Estimating Multidimensional Development Resilience

Seungmin Lee
Cornell University
sl3235@cornell.edu

Kibrom A. Abay
IFPRI
K.Abay@cgiar.org

Christopher B. Barrett
Cornell University
cbb2@cornell.edu

John F. Hoddinott
Cornell University
jfh246@cornell.edu

November 2023

Abstract: Resilience measurement has received substantial attention over the past decade or so. Existing measures, however, relate resilience to a single well-being indicator. This may be problematic in contexts where households face deprivations in multiple dimensions. We explore how sensitive estimates of household-level resilience are to the specific well-being indicator used and show that measures are only weakly correlated across different, reasonable indicators based on expenditure-based poverty, dietary diversity, and livestock asset holdings. We then introduce a multidimensional resilience measure, integrating the probabilistic moment-based resilience measurement approach of Cissé and Barrett (2018) with the multidimensional poverty measurement method of Alkire and Foster (2011). Applying the new method to household panel data, we show that univariate and multidimensional resilience measures can yield varied inferences on the development resilience impact of development interventions such as Ethiopia's Productive Safety Net Program.

Keywords: assets, consumption expenditures, dietary diversity, Ethiopia, livestock, nutrition, poverty

1 Introduction

Over the past decade or two, governments, development organizations and donors have invested heavily in interventions that aim to improve the resilience of households or communities to shocks and stressors. Evaluation of the effectiveness of such interventions has proved challenging, however, because there is not yet any consensus on how best to measure resilience. Although the concept of resilience has long existed in various disciplines, including ecology, engineering and psychology, those fields' measurement methods do not adapt easily to the development resilience context. In a recent review, Barrett et al. (2021) classify the broad range of resilience conceptualizations and measures currently in use into three broad categories: (1) resilience as the capacity to withstand exposure to negative stressors or shocks; (2) resilience as return to equilibrium after shocks; and (3) resilience as a normative condition (i.e., the sustained capacity of an entity to avoid falling below some normative threshold standard of living, such as a poverty line). Upton, Constenla-Villoslada, and Barrett (2022) established that household resilience measures are only weakly correlated across these categories, thus users must beware that their empirical findings may be purely an artifact of their chosen measure. It may also be true, however, that even with a single measurement method within a specific category, development resilience estimates may vary depending on the well-being indicator(s) to which the analyst applies the measure. For example, a household that appears resilient in dietary terms may not exhibit resilience in expenditures or livestock holdings, or vice versa. In this paper, we explore and confirm that hypothesis and then develop a new family of multidimensional resilience measures as alternatives to summarize resilience with respect to multiple well-being indicators.

The appeal of a multidimensional resilience measure arises because it is often unclear which well-being indicator(s) best capture(s) resilience. Because a household's productive asset holdings determine its stochastic conditional income distribution over time, many studies define development resilience with respect to productive asset holdings, measured in terms of livestock or an asset index (Cissé and Barrett (2018), Phadera et al. (2019), Scognamillo, Song, and Ignaciuk (2023), and Yao et al. (2023)). Because resilience measurement has commonly been tied to food security interventions, other studies anchor resilience measures to various food security or nutritional indicators (Upton, Cissé, and Barrett 2016; Knippenberg, Jensen, and Constas 2019; Vaitla et al. 2020; Upton, Constenla-Villoslada, and Barrett 2022). Still others tie resilience measures directly to consumption expenditures and official poverty lines (Abay et al. 2022; Premand and Stoeffler 2022; Upton, Constenla-Villoslada, and Barrett 2022). Resilience measures constructed based on different indicators may not generate similar orderings of households. Thus the choice of outcome variable with respect to which one measures resilience could influence intervention targeting or evaluation. In extending existing unidimensional resilience measurement to confront multiple dimensions of deprivation commonly faced by residents of low-income communities, we follow the lead of prior advances in multidimensional poverty measurement (Alkire and Foster 2011; Alkire and Santos 2014), which expressly built on existing unidimensional poverty measurement methods (Foster, Greer, and Thorbecke 1984).

The choice of measurement method and indicator(s) may matter to evaluations of the effectiveness of interventions intended to improve development resilience. Some interventions may be more effective in improving some dimensions of resilience than others. For example, Phadera et al. (2019) find that although a livestock transfer program in rural Zambia significantly improved short-term welfare outcomes, many households who received the treatment have a low likelihood of escaping expenditure-based poverty sustainably. Similarly, Sabates-Wheeler et al. (2021) concluded while Ethiopia's Productive Safety Net Program has been successful in smoothing consumption shortfalls, it underperformed in building household assets and hence ultimate graduation out of poverty. Abay et al. (2022) likewise show that building household resilience may require significant transfers and continuous participation in safety net programs as well as complementary income generating programs.

Like most recent academic research on resilience measurement (Upton, Cissé, and Barrett 2016; Knippenberg, Jensen, and Constas 2019; Phadera et al. 2019; Vaitla et al. 2020; Abay et al. 2022; Premand and Stoeffler 2022; Upton, Constenla-Villoslada, and Barrett 2022; Scognamillo, Song, and Ignaciuk 2023; Yao et al. 2023), we follow the moment-based approach developed by Cissé and Barrett (2018), wherein one estimates the household-level conditional mean and variance of a relevant well-being indicator and uses the resulting estimates and an appropriate distributional assumption to estimate the conditional probability of attaining at least some minimal threshold value of that indicator. In this paper, we first estimate the development resilience of Ethiopian households using three different measures: per capita consumption expenditures, dietary diversity and livestock asset ownership. But resilience is a broad concept that may be represented in any of several welfare dimensions; households may be more resilient in some dimensions than other dimensions. We therefore introduce a method that extends the Cissé and Barrett (2018) approach to allow for more comprehensive, multidimensional resilience measurement.

After explaining the family of measures available under this multidimensional approach, we then apply these measures to five rounds of household panel data (2006-2014) collected for the impact evaluation of Ethiopia's Productive Safety Net Program (PSNP). These data provide longitudinal information on consumption expenditures, dietary diversity, and livestock assets. We show that even using the same data and resilience estimation method, univariate household resilience indicators based on different well-being indicators are only weakly correlated. As a result, inference about the efficacy of PSNP in building household resilience varies depending on the well-being indicator against which one defines resilience measurement.When one combines multiple indicators into a multidimensional resilience indicator, the household-level rank correlation coefficients among different resilience estimators become appreciably greater, implying that inferences for the purposes of targeting or impact evaluation are more likely robust to reasonable variation in the well-being indicators employed to assess resilience. The empirical findings highlight the need for caution and sensitivity testing when estimating resilience measures for the purpose of targeting interventions or of evaluating policy or program interventions.

2 Data

2.1 Data Source and Sample Description

We use five rounds of household-level panel survey data from rural Ethiopia. These data were collected biennially in 2006, 2008, 2010, 2012 and 2014. The data were collected from the four Highland regions of Ethiopia- Amhara, Oromiya, SNNP and Tigray - by the Central Statistics Agency (CSA) together with the International Food Policy Research Institute (IFPRI) to evaluate Ethiopia's flasghip social safety net program, PSNP. The study sample was selected through the two-stage clustered sampling. First, the CSA randomly selected 68 *woredas* (districts) from the 153 chronically food insecure *woredas* in the four regions, then 2 to 3 *kebeles* (wards) were randomly selected from each *woreda*. Second, each *kebele* randomly selected 15 PSNP beneficiaries and 10 non-beneficiaries from an exhaustive list of households.[1] The first round covered about 3,700 households from 146 enumeration areas (EAs). The study sample was gradually increased in every round, from 3,700 households in

1. See Gilligan, Hoddinott, and Taffesse (2009), Hoddinott et al. (2012), and Berhane et al. (2014) for a comprehensive description of the data and sampling design for these data.

2006 to 5,300 households in 2014. For the purpose of the current study, we focus on those households who were part of the first round. All surveys were done during the same months of the year (June/July) which effectively controls for seasonality in our analysis.

Table 1 shows the summary statistics of our study sample, pooled from 2006 to 2014.[2] Table 1 shows that 73% of households are male-headed, and 70% of them are married, and 81% of them are farmworkers. The average household size comprises 5 members.

Table 1 shows that 45 percent of households were PSNP beneficiaries. Ethiopia's Productive Safety Net Program (PSNP) is a flagship social protection program funded by the Government of Ethiopia and a consortium of donors. The PSNP was introduced in 2005 to respond to chronic and recurring food insecurity. The PSNP provides regular transfers to food insecure households to bridging consumption gaps while also building community assets through labor-intensive Public Works (PWs) (GFDRE, 2004; 2010). Targeting and selection to the program entails a mix of geographic and community-based targeting. The PSNP targets historically food insecure woredas (districts) while the household level selection follows a series of criteria, including food insecurity asset holdings (e.g., land, oxen) and income sources. The PSNP involves both public work, through which about 80 percent of the PSNP beneficiaries participate in labor-intensive PW projects in return for receing the transfers, as well as Direct Support (DS) component covering about 20 beneficiaries who lack labor needed for the PW and hence receive unconditional transfers (Berhane and Gardebroek 2011; Coll-Black et al. 2011; Berhane et al. 2014; Sabates-Wheeler et al. 2021). Table 2 shows that 34 percent of hosuseholds in our sample benefited from the PW program while another 10 percent received direct support. On average PSNP beneficiaries received 285 Birr per household member. 42 percent of households benefited from a complementary asset building and income generating program, namely Household Asset Building Program (HABP), which was designed to complement the PSNP by supporting households to diversify their income sources and increase productive assets.[3]

The last three rows in Table 1 report our main outcomes for measuring normative conditions and living standards. These include: annual consumption expenditure per capita, household dietary score (HDDS) and livestock asset ownership in TLU. We express all monetary values in Table 1 in 2014

2. In Table A1 in the Appendix we report disaggregate statistics, across waves.

3. The HABP provides technical support and agricultural input services along with access to credit services. Households were offered technical support including on use of improved agricultural inputs, beekeeping, livestock production, and soil and water conservation activities. The HABP has gone though several adjustments but continued to be implemented by microfinance institutions (MFI), which were tasked to facilitate access to credit services, and rural-based development agents for delivering technical support (Berhane et al. 2014).

constant prices.[4] Households spent 6,464 Ethiopian Birr per adult-equivalent per year.[5] Mean Household Dietary Diversity Score (HDDS) in our sample is low, 3.68 food groups. On average, households own 3.82 Tropical Livestock Unit (TLU).

Table 1: Summary Statistics

	count	mean	sd
Male headed household	16649	0.73	0.44
Age of household head	16301	47.76	15.37
Household head no education	16649	0.67	0.47
Household head married	16649	0.69	0.46
Household size	16301	5.24	2.28
Main occupation farming	16649	0.81	0.39
Main occupation non-farming	16649	0.04	0.20
IHS (farm size)	16269	0.30	0.27
IHS (livestock value per adult)	15593	9.08	2.40
IHS (Productive asset value per adult)	15548	5.07	1.30
Household has electricity access	16649	0.14	0.35
IHS (distance to nearest town)	16151	3.13	0.76
Average annual rainfall (mm)	15149	948.77	286.94
PSNP beneficiaries	16649	0.45	0.50
PSNP direct support (DS) beneficiaries	16649	0.10	0.30
PSNP public work (PW) beneficiaries	16649	0.34	0.47
HABP beneficiaries	16649	0.42	0.49
PSNP and HABP beneficiaries	16649	0.20	0.40
PSNP benefit amount per capita (birr)	7413	285.19	291.95
Annual real consumption per aeu	16235	6464.26	7062.99
Household Dietary Diversity Score (HDDS)	16649	3.68	1.86
Tropical Livestock Unit (TLU)	15412	3.82	3.34

*Including only PSNP beneficiaries. Non-beneficiaries have zero-value.
All monetary variables are in 2014 constant price.

