of transport animals owned (in TLU)	0.41 (0.69)	0.78 (1.50)	-0.67*** (-4.58)
Total cultivated land (in ha)	1.23 (1.29)	1.66 (1.63)	-0.44*** (-4.64)
Agricultural inputs use			
Fertilizer use; 1 if yes	0.09 (0.23)	0.17 (0.38)	-0.08*** (-3.47)
Manure use; 1 if yes	0.45 (0.49)	0.55 (0.49)	-0.92*** (-3.01)
Irrigation use; 1 if yes	0.03 (0.18)	0.15 (0.12)	0.018* (1.98)
Access to Information and income diversification			
Have advised extension agents; 1 if yes	0.31 (0.46)	0.44 (0.49)	-0.13*** (-4.24)
Radio ownership; 1 if yes	0.09 (0.28)	0.21 (0.41)	-0.11*** (-5.14)
Household members in a leadership position	0.49 (0.33)	0.53 (0.32)	-0.05*** (-2.38)
Participation in casual wage employment; 1 if yes	0.25 (0.43)	0.19 (0.39)	0.06*** (2.34)
Household demographics			
Sex of household head	0.76 (0.42)	0.87 (0.34)	-0.11*** (-4.84)
Age of head (in years)	44.6 (15.6)	50.35 (14.7)	-5.72*** (-6.16)
Head completed primary school; 1 if yes	0.14 (0.34)	0.16 (0.37)	-0.02 (-0.90)
Head competed secondary school; 1 if yes	0.03 (0.26)	0.08 (0.26)	-0.38*** (-2.50)
Higher dependency ratio	0.50 (0.21)	0.47 (0.18)	0.03** (2.20)

Source: Authors' computation from 1994 ERHS data

22 Two-sample t-tests with unequal variances

23 The astriks *** indicates significance at 1 percent; ** and * indicate significance at 5% and 10%, respectively

Annex 3. Household's resilience status over the course of the survey periods (in %); first components

	Non-resilient in all times	Once	Twice	Three times	Four times	Resilient in all times
All	46.77	3.6	6.65	9.05	12.32	21.61
Haresaw	57.87	4.53	11.20	14.40	10.67	1.33
Geblen	67.46	7.12	6.78	14.24	2.71	1.69
Dinki	60.26	4.21	8.95	8.68	7.37	10.53
Yetmen	17.04	0.37	2.96	10.00	17.78	51.85
Shumsha	47.89	3.85	6.61	12.66	16.15	12.84
Sirbana Godeti	31.35	1.35	5.41	8.92	20.54	32.43
Adele Keke	44.09	3.18	8.18	12.27	16.36	15.91
Korodegaga	27.69	0.88	6.15	10.55	27.25	27.47
Trirufe Ketchema	28.86	1.59	5.00	12.95	20.91	30.68
Imdibir	91.80	4.92	3.28	0.00	0.00	0.00
Aze Deboa	67.54	5.51	11.01	9.57	3.48	2.90
Adado	76.34	6.10	9.76	5.85	1.95	0.00
Gara Godo	74.29	9.45	10.99	2.64	2.64	0.00
Doma	56.43	5.00	7.86	16.07	12.86	1.79
D/Brihan – Milki	7.02	0.00	0.70	3.16	15.44	73.68
- Kormargefia	6.42	0.00	0.00	2.26	19.62	71.70
- Karafino	10.91	0.61	1.21	7.27	7.27	72.73
- Bokafia	6.67	0	1.67	2.5	10	79.17

Source: Authors' computation from survey rounds

KJ-NA-29111-EN-N

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doi:10.2760/973096
ISBN 978-92-79-79830-6