Research article

Rural households vulnerability to covariate and idiosyncratic shocks using multilevel longitudinal model: evidence from Ethiopia

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ABSTRACT

The economic reports on income inequality, poverty, and other welfare indicators are relevant if it was supported by the evidence of income traps because rural households in developing countries were frequently hit by several shocks. This study intended to investigate the households' vulnerability to covariate and idiosyncratic shocks in Ethiopia using three waves of the household panel survey for the period of 2011–2016. The study applied a three-level mixed effect model for analysis. The result of the three-level mixed effect model points out that both covariate and idiosyncratic shocks were found to influence household consumption and covariate shocks are a relatively larger and more significant effect on households' consumption than idiosyncratic shocks. Based on the finding of this study, it is suggested that the implementation of different policies that address factors contributing vulnerability to covariate and idiosyncratic shocks of rural households in Ethiopia.

1. Introduction

Measuring household welfare based on income, consumption, asset, and other indicators was gaining increasing importance in the economics literature. However, a study by Sen (1997) stated that the welfare difference mainly depends on the ability to absorb shocks occurred during course of action. A broad grasp of the current state of welfare is insufficient without considering the current state of households' exposure to various shocks (Wassie, 2019; Dercon, 2006; Krätli et al., 2013; Calvo and Dercon, 2013; Klasen et al., 2015). While it is becoming increasingly obvious that measures to reduce household vulnerability must be a cornerstone of any welfare improvement plan (World bank, 2015), the quantitative links between shocks and welfare are little established. This exposure to shocks defines as vulnerability, having a probability of suffering a future shortfall where vulnerable households are those with low opportunities and encounter difficulties when exposed to shocks (Asfaw et al., 2012; Lovo and Veronesi, 2019; Hassen et al., 2017; Singh et al., 2016; Elbers et al., 2003).

Studies of shocks are inextricably tied to vulnerability research. They seek to identify the systems, elements of systems, or people groups that are most vulnerable to the effects of a severe disturbance. These methods have resulted in the identification of vulnerable systems or vulnerable populations to implement activities in a prevention policy that will lessen the effects of shocks on the elements targeted. The theoretical bases of vulnerability are argued based on two perspectives; from broad perspective, a number of studies have attempted to classify the idea of vulnerability based on four basic approaches: the risk hazard approach, the political economics method, the coupled vulnerability approach, and the poverty viewpoint. From specific perspectives, the vulnerability assessment should answer issues like the extent of the vulnerability, the sources of vulnerability, and households' response to shocks using approaches including vulnerability measurement based on poverty, index-based, proxy means testing, expects utility and uninsured exposure to risk.

Rural households in Ethiopia are engaged in farming as the main sources of income; though, their income is an unstable duo to change in weather conditions, pest infestation, drought, market forces and the like. The exposure to shock is not only reducing income but also leads to the loss of critical, productive assets. A household that is not poor at present may face the risk of becoming poor in the future due to exposure to different shocks including covariate shocks, events that occurred among living within the same localities and idiosyncratic shocks, events that occurred for only within households or persons (Chaudhuri, 2002; Hoddinott and Quisumbing, 2003; Wossen et al., 2014; Seipt et al., 2013; Dercon, 2005; Krätli et al., 2013; Calvo and Dercon, 2013; Klasen et al., 2015; Wassie, 2019).

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Although there has been a recent growing interest in the area of vulnerability, relevant empirical studies on vulnerability by decomposing shocks into covariate and idiosyncratic shocks still because, the majority of the studies are constrained by limited information on a full range of shocks (Tesfay et al., 2015; Günther and Harttgen, 2009; Hoddinott, 2006; Dercon et al., 2005; Christiaensen, 2000; Chaudhuri, 2003; Ligot and Schechter, 2002). This is because empirical studies are still dominated on the vulnerability to poverty and climate change. One of the main reasons for this is the lack of nationally representative data in Ethiopia and limited scope in incorporating types of shocks in the study such as taking into account individual as well as community-level shocks (Dercon and Krishnan, 2006; Dercon, 2005). In light of this, our study made an effort to close the gap by conducting a vulnerability analysis (VA). The ability to identify (I) the vulnerable and (ii) the sources of vulnerability substantially improves the formulation of preventative welfare strategies.