Table 2 shows the temporal dynamics of our well-being indicators and welfare outcomes. We disaggregate them across PSNP beneficiaries and non-beneficiaries. The first three columns provides poverty dynamics using consumption expenditure and national poverty line. As expected, poverty rates are much higher than national averages because our sample comes from among the poorest areas of the country. As documented by other studies, there is significant poverty reduction recorded. Poverty rates appear to be generally comparable between PSNP beneficiaries and non-beneficiaries. The next three columns in Table 2 shows the share of households consuming below the minimum dietary diversity score, which again appears to be comparable across PSNP beneficia-

4. This conversion was applied for all welfare outcomes, PSNP transfers, value of productive assets, value of livestock as well as national poverty line.

5. Birr is the Ethiopian currency and at the latest survey round (2014), 1 USD 17 Birr.

Table 2: Welfare dynamics by PSNP status and year

	Consumption expenditure Below poverty line			HDDS Below 5			TLU Below 2		
	(1) Full sample	(2) non-PSNP	(3) PSNP	(4) Full sample	(5) non-PSNP	(6) PSNP	(7) Full sample	(8) non-PSNP	(9) PSNP
2006	0.80	0.79	0.81	0.81	0.81	0.82	0.26	0.20	0.32
2008	0.82	0.82	0.83	0.74	0.74	0.73	0.27	0.22	0.31
2010	0.62	0.60	0.63	0.70	0.68	0.71	0.25	0.19	0.32
2012	0.58	0.59	0.58	0.65	0.64	0.67	0.28	0.19	0.39
2014	0.45	0.44	0.47	0.59	0.57	0.63	0.32	0.25	0.45
Total	0.66	0.64	0.68	0.70	0.69	0.72	0.28	0.21	0.35

Source: Authors' computation based on household surveys in 2006, 2008, 2010, 2012, and 2014.

ries and non-beneficiaries. The last three columns report the share of households owning below the minimum (2) TLU. We can clearly observe significant differences between PSNP beneficiaries and non-beneficiaries, mainly because livestock ownership is an important criterion for PSNP participation.

The three well-being indicators reported in Table 2 are likely to capture slightly different dimensions of welfare and related household capacity. In terms of correlation among outcomes, all three outcomes are positively correlated, but the magnitude of correlations are different. Household consumption expenditure and the HDDS are modestly correlated (0.34), the HDDS and the TLU are weakly correlated (0.17), and household consumption and TLU are very weakly correlated (0.09). These generally weak correlation patterns imply that resilience measures built using these normative condition of living standards may capture different dimensions of household resilience. Given that rural households in Africa face varying degrees and sometimes unique markets and institutions, some households can be more resilient in some dimensions and less resilient in other dimensions. Capturing and quantifying these varying dimensions of resilience can inform appropriate interventions.

Figure 1 shows the distribution of the three main outcomes (consumption expenditure, HDDS and TLU). We report these distributions for the full sample as well as for PSNP beneficiaries and non-beneficiaries. We find that non-beneficiaries report slightly higher consumption expenditure compared to the PSNP beneficiaries, but the difference is not significant, making the two groups comparable. Regarding the shape of the distribution, the log of expenditure is normally distributed, implying that the expenditure follows the normal distribution. The HDDS is not sufficiently continuous outcome, but its overall shape is similar to normal distribution centered around its mean (3.7). The inverse hyperbolic sine of the TLU is "roughly" normal, except a large share of households near 0. Based on these distributional shapes, we regard all three outcomes, after appropriate transformation, to follow normal distribution.

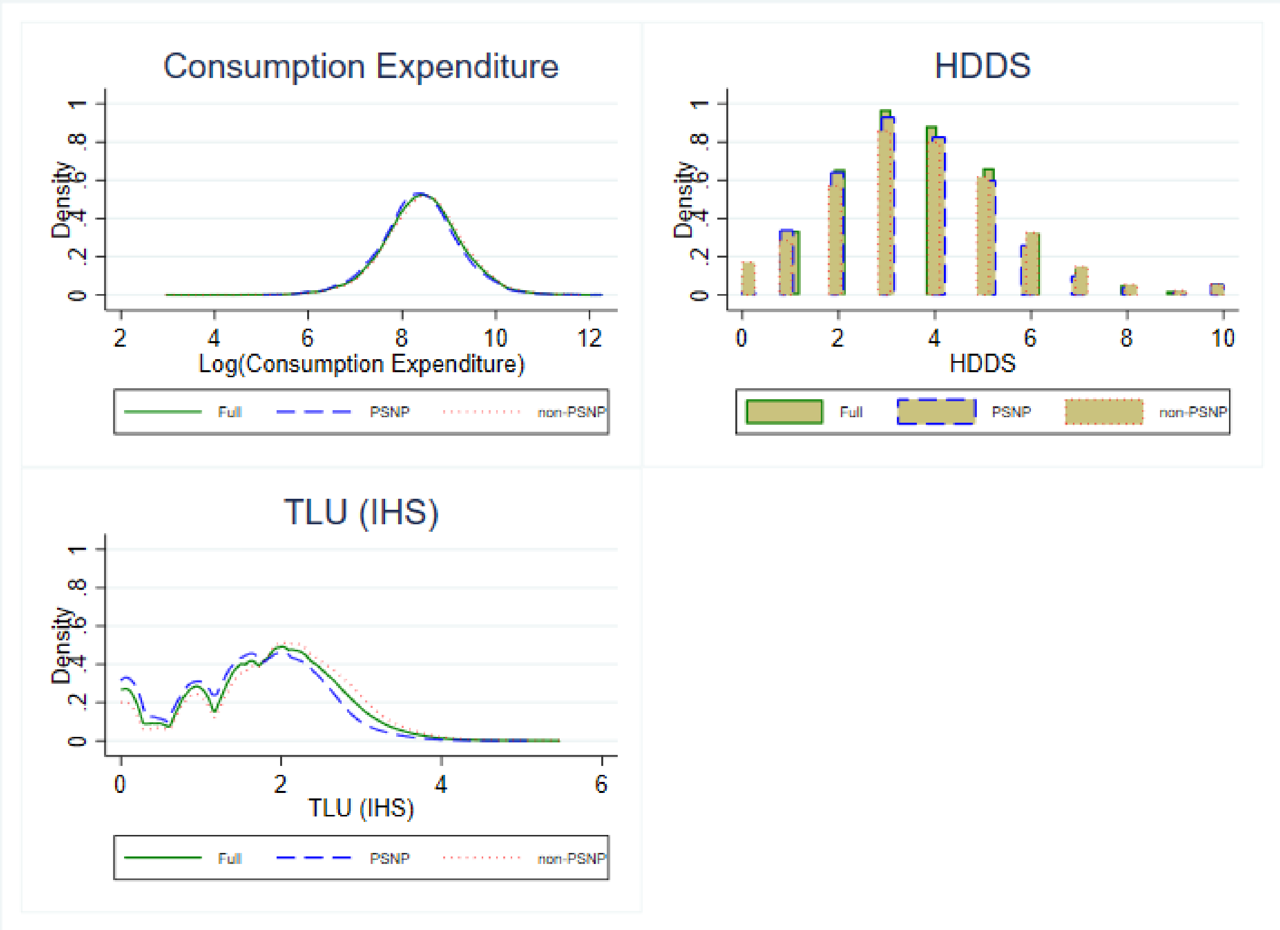

Figure 1: Distribution of Welfare Outcomes

2.2 Selecting Well-being Indicators and Normative Thresholds

We follow the literature conceptualizing resilience as a normative condition, the sustained capacity of an entity to avoid falling below some normative threshold of living standard. Computing resilience as an individual's probability to achieve some minimal threshold of living standard and well-being requires identifying a plausible indicator of well-being as well as normative threshold in this indicator. While some of these normative thresholds may be well-defined and widely accepted, some well-being indicators may not have well-defined thresholds to define the minimum threshold below which a household can be considered as not satisfying the minimum living of standard. In this study, we employ three indicators of well-being to capture multiple dimensions of well-being and living standard. Consumption is expenditure is the most widely used measure of well-being and living standard. Hence our first indicator is annual consumption expenditure, which generally follows a lognormal distribution in levels (and hence normal distribution log-transformed consumption values) as shown in Figure 1. Defining normative threshold for consumption and poverty-based measures of well-being is easier because of the concept of national poverty lines. Thus, for our first measure of normative well-being, we use national poverty lines for Ethiopia. National poverty lines are intuitive normative thresholds because they are computed and defined considering the costs of satisfying basic food and non-food needs. The poverty line for Ethiopia is estimated as the cost of food for satisfying minimum daily caloric requirement as well as basic non-food items. As we are expressing all monetary values in in 2014 constant prices, we also need to apply the same procedure for the national poverty line. The national poverty line for Ethiopia was 3781 Birr in 2011 which is equivalent to 4930.4 in 2014 prices (The World Bank 2015).

Our second measure of well-being and hence normative measure of living standard complements the usual consumption/income-based poverty metrics using a measure that captures access to healthy diets. The commonly used consumption/income-based poverty metrics are less likely to sufficiently capture nutritional resilience and households' sustained capacity to meet basic nutritional needs and access to healthy diets (Hoddinott 2006; Mahrt et al. 2022). For this purpose, we use household dietary diversity (HDDS) as an additional normative indicator of quality of living of standard. Although the minimum threshold for household dietary diversity is not commonly defined, FAO and FHI360 (2016) offers some guidance using women's dietary diversity outcomes. FAO and FHI360 (2016) sets that five or more food groups to be the minimum threshold for women's diet quality (micronutrient adequacy). We follow this benchmark and apply it to our sample. As shown in Figure 1 HDDS broadly follows a normal distribution.

The third measure of well-being we use in this study uses livestock asset ownership. We chose livestock assets for two major reasons. First, in Ethiopia livestock production and livestock assets are major source of livelihood. Rural households rely on livestock for generating income and for conducting their farming. Second, livestock sales serves as major insurance against shocks in many parts of rural Ethiopia (Dercon and Christiaensen 2011). Many rural households lack formal source of insurance and hence livestock is the most important liquid asset in rural Ethiopia (Dercon and Christiaensen 2011). This implies that households may face important trade-off between satisfying their consumption and maintaining their livestock assets. If households are satisfying their minimum consumption by depleting their livestock assets they may not be sustainably resilient. Thus, we use livestock asset ownership to capture households' risk bearing capacity. We build on two empirical and contextual patterns to define the minimum threshold for livestock asset. First, rural households in Ethiopia and many other African countries use two oxen for ploughing land. Similarly, to maintain herd size households need some minimum number of cows or heifers. Consistent with this and considering the case of rural households in Zambia, Hoddinott (2006) shows that households with one or two oxen(cows) were much less likely to sell than households with more than two of these animals. Following these contexts, Hoddinott (2006) argue that two oxen or two cows provide a minima ”threshold” for successful asset or consumption smoothing. In a slightly different context, Balboni et al. (2022) identifies a similar level and value of livestock asset ownership threshold, above which households accumulate assets and grow out of poverty.

Second, we empirically evaluate the relationship between livestock ownership and other measures of well-being to gauge the level of livestock that is positively associated with higher welfare. Figure 2 shows some nonlinear relationships between consumption and livestock assets (measured in Tropical Livestock Units, TLU): consumption is positively associated with livestock ownership but only after a minimum of two TLU. This confirms the contextual evidence that two oxen (or two cows) are needed to plough farm or maintain minimum herd size and hence household welfare. Thus, computing the probability that a household maintains this minimum level of productive input can inform about households' risk bearing capacity and hence resilience. We note that our sample comes from the highland regions in Ethiopia, where households rely on mixed farming practices.[6]

3 Constructing Resilience Measures

3.1 Univariate Resilience Measures

We adopt a probabilistic moment-based approach to compute households' resilience againsts alternative normative indicators and benchmarks, following Cissé and Barrett (2018). This approach employs the first two moments of households' welfare, i.e., the conditional mean and conditional variance, to characterize household resilience. This estimation involves three steps. First, we estimate the expected well-being (measured using consumption expenditure, household dietary diversity score and tropical livestock units) of households i in district d in year t (W_{idt}) as a function of lagged well-being

6. Livestock ownership in pastoral communities and lowlands of Ethiopia are larger than the highland regions. These regions rely heavily on livestock production as source of income and livelihood. Thus, as shown by Lybbert et al. (2004) or Cissé and Barrett (2018) the threshold for these communities is likely to be higher than two TLU.

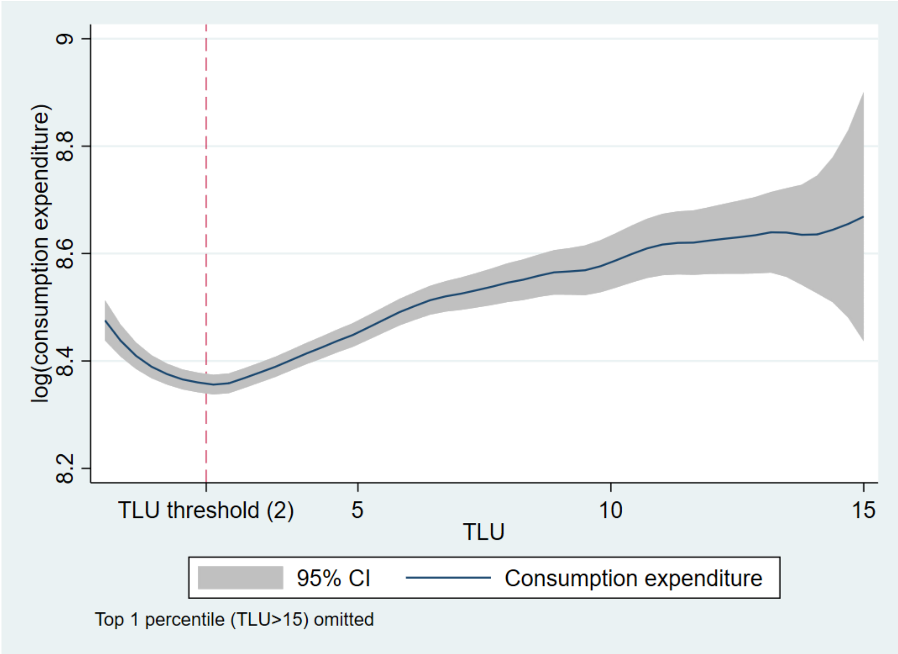

Figure 2: Distribution of Consumption Expenditure over TLU

(W_{dit-1}) as well as a vector of household and community characteristics (X_{it}). Besides quantifying households' resilience using alternative well-being indicators, we are also interested to assess how sensitive statistical inferences are to the way we define well-being and associated benchmarks. For this purpose, we include an indicator variable for PSNP participation and the continuous real value of PSNP transfers in our specifications as follows.

$$
\begin{aligned}
W_{idt} = \alpha_0 + \alpha_1 W_{idt-1} + \alpha_2 W^2_{idt-1} + \alpha_3 PSNP_{it} + \alpha_4 PSNPamt_{it} \\
+ \alpha_X X_{it} + \gamma_t + \mu_d + \mu_{idt}
\end{aligned}
\tag{1}
$$

We note that due to significant persistence in non-linear welfare dynamics including lagged welfare and its squared term is likely to capture significant heterogeneity in static welfare across households. $PSNP_{it}$ stands for an indicator variable assuming a value of 1 for those households receiving PSNP transfers and 0 otherwise. $PSNPamt_{it}$ stands for amount of PSNP transfer received, per household member. We include both binary participation indicator as well as levels of PSNP transfers to identify differential implication of program participation, depending on the levels of transfers received. Although earlier studies argue that PSNP participation was largely driven by observable criteria, including asset ownership, landholding, livestock ownership and income from farm and non-farm activities (Gilligan, Hoddinott, and Taffesse 2009; Hoddinott et al. 2012; Berhane et al. 2014), which we control in our empirical specifications along with lagged welfare outcomes and geographic fixed effects, we are not aiming to establish causal relationships.[7] γ_t and μ_d are year- and district- fixed effects. The predicted well-being measure $\hat{W}_{idt}$ of the equation (1) serves as the conditional mean of households' well-being.

In the second step, we model variation in the dispersion of welfare (the second moment). We assume a similar specification to that shown in equation (1) to characterize the variance of household well-being. Taking the residuals from the regression estimation of equation (1) and squaring them provides an estimate of the variance of household welfare ($\sigma^2_{idt} = E[\mu^2_{idt}]$), given that $E[\mu_{idt}] = 0$, which we characterize using the following empirical specification:

$$\begin{aligned}\sigma^2_{idt} = \hat{u}_{idt} = \beta_0 + \beta_1 W_{idt-1} + \beta_2 W^2_{idt-1} + \beta_3 PSNP_{it} + \beta_4 PSNPamt_{it} \\ + \beta_X X_{it} + \delta_t + \lambda_d + \epsilon_{idt}\end{aligned} \tag{2}$$

where we use the predicted value $\hat{\sigma}^2_{idt}$ as the conditional variance of household well-being.[8]

Finally, we estimate households' resilience (τ_{idt}) as the conditional probability that a households' well-being in each period lies above a normative threshold $\underline{W}$ as shown in equation (3) below.

$$\begin{aligned}\tau_{idt} &= Pr(W_{it} \geq \underline{W} | X_{it}, W_{it-1}, PSNP_{it}) \\ &= 1 - F_{W_{it}}(\underline{W}; \hat{W}_{idt}, \hat{\sigma}^2_{idt})\end{aligned} \tag{3}$$

where $F_{W_{it}}(\cdot)$ is household-time-specific conditional cumulative density function (CDF) of well-being. Assuming the well-being outcomes follow normal distribution based on the Figure (1), we estimate $F_{W_{it}}(\underline{W}|\cdot) = \Phi(Z_{idt}|\cdot)$ where $\Phi(\cdot)$ is the CDF of the standard normal distribution and $Z_{idt} = \frac{\underline{W} - \hat{W}_{idt}}{\sqrt{\hat{\sigma}^2_{idt}}}$ is the normalized Z-score. As described in Section 2.2, we use alternative thresholds: for consumption expenditure we use the national poverty line; for Household Dietary Diversity Score (HDDS) we use 5 food groups (FAO and FHI360 2016; FAO 2021). For the well-being indicator using livestock assets, we used 2 TLU as a minimum threshold following some contextual and empirical evidence (Hoddinott 2006; Balboni et al. 2022).

To test the robustness of our assumption that the outcomes are normally distributed, we replicate

7. Even after controlling these observable characteristics, there may be some additional sources of endogeneity that may affect extensive and intensive margins of PSNP participation. For example, despite some limits in the number of days households can participate in public work, households may endogenously decide the amount of labor supply to these public works.

8. Table A2 in the Appendix reports the regression outcomes from the equation (1) and (2) from the three welfare outcomes: log of consumption expenditure, HDDS and TLU (IHS)

the steps above under different distributional assumption and compare its model fit with the normal distribution. A natural candidate is Gamma distribution where outcome is non-negatively distributed. To generate univariate measures under this assumption, we estimate the equation (1) using the Generalized Linear Model (GLM) assuming the outcome W follows the normal distribution. Equation (2) is estimated through OLS since there's no reason to assume that the residuals follow Gamma distribution. Lastly, we calibrate the Gamma distribution parameters using the method of moments such that $\left(\alpha = \frac{\hat{W}_{idt}^2}{\hat{\sigma}_{idt}^2}, \beta = \frac{\hat{\sigma}_{idt}^2}{\hat{W}_{idt}}\right)$, and construct the CDF $F_{W_{it}}(\cdot)$ with these parameters.

3.2 Multivariate Resilience Measures

In addition to the above three univariate resilience measures, we further construct multivariate resilience measures where households' resilience considers two or more normative indicators and benchmarks. Analogous to multidimensional poverty measurement, computing and aggregating different dimensions of resilience requires choice over how to aggregate the univariate measures of resilience. We present three different approaches. We follow Alkire and Foster (2011) in offering a family of different multivariate measures.

First, we construct weighted average resilience measures of each possible combination of the M univariate measures used. In our case, one can use $M = 2$ for any pair of consumption expenditures, HDDS, and TLU, or $M = 3$ for all three together. One could use weights specific to each univariate measure, w_m, if one dimension seemed more important than others:

$$\tau_{ave,idt} = [\sum_{m=1}^{M} w_m {\tau_{idt}}^m]/M \tag{4}$$

In the absence of a clear basis for differential weighting, we use equal weights, so that $w_m = w, \forall m$. This equally weighted average measure is intuitive, treating a probability point change in each measure as equally important.

Second, we construct *adjusted headcount ratio* of resilience following the multidimensional poverty literature (e.g., Alkire and Foster, 2011) as follows:

$$M_0(y,k) = H(y,k) \times A(y,k) \tag{5}$$

$y = (y_1, ..., y_d)$ is a vector of d univariate resilience measures and k is the number of univariate resilience measures below certain cut-off which determines households as “non-resilient. This study use 0.5 as a cut-off for each univariate resilience measure and applied equal weights to them, but it is researchers’ choice to choose the cut-off point depending on the context and the question. For instance, $k = 1$ implies that a household is defined as non-resilient if *any* of the univariate resilience in y is below cut-off, and $k = d$ implies that a household is defined as non-resilient only if *all* of the univariate resilience measures are below cut-off. $H(y, k)$ is the share of non-resilient households (or *unadjusted* headcount ratio), and $A(y, k)$ is the average number of univariate resilience measures below cut-off among non-resilient households (or intensity of non-resilience).

Third, we construct bivariate and trivariate resilience measures using the concepts of union and intersection. We start with two well-being indicators (consumption expenditure & diet, expenditure & livestock, and diet & livestock), assuming they follow bivariate normal distribution with some correlation coefficient ρ. We use the Pearson’s correlation coefficient $\hat{\rho}$ between two welfare outcomes in the data as our estimate of ρ. For each pair of the outcomes, we construct two different types of bivariate resilience measures as the equation (6) and (7) below.

$$\begin{aligned} \tau_{uni,it} &= Pr(W_{1it} \geq \underline{W_1} \text{ or } W_{2it} \geq \underline{W_2}|\cdot) \\ &= 1 - F_{W_{1it},W_{2it}}(\underline{W_1}, \underline{W_2}; \hat{W}_{1idt}, \hat{\sigma}^2_{1idt}, \hat{W}_{2idt}, \hat{\sigma}^2_{2idt}, \hat{\rho}_{12}) \end{aligned} \tag{6}$$

$$\begin{aligned} \tau_{int,it} &= Pr(W_{1it} \geq \underline{W_1}, W_{2it} \geq \underline{W_2}|\cdot) \\ &= 1 - F_{W_{1it}}(\underline{W_1}; \hat{W}_{1idt}, \hat{\sigma}^2_{1idt}) - F_{W_{2it}}(\underline{W_2}; \hat{W}_{2idt}, \hat{\sigma}^2_{2idt}) \\ &+ F_{W_{1it},W_{2it}}(\underline{W_1}, \underline{W_2}; \hat{W}_{1idt}, \hat{\sigma}^2_{1idt}, \hat{W}_{2idt}, \hat{\sigma}^2_{2idt}, \hat{\rho}_{12}) \end{aligned} \tag{7}$$

$\tau_{uni,idt}$ in the equation (6) assesses the conditional probability that either welfare outcome is above the normative threshold, while $\tau_{int,idt}$ in the equation (7) assesses the conditional probability that both welfare outcomes are above their thresholds. Similarly, we estimate the trivariate resilience measures as the equation (8) and (9) below.

$$\tau_{uni,it} = Pr(W_{1it} \geq \underline{W_1} \text{ or } W_{2it} \geq \underline{W_2} \text{ or } W_{3it} \geq \underline{W_3}|\cdot)$$
$$= 1 - F_{W_{1it},W_{2it},W_{3it}}(\underline{W_1}, \underline{W_2}, \underline{W_3}; \hat{W}_{1idt}, \hat{\sigma}^2_{1idt}, \hat{W}_{2idt}, \hat{\sigma}^2_{2idt}, \hat{W}_{3idt}, \hat{\sigma}^2_{3idt}, \hat{\rho}_{12}, \hat{\rho}_{13}, \hat{\rho}_{23}) \quad (8)$$

$$\begin{aligned}\tau_{int,it} &= Pr(W_{1it} \geq \underline{W_1}, W_{2it} \geq \underline{W_2}, W_{3it} \geq \underline{W_3}|\cdot) \\ &= 1 - F_{W_{1it}}(\underline{W_1}; \hat{W}_{1idt}, \hat{\sigma}^2_{1idt}) - F_{W_{2it}}(\underline{W_2}; \hat{W}_{2idt}, \hat{\sigma}^2_{2idt}) - F_{W_{3it}}(\underline{W_3}; \hat{W}_{3idt}, \hat{\sigma}^2_{3idt}) \\ &+ F_{W_{1it},W_{2it}}(\underline{W_1}, \underline{W_2}; \cdot) + F_{W_{1it},W_{3it}}(\underline{W_1}, \underline{W_3}; \cdot) + F_{W_{2it},W_{3it}}(\underline{W_2}, \underline{W_3}; \cdot) \\ &- F_{W_{1it},W_{2it},W_{3it}}(\underline{W_1}, \underline{W_2}, \underline{W_3}; \hat{W}_{1idt}, \hat{\sigma}^2_{1idt}, \hat{W}_{2idt}, \hat{\sigma}^2_{2idt}, \hat{W}_{3idt}, \hat{\sigma}^2_{3idt}, \hat{\rho}_{12}, \hat{\rho}_{13}, \hat{\rho}_{23})\end{aligned} \quad (9)$$

One can understand the multidimensional measure as offering the analyst different options for weighting among well-being measures that are imperfectly correlated. The union and intersection measures are necessarily limiting constructs. Adopting the intersection measures imposes the strict normative standard that a household is only considered resilient if it meets the resilience criterion in each dimension. By contrast, the union measure is a relatively permissive measure, wherein a household is declared resilient if it appears resilient in just a single dimension. Under these logical frameworks,no tradeoffs are permitted across indicators, so that considerably higher dietary resilience, for example, cannot compensate for modestly lower asset resilience. Indeed, as the number of imperfectly correlated measures grows, the intersection measure weakly falls while the union measure weakly increases. The rate of change in each of those varies inversely with the correlation among the measures. As a result, the union and intersection measures somewhat mechanically generate skewed distributions when one combines multiple weakly correlated measures. The intersection and union measures are informative. But we favor the average measure,$\tau_{ave,idt}$, as the best summary measure because it does not vary mechanically based on the multivariate correlation structure and the number of measures one includes and it can in principle allow the analyst to weight different indicators to permit tradeoffs in different dimensions.

We are also interested in examining the implication of PNSP participation as well as associated levels of transfers on households' resilience. This can help us identify potential non-linearities and differential implications of the levels of transfers. For example, small transfers may not significantly contribute to improving household's resilience. Compared to non-beneficiaries, PSNP participants are likely poorer and less resilient without the transfer. But additional investments in social safety nets and hence PSNP transfers can improve beneficiaries' resilience. Including both the PSNP participation indicator as well as levels of transfers allow us to identify the transfer levels needed to make the welfare and resilience of PSNP beneficiaries comparable or above non-beneficiaries. We study these associations by regressing outcomes and resilience measures on the set of independent variables same as the equation (1).

4 Estimation Results

4.1 Univariate Resilience Estimates

Figure 3 shows the distribution of three univariate resilience measures. The first is constructed using consumption expenditure and hence national poverty line as a minimum normative threshold. Thus, we can interpret this measure as "resilience in expenditure", or "expenditure resilience". The second measure builds on dietary quality and hence we label it as "dietary resilience" (Zaharia et al. 2021). The third measure captures households' capacity to maintain minimum productive assets and hence we interpret it as "resilience in livestock holding", or "livestock resilience". The distribution of univariate resilience measures show some notable differences in their overall distribution as well as their distribution across PSNP and non-PSNP beneficiaries. Expenditure resilience and dietary resilience show comparable distribution, while households' exhibit relatively higher livestock resilience. The difference between PSNP and non-PSNP households is also more visible when comparing livestock resilience.

Figure 4 shows the distributions of welfare outcomes and their predicted values under two different distributional assumptions (normal, Gamma). Outcomes are similarly predicted under the two distributional assumptions, but Gamma distribution tends to generate extremely large predicted outcomes, which is why we use normal distribution in this study. Also, the average sizes of the residuals are nearly identical in expenditure and HDDS (up to one decimal point), and significantly smaller in TLU (IHS) (0.2 vs 37.1).

Table 3 shows the temporal dynamics and distribution of the three univariate resilience measures. As expected, households' expenditure resilience have significantly improved across time and both for

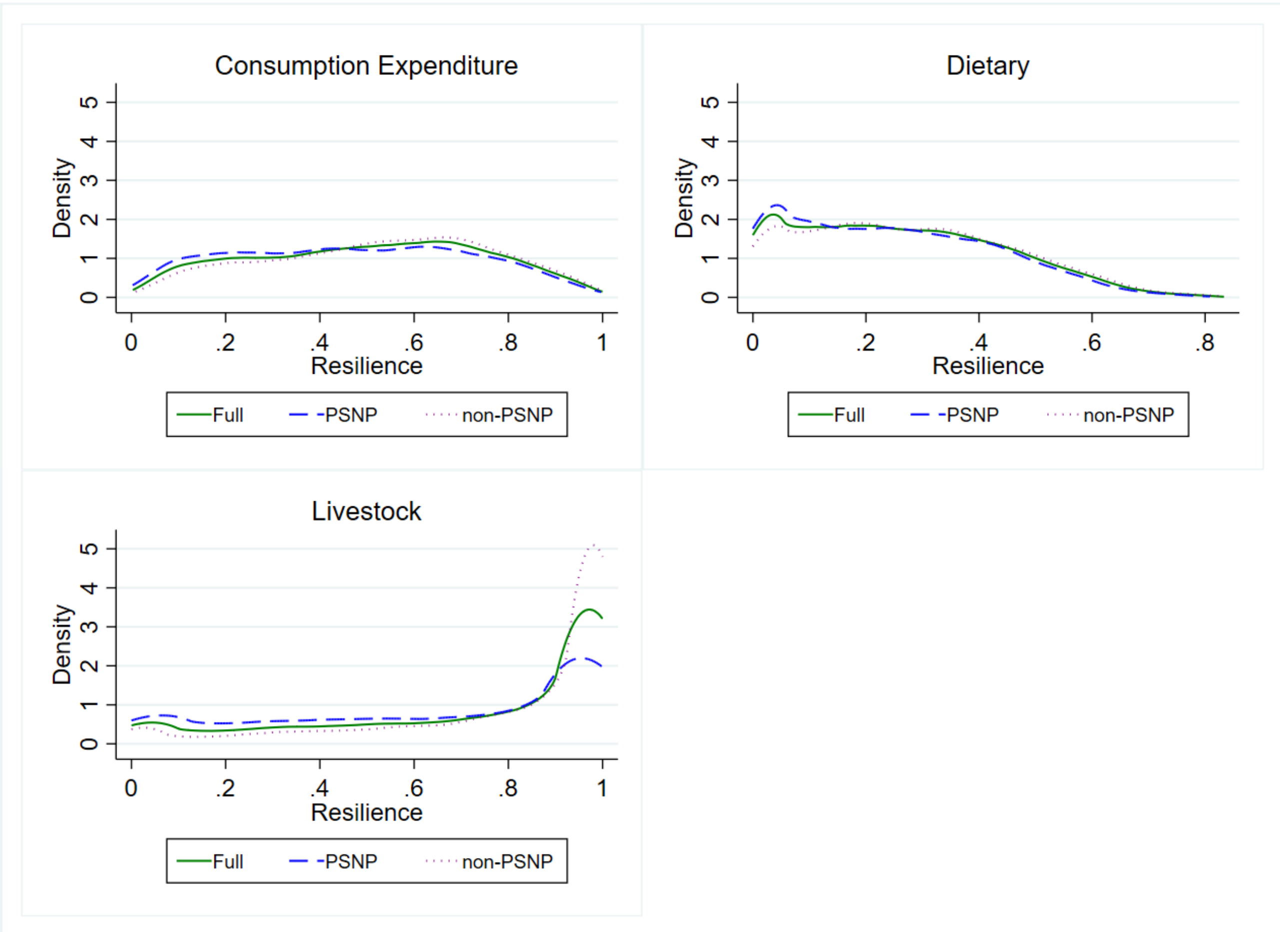

Figure 3: Distribution of Univariate Resilience

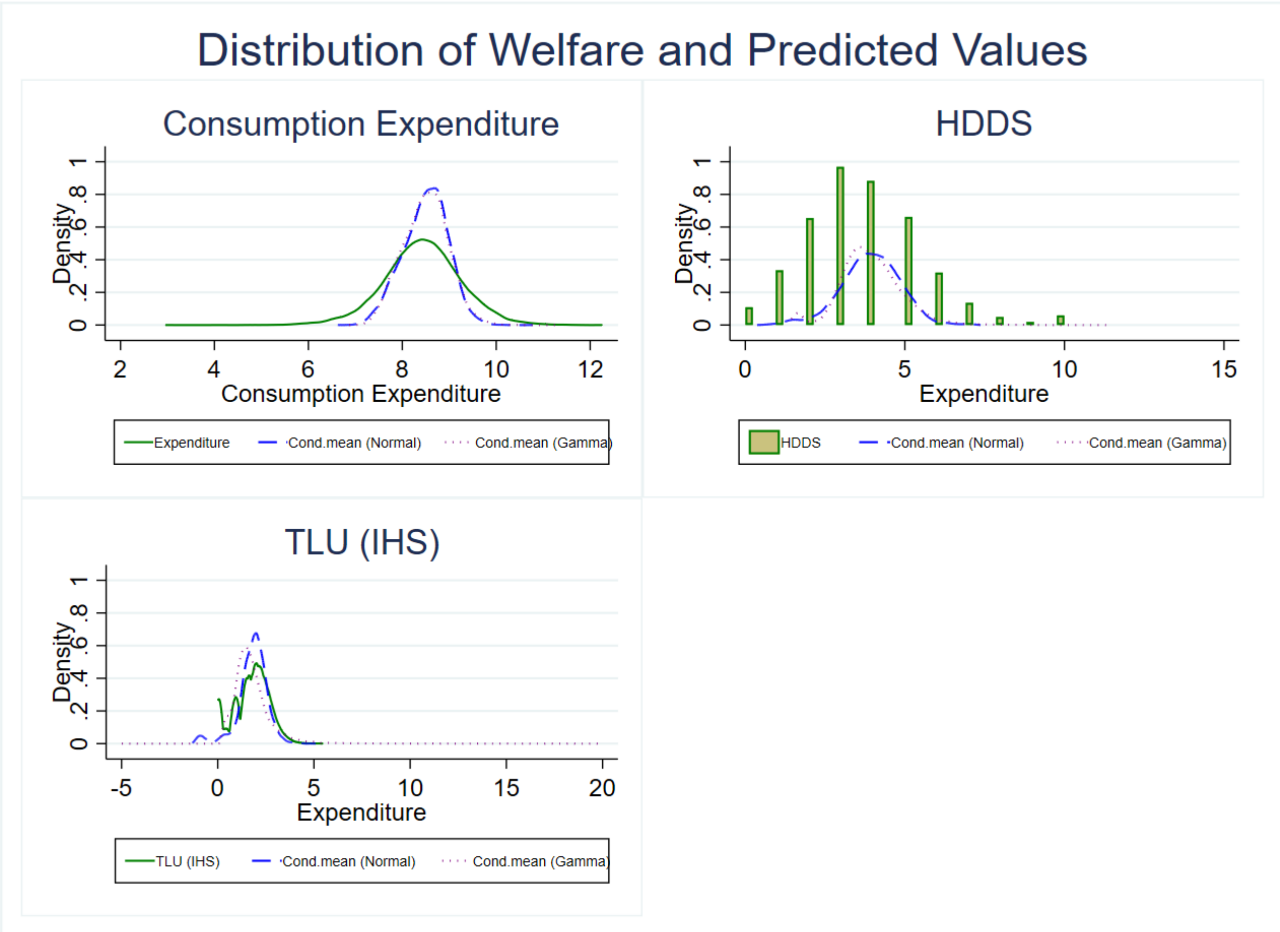

Figure 4: Distribution of Welfare Outcomes and Predicted Values under Normal and Gamma Assumption

PSNP beneficiaries and non-beneficiaries. This is consistent with Ethiopia's poverty reduction records during this period. Similarly, households' dietary resilience show modest improvements across time. However, households' resilience and hence capacity to maintain a minimum level of livestock asset remained stagnant across rounds. This suggests that the significant poverty reduction recorded in Ethiopia may not have translated to asset accumulation. These patterns and trends are slightly different across PSNP and non-PSNP households, with the former exhibiting significantly lower resilience despite some improvements across rounds. However, these differences clearly justify the rationale for estimating alternative dimensions of households' resilience.

Table 3: Resilience dynamics by PSNP status and year

	Consumption Expenditure Resilience			Dietary Resilience			Livestock Resilience		
	(1) Full sample	(2) non-PSNP	(3) PSNP	(4) Full sample	(5) non-PSNP	(6) PSNP	(7) Full sample	(8) non-PSNP	(9) PSNP
2008	0.24	0.27	0.22	0.19	0.19	0.19	0.74	0.79	0.68
2010	0.52	0.54	0.49	0.24	0.24	0.23	0.74	0.81	0.66
2012	0.60	0.60	0.59	0.32	0.33	0.30	0.72	0.80	0.61
2014	0.66	0.67	0.66	0.31	0.32	0.28	0.73	0.80	0.59
Total	0.50	0.53	0.47	0.26	0.28	0.25	0.73	0.80	0.64

Table 4 shows the unadjusted (a) and adjusted (b) headcount ratios. Column (1) in panel (a) shows that more than 92% of households are non-resilient with $k = 1$ (at least one resilience measure is below 0.5), and 13% of households are non-resilient across all three resilience measures. Column (1) in panel (b) shows that non-resilient households with $k = 1$ is non-resilient with 1.6 measures on average. The gap between non-PSNP and PSNP greater with larger value of k.

Table 5 characterizes the distribution of the three univariate resilience measures as a function of household and community characteristics and program participation.[9] The distribution of these resilience measures across the observable characteristics exhibit some notable differences. For example, the consumption-based resilience is positive associated with PSNP transfers while this reverses for two other measures, partly because of selection-bias in PSNP participation. Furthermore, the amount of PSNP transfers are generally too small to affect the household livestock ownership. Livestock index positively associated with rainfall indicators reflect the positive impacts of rainfall on livestock (Barrett and Santos 2014; Emediegwu and Ubabukoh 2023). Overall, the results in Table 5 demonstrates that statistical inferences on the impact and implication of alternative development programs and interventions can be sensitive to how we measure resilience.

9. Table A3 has the full regression result.

Table 4: Headcount Ratio by PSNP status and year

	$k=1$			$k=2$			$k=3$		
	(1) Full sample	(2) non-PSNP	(3) PSNP	(4) Full sample	(5) non-PSNP	(6) PSNP	(7) Full sample	(8) non-PSNP	(9) PSNP
2008	0.99	0.99	1.00	0.89	0.87	0.93	0.21	0.15	0.28
2010	0.94	0.93	0.95	0.55	0.48	0.63	0.13	0.07	0.19
2012	0.89	0.87	0.91	0.43	0.35	0.54	0.10	0.07	0.14
2014	0.85	0.84	0.88	0.32	0.25	0.46	0.06	0.04	0.09
Total	0.92	0.90	0.94	0.55	0.47	0.66	0.13	0.08	0.19

(a) Unadjusted

	$k=1$			$k=2$			$k=3$		
	(1) Full sample	(2) non-PSNP	(3) PSNP	(4) Full sample	(5) non-PSNP	(6) PSNP	(7) Full sample	(8) non-PSNP	(9) PSNP
2008	2.10	2.00	2.21	2.00	1.88	2.14	0.64	0.44	0.85
2010	1.61	1.48	1.77	1.22	1.02	1.45	0.38	0.21	0.57
2012	1.42	1.29	1.59	0.96	0.77	1.22	0.30	0.21	0.42
2014	1.23	1.13	1.43	0.70	0.54	1.00	0.17	0.12	0.27
Total	1.60	1.46	1.78	1.23	1.03	1.50	0.38	0.24	0.56

(b) Adjusted

Table 5: Regression of univariate resilience measure on household characteristics

	(1) Consumption Expenditure b/se	(2) Dietary b/se	(3) Livestock b/se
PSNP beneficiaries	-0.200***	0.081***	0.006
	(0.01)	(0.01)	(0.01)
HABP beneficiaries	0.002	0.056***	0.023***
	(0.00)	(0.00)	(0.00)
PSNP beneficiaries × HABP beneficiaries	0.006**	-0.021***	-0.006
	(0.00)	(0.00)	(0.01)
IHS (PSNP transfer per capita)	0.028***	-0.018***	-0.009***
	(0.00)	(0.00)	(0.00)
ln(Average annual rainfall (mm))	-0.780	35.172***	7.106
	(1.15)	(2.20)	(7.79)
Deviation in 30-year average annual rainfall (m)	-0.006	-0.046***	0.042**
	(0.01)	(0.01)	(0.02)
Constant	6.185	-215.547***	-45.888
	(7.14)	(13.64)	(48.19)
N	10444	10458	10093
R^2	0.967	0.946	0.850
Controls and Lagged outcome	Y	Y	Y
District and Year FE	Y	Y	Y

Standard error clustered at village level.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.2 Multivariate Resilience Estimates

We start by characterizing potential correlations between univariate resilience measures. Table 6 is the Spearman's rank correlation matrix among univariate and multivariate resilience measures. Although these measures are statistically correlated (all significant at 95%), the strength of the bivariate correlations appear to be weak. For example, the correlation between our livestock-based resilience indicator and expenditure-based indicator is only 0.11. This is not surprising given that rural households face significant trade-offs between maintaining consumption levels above the poverty line and livestock asset accumulation, mainly because livestock sales are major sources of insurance against consumption shortfalls (Dercon and Christiaensen 2011). These weak correlations suggest each metric captures a specific dimension of household resilience, and hence relying on these partial measures of household resilience would generate an incomplete picture of households' capacity and overall resilience.

Figure 5 shows the distribution of multivariate resilience measures (average, union and intersection) of 4 different combinations. Again, these patterns exhibit distinct distributions depending on how you define the multidimensional resilience. As expected, while those measures based on the union and intersection show two extremes, average resilience estimates provide a middle ground. Depending on the specific purposes of empirical analyses, these metrics can capture additional dimensions of household resilience that are not captured in the univariate measures.

Table 7 reports the regression of bivariate and trivariate resilience measures on program participation and rainfall status.[10] Again, these empirical regressions show two key insights and patterns. First, the way we aggregate the different dimensions of resilience: average, union and intersection, matters for the distribution of these aggregate outcomes across observable characteristics of households. Second, comparing the implication of program participation on univariate and multivariate suggests that influencing specific dimensions of household resilience may be easier than improving overall resilience. For example, PSNP transfers are associated significantly associated with expenditure-based resilience (Table 5) but the strength of this association weakens when consider dietary diversity and livestock-based resilience outcomes (Table 7). For example, such relationship disappears when using average resilience across the three univariate measures. To sum up, the patterns we observe in Table 7 along with those in Table 5 reinforce that statistical inferences associated with the impact

10. Table A4 and A4 have the full regression results.

Table 6: Rank correlation among resilience measures

	Consumption Expenditure	Dietary
Dietary	0.36	1.00
Livestock	0.11	0.19

(a) Correlation across dimensions - univariate

	CE & Dietary	CE & Livestock	Dietary & Livestock
(a) Average			
CE & Livestock	0.65	1.00	0.78
Dietary & Livestock	0.51	0.78	1.00
CE & Dietary & Livestock	0.79	0.94	0.87
(b) Union			
CE & Livestock	0.35	1.00	0.96
Dietary & Livestock	0.20	0.96	1.00
CE & Dietary & Livestock	0.37	1.00	0.97
(c) Intersection			
CE & Livestock	0.58	1.00	0.62
Dietary & Livestock	0.78	0.62	1.00
CE & Dietary & Livestock	0.88	0.80	0.93

Note: CE stands for consumption expenditure

(b) Correlation across dimensions - multivariate

	CE & Dietary		CE & Livestock	
	Average	Union	Average	Union
Union	0.97	1.00	0.82	1.00
Intersection	0.93	0.82	0.97	0.70
	Dietary & Livestock		CE & Dietary & Livestock	
	Average	Union	Average	Union
Union	0.86	1.00	0.79	1.00
Intersection	0.90	0.60	0.92	0.61

(c) Correlation within dimension - multivariate

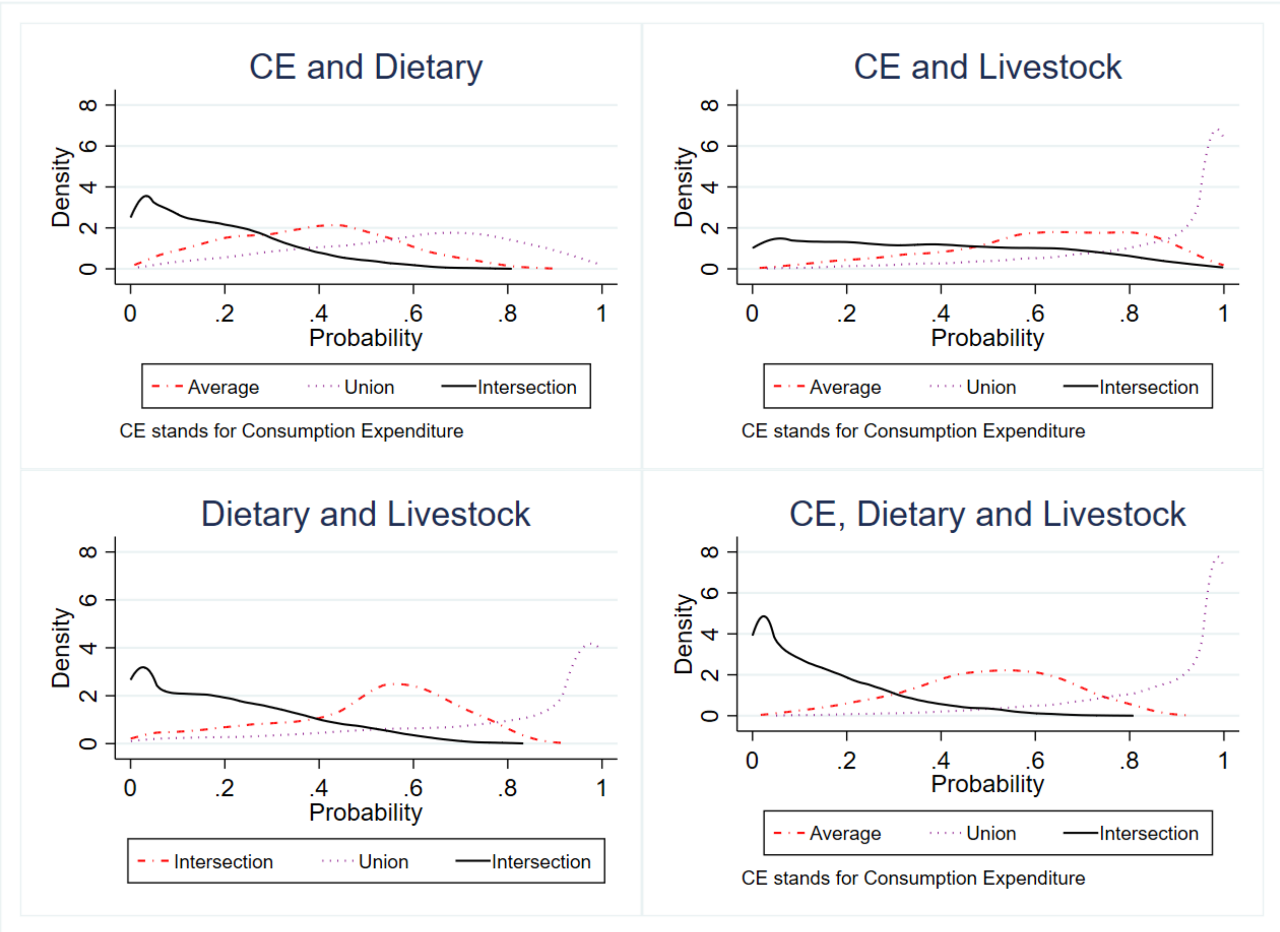

Figure 5: Distribution of Multivariate Resilience

and implication of social protection on development resilience are sensitive to the way one construct resilience.

Table 7: Regression of multivariate resilience on household characteristics

	CE and Dietary			CE and Livestock		
	(1)	(2)	(3)	(4)	(5)	(6)
	Avg	Uni	Int	Avg	Uni	Int
	b/se	b/se	b/se	b/se	b/se	b/se
PSNP beneficiaries	-0.060***	-0.132***	0.013	-0.097***	-0.094***	-0.100***
	(0.007)	(0.011)	(0.014)	(0.008)	(0.015)	(0.014)
HABP beneficiaries	0.029***	0.022***	0.037***	0.013***	0.008**	0.017***
	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)	(0.004)
PSNP beneficiaries × HABP beneficiaries	-0.008***	0.000	-0.015***	0.000	0.007	-0.006
	(0.002)	(0.003)	(0.003)	(0.003)	(0.005)	(0.006)
IHS (PSNP transfer per capita)	0.005***	0.017***	-0.006***	0.010***	0.010***	0.009***
	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)
ln(Average annual rainfall (mm))	17.155***	13.765***	20.545***	3.000	7.523	-1.524
	(1.529)	(1.044)	(2.609)	(3.548)	(6.270)	(1.364)
Deviation in 30-year average annual rainfall (m)	-0.026**	-0.010	-0.043**	0.018*	0.047***	-0.010
	(0.011)	(0.014)	(0.020)	(0.011)	(0.016)	(0.016)
N	10444	10444	10444	10085	10085	10085
r2	0.965	0.952	0.886	0.902	0.749	0.848
Controls	Y	Y	Y	Y	Y	Y
District and Year FE	Y	Y	Y	Y	Y	Y

CE stands for consumption expenditure. Standard error clustered at village level.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Panel A: CE & Dietary Resilience, and CE & Livestock Resilience

	Dietary and Livestock			CE, Dietary and Livestock		
	(1)	(2)	(3)	(4)	(5)	(6)
	Avg	Uni	Int	Avg	Uni	Int
	b/se	b/se	b/se	b/se	b/se	b/se
PSNP beneficiaries	0.044***	0.010	0.078***	-0.038***	-0.075***	0.028**
	(0.008)	(0.012)	(0.010)	(0.006)	(0.013)	(0.011)
HABP beneficiaries	0.039***	0.027***	0.052***	0.027***	0.011***	0.036***
	(0.002)	(0.004)	(0.003)	(0.002)	(0.003)	(0.003)
PSNP beneficiaries × HABP beneficiaries	-0.014***	0.002	-0.029***	-0.007***	0.008*	-0.022***
	(0.003)	(0.005)	(0.004)	(0.002)	(0.004)	(0.004)
IHS (PSNP transfer per capita)	-0.014***	-0.010***	-0.017***	0.000	0.007***	-0.008***
	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)
ln(Average annual rainfall (mm))	21.425***	11.031*	31.820***	13.894***	8.167	17.529***
	(4.309)	(6.427)	(3.709)	(2.728)	(5.328)	(3.036)
Deviation in 30-year average annual rainfall (m)	-0.001	0.014	-0.017	-0.003	0.031**	-0.030*
	(0.010)	(0.015)	(0.014)	(0.009)	(0.014)	(0.017)
N	10093	10093	10093	10085	10085	10085
r2	0.888	0.819	0.837	0.924	0.735	0.805
Controls	Y	Y	Y	Y	Y	Y
District and Year FE	Y	Y	Y	Y	Y	Y

CE stands for consumption expenditure. Standard error clustered at village level.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Panel B: Dietary & Livestock Resilience, and CE, Dietary & Livestock Resilience

5 Conclusion and Future Extension

The last decade has seen major progress in the conceptualization, measurement and operationalization of resilience in international development programming. To date, however, resilience measures have considered just a single dimension of well-being, although the concept encompasses several dimensions of well-being. As a result, for example, resilience indicators that rely on income-based indicators and poverty thresholds may ignore households' dietary resilience and the resilience of their productive livestock holdings that form the basis for future, sustained capacity to generate a non-poor income and access a healthy diet (Hoddinott 2006). Much as unidimensional poverty measures may provide overly reductionist indicators of current well-being, thereby motivating the use of multidimensional poverty measures (Alkire and Foster 2011; Alkire and Santos 2014), so too might multidimensional resilience measures prove useful to analysts trying to target or evaluate interventions intended to build resilience among populations facing a range of imperfectly correlated deprivations.

Using five rounds of household panel data from Ethiopia, we first evaluate the implication using alternative indicators of well-being for measuring household resilience using the probabilistic moment-based approach developed by Cissé and Barrett (2018). We then extend the existing univariate resilience measurement approach to capture multidimensional well-being indicators. We compute alternative aggregate resilience measures considering multiple dimensions and normative benchmarks (e.g., consumption expenditures-based poverty line, minimum dietary diversity, minimum livestock asset holding).We also explore the implication of multidimensional resilience measurement for inferences about the impacts of transfers from Ethiopia's main social protection programs, the Productive Safety Net Program (PSNP) and the Household Asset Building Program (HABP). Perhaps not surprisingly, an analyst's choice of resilience measurement method influences statistical inference on the efficacy of social protection programs in building household resilience.

Our analyses highlight four important findings. First, we find that univariate resilience indicators constructed using alternative normative well-being indicators (consumption expenditures, dietary diversity score, and livestock asset holdings) are only weakly correlated. This implies that households that can be classified as "most resilient" using one indicator and its associated normative threshold may not be classified as resilient by another metric. Where Upton, Constenla-Villoslada, and Barrett 2022 showed that such variation occurs using different resilience measurement algorithms, we show that even using a single algorithm one gets such variation just by varying the underlying well-being indicator.

Second, the univariate and multidimensional resilience measures we construct exhibit significantly different distributions and orderings among households based on their estimated resilience. The variation inherent to one's choice of indicators can thereby influence targeting based on ex ante resilience estimates.

Third, social protection programs such the PSNP and HABP that expressly aim to build resilience are positively associated with some dimensions of household resilience but not in other dimensions of resilience. Thus the indicators used for resilience estimation appear to matter to impact evaluation, not only to targeting. For example, while PSNP and associated transfers are positively associated with consumption-based welfare and resilience indicators, they are not statistically significantly correlated with resilience measures that consider multiple dimensions of welfare such as dietary quality and livestock assets.

There are some important limitations to our analysis. Most notably,we assume that the alternative welfare indicators are normally distributed (after appropriate transformations), which may not always be true. A natural extension of our approach will allow greater flexibility for heterogeneous distributions among included indicators. We also lack exogenous variation in households' participation in the social protection programs we study, so can only provided correlational evidence, not rigorous multidimensional resilience impact analysis.

References

Abay, Kibrom A., Mehari H. Abay, Guush Berhane, and Jordan Chamberlin. 2022. "Social protection and resilience: The case of the productive safety net program in Ethiopia." *Food Policy* 112 (1, 2022): 102367.

Alkire, Sabina, and James Foster. 2011. "Counting and multidimensional poverty measurement." *Journal of Public Economics* 95 (7): 476–487.

Alkire, Sabina, and Maria Emma Santos. 2014. "Measuring Acute Poverty in the Developing World: Robustness and Scope of the Multidimensional Poverty Index." *World Development* 59 (1, 2014): 251–274.

Balboni, Clare, Oriana Bandiera, Robin Burgess, Maitreesh Ghatak, and Anton Heil. 2022. "Why Do People Stay Poor?" *The Quarterly Journal of Economics* 137, no. 2 (1, 2022): 785–844.

Barrett, Christopher B., Kate Ghezzi-Kopel, John Hoddinott, Nima Homami, Elizabeth Tennant, Joanna Upton, and Tong Wu. 2021. "A scoping review of the development resilience literature: Theory, methods and evidence." *World Development* 146:105612.

Barrett, Christopher B., and Paulo Santos. 2014. "The impact of changing rainfall variability on resource-dependent wealth dynamics." *Ecological Economics* 105 (1, 2014): 48–54.

Berhane, Guush, and Cornelis Gardebroek. 2011. "Does Microfinance Reduce Rural Poverty? Evidence Based on Household Panel Data from Northern Ethiopia." *American Journal of Agricultural Economics* 93 (1): 43–55.

Berhane, Guush, Daniel O. Gilligan, John Hoddinott, Neha Kumar, and Alemayehu Seyoum Taffesse. 2014. "Can Social Protection Work in Africa? The Impact of Ethiopia's Productive Safety Net Programme." *Economic Development and Cultural Change* 63 (1): 1–26.

Cissé, Jennifer Denno, and Christopher B. Barrett. 2018. "Estimating development resilience: A conditional moments-based approach." *Journal of Development Economics* 135:272–284.

Coll-Black, Sarah, Daniel O. Gilligan, John Hoddinott, Neha Kumar, Alemayehu Seyoum Taffesse, and William Wiseman. 2011. *Targeting food security interventions when "everyone is poor": The case of Ethiopia's Productive Safety Net Programme.* 24. International Food Policy Research Institute.

Dercon, Stefan, and Luc Christiaensen. 2011. "Consumption risk, technology adoption and poverty traps: Evidence from Ethiopia." *Journal of Development Economics* 96 (2): 159–173.

Emediegwu, Lotanna E., and Chisom L. Ubabukoh. 2023. "Re-examining the impact of annual weather fluctuations on global livestock production." *Ecological Economics* 204 (1, 2023): 107662.

FAO. 2021. *Minimum Dietary Diversity for Women: An updated guide for measurement: from collection to action.*

FAO and FHI360. 2016. *Minimum Dietary Diversity for Women: A Guide to Measurement.*

Foster, James, Joel Greer, and Erik Thorbecke. 1984. "A Class of Decomposable Poverty Measures." *Econometrica* 52 (3): 761–766.

Gilligan, Daniel O., John Hoddinott, and Alemayehu Seyoum Taffesse. 2009. "The Impact of Ethiopia's Productive Safety Net Programme and its Linkages." *The Journal of Development Studies* 45 (10): 1684–1706.

Hoddinott, John. 2006. "Shocks and their consequences across and within households in Rural Zimbabwe." *The Journal of Development Studies* 42 (2): 301–321.

Hoddinott, John, Guush Berhane, Daniel O. Gilligan, Neha Kumar, and Alemayehu Seyoum Taffesse. 2012. "The Impact of Ethiopia's Productive Safety Net Programme and Related Transfers on Agricultural Productivity." *Journal of African Economies* 21 (5): 761–786.

Knippenberg, Erwin, Nathaniel Jensen, and Mark Constas. 2019. "Quantifying household resilience with high frequency data: Temporal dynamics and methodological options." *World Development* 121:1–15.

Lybbert, Travis J., Christopher B. Barrett, Solomon Desta, and D. Layne Coppock. 2004. "Stochastic Wealth Dynamics and Risk Management among a Poor Population." *The Economic Journal* 114 (498): 750–777.

Mahrt, Kristi, Anna W. Herforth, Sherman Robinson, Channing Arndt, and Headey D Derek. 2022. *Nutrition as a basic need: A new method for utility-consistent and nutritionally adequate food poverty lines.* Google-Books-ID: dH5vEAAAQBAJ. International Food Policy Research Institute.

Phadera, Lokendra, Hope Michelson, Alex Winter-Nelson, and Peter Goldsmith. 2019. "Do asset transfers build household resilience?" *Journal of Development Economics* 138:205–227.

Premand, Patrick, and Quentin Stoeffler. 2022. "Cash transfers, climatic shocks and resilience in the Sahel." *Journal of Environmental Economics and Management* 116:102744.

Sabates-Wheeler, Rachel, Jeremy Lind, John Hoddinott, and Mulugeta Tefera Taye. 2021. "Graduation after 10 years of Ethiopia's Productive Safety Net Programme: Surviving but still not thriving." *Development Policy Review* 39 (4): 511–531.

Scognamillo, Antonio, Chun Song, and Adriana Ignaciuk. 2023. "No man is an Island: A spatially explicit approach to measure development resilience." *World Development* 171:106358.

The World Bank. 2015. *Ethiopia Poverty Assessment 2014.*

Upton, Joanna, Susana Constenla-Villoslada, and Christopher B. Barrett. 2022. "Caveat utilitor: A comparative assessment of resilience measurement approaches." *Journal of Development Economics* 157:102873.

Upton, Joanna B., Jennifer Denno Cissé, and Christopher B. Barrett. 2016. "Food security as resilience: reconciling definition and measurement." *Agricultural Economics* 47 (S1): 135–147.

Vaitla, Bapu, Jennifer Denno Cissé, Joanna Upton, Girmay Tesfay, Nigussie Abadi, and Daniel Maxwell. 2020. "How the choice of food security indicators affects the assessment of resilience—an example from northern Ethiopia." *Food Security* 12 (1): 137–150.

Yao, Becatien, Aleksan Shanoyan, Ben Schwab, and Vincent Amanor-Boadu. 2023. "The role of mobile money in household resilience: Evidence from Kenya." *World Development* 165:106198.

Zaharia, Sonia, William A. Masters, Shibani Ghosh, Gerald E. Shively, Sabi Gurung, Swetha Manohar, Andrew L. Thorne-Lyman, et al. 2021. "Recovery without resilience? A novel way to measure nutritional resilience in Nepal, Bangladesh, and Uganda." *Global Food Security* 31:100573.

Appendices

A Additional Tables and Figures

Table A1: Summary statistics by PSNP status and survey round

	(1) non-PSNP mean/sd	(2) PSNP mean/sd	(3) 2006 mean/sd	(4) 2008 mean/sd	(5) 2010 mean/sd	(6) 2012 mean/sd	(7) 2014 mean/sd
Male headed household	0.75	0.70	0.73	0.74	0.72	0.72	0.73
	(0.43)	(0.46)	(0.45)	(0.44)	(0.45)	(0.45)	(0.45)
Age of household head	47.33	48.28	45.06	46.63	47.65	49.46	50.45
	(15.29)	(15.45)	(15.73)	(15.38)	(15.38)	(14.84)	(14.82)
Household head no education	0.65	0.70	0.75	0.74	0.48	0.63	0.74
	(0.48)	(0.46)	(0.44)	(0.44)	(0.50)	(0.48)	(0.44)
Household head married	0.72	0.66	0.68	0.72	0.69	0.68	0.70
	(0.45)	(0.47)	(0.47)	(0.45)	(0.46)	(0.47)	(0.46)
Household size	5.35	5.10	4.92	5.26	5.36	5.37	5.33
	(2.30)	(2.26)	(2.24)	(2.28)	(2.27)	(2.29)	(2.30)
Main occupation farming	0.81	0.80	0.79	0.83	0.80	0.81	0.82
	(0.39)	(0.40)	(0.41)	(0.38)	(0.40)	(0.39)	(0.39)
Main occupation non-farming	0.04	0.04	0.05	0.04	0.06	0.04	0.02
	(0.20)	(0.20)	(0.23)	(0.20)	(0.23)	(0.19)	(0.13)
IHS (farm size)	0.31	0.28	0.32	0.29	0.30	0.30	0.27
	(0.28)	(0.27)	(0.27)	(0.27)	(0.25)	(0.30)	(0.27)
IHS (livestock value per adult)	9.39	8.69	9.25	8.57	9.28	9.31	8.99
	(2.27)	(2.49)	(2.00)	(2.16)	(2.04)	(2.39)	(3.16)
IHS (Productive asset value per adult)	5.18	4.94	4.96	4.41	5.27	5.31	5.43
	(1.28)	(1.32)	(1.25)	(1.28)	(1.26)	(1.29)	(1.17)
Household has electricity access	0.14	0.14	0.05	0.11	0.15	0.14	0.26
	(0.35)	(0.34)	(0.22)	(0.31)	(0.36)	(0.35)	(0.44)
IHS (distance to nearest town)	3.13	3.13	3.15	3.11	3.14	3.14	3.13
	(0.79)	(0.72)	(0.78)	(0.75)	(0.78)	(0.73)	(0.74)
Average annual rainfall (mm)	981.76	908.68	1,001.09	884.59	1,009.02	907.20	935.45
	(269.90)	(301.58)	(273.32)	(274.42)	(268.09)	(260.56)	(333.47)
PSNP beneficiaries	0.00	1.00	0.49	0.47	0.46	0.44	0.36
	(0.00)	(0.00)	(0.50)	(0.50)	(0.50)	(0.50)	(0.48)
PSNP direct support (DS) beneficiaries	0.00	0.23	0.11	0.07	0.11	0.11	0.11
	(0.00)	(0.42)	(0.31)	(0.26)	(0.32)	(0.32)	(0.31)
PSNP public work (PW) beneficiaries	0.00	0.77	0.38	0.40	0.34	0.32	0.25
	(0.00)	(0.42)	(0.49)	(0.49)	(0.48)	(0.47)	(0.43)
HABP beneficiaries	0.38	0.46	0.25	0.37	0.50	0.52	0.46
	(0.49)	(0.50)	(0.43)	(0.48)	(0.50)	(0.50)	(0.50)
PSNP and HABP beneficiaries	0.00	0.46	0.14	0.21	0.24	0.25	0.18
	(0.00)	(0.50)	(0.35)	(0.41)	(0.43)	(0.43)	(0.38)
PSNP benefit amount per capita (birr)	.	285.19	265.09	147.06	227.46	414.21	431.15
	(.)	(291.95)	(258.76)	(132.15)	(263.38)	(308.48)	(382.10)
Annual real consumption per aeu	6,814.33	6,044.74	4,779.04	3,890.08	6,807.04	7,787.25	9,444.75
	(7,285.54)	(6,763.36)	(4,110.87)	(3,666.40)	(6,634.32)	(8,645.63)	(9,306.83)
rexpaeu_peryear_USD	400.84	355.57	281.12	228.83	400.41	458.07	555.57
	(428.56)	(397.84)	(241.82)	(215.67)	(390.25)	(508.57)	(547.46)
Household Dietary Diversity Score (HDDS)	3.70	3.64	3.18	3.47	3.70	4.03	4.10
	(1.94)	(1.75)	(1.62)	(1.80)	(1.71)	(2.19)	(1.78)
Tropical Livestock Unit (TLU)	4.42	3.11	3.82	3.84	3.98	3.83	3.65
	(3.59)	(2.86)	(3.32)	(3.24)	(3.38)	(3.37)	(3.39)

Table A2: Regression of welfare outcome and conditional variance on household characteristics

	Consumption expenditure		HDDS		TLU (IHS)	
	(1)	(2)	(3)	(4)	(5)	(6)
	Welfare outcome	Cond.var	Welfare outcome	Cond.var	Welfare outcome	Cond.var
	b/se	b/se	b/se	b/se	b/se	b/se
Lagged welfare	-0.381**	-0.0448	0.240***	0.450***	0.0466**	-0.0505***
	(0.17)	(0.18)	(0.06)	(0.15)	(0.02)	(0.02)
(Lagged welfare)^2	0.0259***	0.00438	-0.0237***	-0.0525***	0.0713***	0.0171***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)
PSNP beneficiaries	-0.396***	-0.0148	0.0955	1.402**	-0.00984	-0.0179
	(0.09)	(0.08)	(0.21)	(0.56)	(0.05)	(0.02)
HABP beneficiaries	0.00362	-0.0230	0.276***	0.165	0.0460***	-0.0152**
	(0.02)	(0.02)	(0.07)	(0.19)	(0.01)	(0.01)
PSNP beneficiaries × HABP beneficiaries	0.0242	-0.0103	-0.123*	0.107	-0.0357**	0.00819
	(0.03)	(0.03)	(0.07)	(0.24)	(0.02)	(0.01)
IHS (PSNP transfer per capita)	0.0564***	0.00329	-0.0302	-0.279**	-0.0111	0.000214
	(0.01)	(0.01)	(0.04)	(0.11)	(0.01)	(0.00)
Log(household head age)	-1.310***	-0.478	-4.358***	-8.966**	0.466	-0.331
	(0.48)	(0.45)	(1.15)	(3.53)	(0.37)	(0.24)
Log(household head age) squared	0.170***	0.0651	0.538***	1.173**	-0.0589	0.0442
	(0.06)	(0.06)	(0.15)	(0.46)	(0.05)	(0.03)
Male headed household	-0.0518**	-0.0129	-0.102**	0.0956	0.0214	-0.00353
	(0.02)	(0.02)	(0.05)	(0.16)	(0.01)	(0.01)
Household head no education	-0.0411**	0.0275	-0.0287	0.264**	0.0128	-0.000555
	(0.02)	(0.02)	(0.05)	(0.13)	(0.01)	(0.01)
Household head married	-0.0220	-0.0182	0.0382	-0.133	0.00976	-0.0191**
	(0.02)	(0.02)	(0.05)	(0.13)	(0.01)	(0.01)
Household size	-0.0617***	0.00366	0.0890***	0.0473*	0.0373***	0.00608***
	(0.01)	(0.01)	(0.01)	(0.03)	(0.00)	(0.00)
IHS (distance to nearest town)	-0.0573***	0.0384**	-0.367***	-0.309	0.0401***	-0.00631
	(0.02)	(0.02)	(0.07)	(0.25)	(0.01)	(0.00)
Main occupation non-farming	0.0856*	-0.0165	0.339***	0.551*	-0.0452*	-0.0361***
	(0.05)	(0.04)	(0.10)	(0.31)	(0.02)	(0.01)
IHS (farm size)	0.236***	-0.00236	0.523***	0.502**	0.135***	0.0807***
	(0.04)	(0.04)	(0.09)	(0.23)	(0.03)	(0.02)
IHS (livestock value per adult)	0.0255***	-0.0108***	0.0440***	-0.0460	0.244***	-0.0488***
	(0.00)	(0.00)	(0.01)	(0.04)	(0.01)	(0.00)
IHS (Productive asset value per adult)	0.130***	-0.0223**	0.133***	0.00880	0.0346***	0.0136***
	(0.01)	(0.01)	(0.03)	(0.09)	(0.01)	(0.00)
Household has electricity access	0.0670*	0.00788	0.116	0.358	0.0168	-0.0103
	(0.04)	(0.02)	(0.13)	(0.39)	(0.02)	(0.01)
Ln (Average rainfall this year (mm))	0.673**	-0.175	1.610***	1.680	0.446**	0.150
	(0.27)	(0.12)	(0.35)	(1.59)	(0.21)	(0.10)
Constant	7.613***	2.478*	1.312	8.315	-4.924***	0.223
	(2.01)	(1.41)	(3.30)	(13.11)	(1.44)	(0.70)
N	11375	11375	11425	11425	11035	11035
R^2	0.347	0.0371	0.258	0.0991	0.769	0.160
District and Year FE	Y	Y	Y	Y	Y	Y

Table A3: Regression of univariate resilience measure on household characteristics - Full

	(1) Expenditure b/se	(2) Dietary b/se	(3) Livestock b/se
PSNP beneficiaries	-0.200***	0.081***	0.006
	(0.01)	(0.01)	(0.01)
HABP beneficiaries	0.002	0.056***	0.023***
	(0.00)	(0.00)	(0.00)
PSNP beneficiaries × HABP beneficiaries	0.006**	-0.021***	-0.006
	(0.00)	(0.00)	(0.01)
IHS (PSNP transfer per capita)	0.028***	-0.018***	-0.009***
	(0.00)	(0.00)	(0.00)
ln(Average annual rainfall (mm))	-0.780	35.172***	7.106
	(1.15)	(2.20)	(7.79)
Deviation in 30-year average annual rainfall (m)	-0.006	-0.046***	0.042**
	(0.01)	(0.01)	(0.02)
Log(household head age)	-0.694***	-1.051***	0.758***
	(0.03)	(0.04)	(0.11)
Log(household head age) squared	0.090***	0.132***	-0.100***
	(0.00)	(0.01)	(0.01)
Male headed household	-0.026***	-0.015***	0.034***
	(0.00)	(0.00)	(0.01)
Household head no education	-0.024***	0.001	0.010***
	(0.00)	(0.00)	(0.00)
Household head married	-0.011***	0.001	0.020***
	(0.00)	(0.00)	(0.00)
Household size	-0.032***	0.018***	0.015***
	(0.00)	(0.00)	(0.00)
IHS (distance to nearest town)	-0.028***	-0.070***	0.019***
	(0.00)	(0.00)	(0.00)
Main occupation non-farming	0.044***	0.079***	-0.040***
	(0.00)	(0.00)	(0.01)
IHS (farm size)	0.107***	0.113***	0.025***
	(0.00)	(0.00)	(0.01)
IHS (livestock value per adult)	0.013***	0.006***	0.076***
	(0.00)	(0.00)	(0.00)
IHS (Productive asset value per adult)	0.065***	0.024***	0.025***
	(0.00)	(0.00)	(0.00)
Household has electricity access	0.034***	0.041***	0.004
	(0.00)	(0.00)	(0.00)
Constant	6.185	-215.547***	-45.888
	(7.14)	(13.64)	(48.19)
N	10444	10458	10093
R^2	0.967	0.946	0.850
Lagged outcome	Y	Y	Y
District and Year FE	Y	Y	Y

Standard error clustered at village level

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A4: Regression of multivariate resilience on household characteristics - part 1

	Poverty and Dietary			Poverty and Asset		
	(1)	(2)	(3)	(4)	(5)	(6)
	Avg	Uni	Int	Avg	Uni	Int
	b/se	b/se	b/se	b/se	b/se	b/se
Log(household head age)	-0.872***	-0.933***	-0.811***	0.0282	0.227**	-0.170*
	(0.027)	(0.043)	(0.034)	(0.058)	(0.087)	(0.095)
Log(household head age) squared	0.111***	0.120***	0.101***	-0.00444	-0.0276**	0.0188
	(0.004)	(0.006)	(0.004)	(0.008)	(0.011)	(0.012)
Male headed household	-0.0202***	-0.0228***	-0.0175***	0.00418	0.00105	0.00731
	(0.001)	(0.002)	(0.002)	(0.003)	(0.004)	(0.004)
Household head no education	-0.0116***	-0.0194***	-0.00371**	-0.00715***	-0.00249	-0.0118***
	(0.001)	(0.001)	(0.002)	(0.002)	(0.003)	(0.002)
Household head married	-0.00518***	-0.0110***	0.000656	0.00488*	0.00472	0.00505
	(0.001)	(0.002)	(0.002)	(0.002)	(0.004)	(0.004)
Household size	-0.00703***	-0.0165***	0.00248***	-0.00868***	0.00199**	-0.0194***
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
IHS (distance to nearest town)	-0.0490***	-0.0514***	-0.0466***	-0.00462*	0.00183	-0.0111***
	(0.003)	(0.001)	(0.006)	(0.003)	(0.004)	(0.003)
Main occupation non-farming	0.0614***	0.0656***	0.0572***	0.00190	-0.00154	0.00535
	(0.003)	(0.003)	(0.003)	(0.005)	(0.008)	(0.009)
IHS (farm size)	0.109***	0.118***	0.101***	0.0659***	0.0527***	0.0791***
	(0.003)	(0.004)	(0.005)	(0.004)	(0.008)	(0.007)
IHS (livestock value per adult)	0.00953***	0.0123***	0.00681***	0.0448***	0.0428***	0.0469***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)
IHS (Productive asset value per adult)	0.0445***	0.0571***	0.0319***	0.0453***	0.0350***	0.0555***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Household has electricity access	0.0374***	0.0403***	0.0345***	0.0184***	0.00606	0.0307***
	(0.003)	(0.005)	(0.005)	(0.003)	(0.004)	(0.006)
ln(Average annual rainfall (mm))	17.12***	13.52***	20.73***	2.881	7.526	-1.763
	(1.539)	(1.044)	(2.609)	(3.549)	(6.283)	(1.381)
IHS(Deviation in average annual rainfall from 30-year average)	-0.000427	0.000473	-0.00133***	0.000666**	0.000949**	0.000383
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
PSNP beneficiaries	-0.0601***	-0.133***	0.0127	-0.0973***	-0.0934***	-0.101***
	(0.007)	(0.011)	(0.014)	(0.008)	(0.014)	(0.014)
HABP beneficiaries	0.0292***	0.0216***	0.0368***	0.0126***	0.00793**	0.0172***
	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)	(0.004)
PSNP beneficiaries × HABP beneficiaries	-0.00760***	0.000195	-0.0154***	0.000433	0.00707	-0.00620
	(0.002)	(0.003)	(0.003)	(0.003)	(0.005)	(0.006)
IHS (PSNP transfer per capita)	0.00538***	0.0168***	-0.00602***	0.00958***	0.00999***	0.00918***
	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)
Constant	-104.2***	-81.75***	-126.7***	-18.09	-46.97	10.79
	(9.531)	(6.471)	(16.165)	(21.968)	(38.889)	(8.552)
N	10444	10444	10444	10085	10085	10085
r2	0.965	0.952	0.886	0.902	0.749	0.848
Lagged Wellbeing	Y	Y	Y	Y	Y	Y
District and Year FE	Y	Y	Y	Y	Y	Y

Standard error clustered at village level

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A5: Regression of multivariate resilience on household characteristics - part 2

	Dietary and Asset			Poverty, Dietary and Asset		
	(1)	(2)	(3)	(4)	(5)	(6)
	Avg	Uni	Int	Avg	Uni	Int
	b/se	b/se	b/se	b/se	b/se	b/se
Log(household head age)	-0.147**	0.299***	-0.593***	-0.332***	0.109	-0.483***
	(0.058)	(0.108)	(0.074)	(0.042)	(0.080)	(0.058)
Log(household head age) squared	0.0160**	-0.0420***	0.0740***	0.0410***	-0.0134	0.0596***
	(0.008)	(0.014)	(0.010)	(0.005)	(0.010)	(0.008)
Male headed household	0.00942***	0.0251***	-0.00621**	-0.00237	0.00264	-0.00754***
	(0.003)	(0.006)	(0.003)	(0.002)	(0.004)	(0.002)
Household head no education	0.00573***	0.0109***	0.000595	-0.00433***	-0.000817	-0.00309*
	(0.002)	(0.003)	(0.002)	(0.001)	(0.002)	(0.002)
Household head married	0.0105***	0.0173***	0.00367	0.00342*	0.00475	0.00364
	(0.003)	(0.004)	(0.003)	(0.002)	(0.003)	(0.002)
Household size	0.0165***	0.0158***	0.0172***	0.000245	0.00368***	0.00305***
	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)
IHS (distance to nearest town)	-0.0263***	-0.0114***	-0.0412***	-0.0268***	-0.0104***	-0.0295***
	(0.004)	(0.003)	(0.007)	(0.003)	(0.002)	(0.006)
Main occupation non-farming	0.0200***	0.00950	0.0305***	0.0278***	0.0148**	0.0255***
	(0.005)	(0.010)	(0.009)	(0.003)	(0.007)	(0.007)
IHS (farm size)	0.0690***	0.0503***	0.0876***	0.0813***	0.0514***	0.0748***
	(0.004)	(0.008)	(0.005)	(0.003)	(0.007)	(0.006)
IHS (livestock value per adult)	0.0410***	0.0592***	0.0228***	0.0318***	0.0367***	0.0178***
	(0.001)	(0.002)	(0.001)	(0.000)	(0.001)	(0.001)
IHS (Productive asset value per adult)	0.0247***	0.0257***	0.0237***	0.0382***	0.0310***	0.0278***
	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)
Household has electricity access	0.0229***	0.0148***	0.0310***	0.0263***	0.00878**	0.0263***
	(0.003)	(0.005)	(0.005)	(0.003)	(0.004)	(0.005)
ln(Average annual rainfall (mm))	21.34***	10.93*	31.75***	13.81***	8.098	17.58***
	(4.315)	(6.430)	(3.719)	(2.730)	(5.337)	(3.042)
IHS(Deviation in average annual rainfall from 30-year average)	0.000198	0.000544	-0.000147	0.000145	0.000797**	-0.000732*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
PSNP beneficiaries	0.0435***	0.00956	0.0775***	-0.0379***	-0.0744***	0.0278**
	(0.008)	(0.012)	(0.010)	(0.006)	(0.012)	(0.011)
HABP beneficiaries	0.0394***	0.0270***	0.0519***	0.0271***	0.0111***	0.0360***
	(0.002)	(0.004)	(0.003)	(0.002)	(0.003)	(0.003)
PSNP beneficiaries × HABP beneficiaries	-0.0138***	0.00185	-0.0295***	-0.00689***	0.00795*	-0.0222***
	(0.003)	(0.005)	(0.004)	(0.002)	(0.004)	(0.004)
IHS (PSNP transfer per capita)	-0.0136***	-0.0101***	-0.0170***	0.000460	0.00698***	-0.00826***
	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)
Constant	-131.9***	-68.31*	-195.6***	-84.95***	-50.15	-108.0***
	(26.708)	(39.797)	(23.030)	(16.903)	(33.034)	(18.845)
N	10093	10093	10093	10085	10085	10085
r2	0.888	0.819	0.837	0.924	0.735	0.805
Lagged Wellbeing	Y	Y	Y	Y	Y	Y
District and Year FE	Y	Y	Y	Y	Y	Y

Standard error clustered at village level

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$