Several empirical working in Ethiopia has focused on households’ income and their vulnerability to poverty and climate change with static or snapshot evidence (Deressa et al., 2008; Tessema and Simane, 2019; Bedeke et al., 2020; Demeke et al., 2011; Bogale, 2012; Gelaw and Sileshi, 2013; Debebe and Zekarias, 2020). This study, however, provides vulnerability to shocks, by decomposing the relative impact of covariate and idiosyncratic shocks using panel data an empirical application to rural households in Ethiopia. This study has the potential to provide important insight into understanding vulnerability to a wide variety of shocks, which are likely to increase rural households’ vulnerability to shocks, holds a great promise for policy and program design that is ex-ant in nature. Having these concerns, this study intended to answers the following questions. Who are households vulnerable to idiosyncratic and covariate shocks in Ethiopia and which factor play role in explaining the vulnerability to idiosyncratic shocks and covariate shocks? Thus, the objective of this study was to assess the households’ vulnerability to covariate and idiosyncratic shocks, specifically, to examine the determinants of households vulnerability to idiosyncratic and covariate shocks, to understand the profile of rural household vulnerability to idiosyncratic and covariate shocks on the household welfare and its impact on the welfare and to identify which shocks have more influence on the rural household vulnerability.

2. Methodology

2.1. Data sources, collection methods and type

This study employed panel data from the Living Standard Measurement Survey-Integrated Agricultural Survey (LSMS-ISA), which was conducted by the World Bank and the Ethiopian Central Statistics Agency (CSA). The first wave, second wave, and third wave of the survey were collected in 2011/2, 2013/4, and 2015/6, respectively. The panel dataset is a nationwide survey that was compiled using household multistage probability samples. Using a stratified random design, the study’s domains (regions, urban/rural) are first identified. Second, probability proportional to size was used to choose the enumeration areas (EAs), thirdly, the country’s most recent population census is used to determine the size of the main sampling units (PSUs), which are geographically specified area units. The final step is the systematic selection of the secondary sampling units (households) (Table 1).

With a total attrition rate of 6.8, a total of 3969 households from wave one, 5262 households from wave two, and 4954 households from wave three were questioned. Large town samples were only taken in the second and third waves, and as the study is primarily on rural families, those samples were automatically omitted from the analysis. In addition, the study limits the sample size due to zero total consumption and missing consumption data (Table 2).

2.2. Method of data analysis

The descriptive statistics and Econometric tools were used for analysis. The descriptive statistics was used to provide a picture of demographic, socio-economic, institutional, wellbeing dynamics of the sampled households. To examine the sources and level of vulnerability the study adopted the method from Mina and Katsushi (2016) which were extended from Günther and Harttgen (2009) and proposed by Chaudhuri (2002), Following Christian and Katsushi (2012, 2015), Günther and Harttgen (2009) and Chaudhuri (2002), the consumption generating process was stated as (Eq. (1)):

\[
\ln cn = \beta_i + \beta_i x_{ij} + \beta j x_{ij} + e_i
\]  

where \( \ln cn \) is per capita (log) consumption that serves as the indicator of household welfare. \( X \) is a set of the household as well as community characteristics such as sex, age, education, land size, livestock, asset, land size, extension and credit service, distance to market and main road. \( \beta \) is a vector of the parameter to be estimated and \( e_i \) is a random error term. The above equation gives the mean level of consumption of the household in Woreda \( j \). To determine the variance of consumption, community-level characteristics can be included as follows;

\[
\bar{\beta}_i = 1000 + 1100 z_i + u_i
\]

\[
\bar{\beta}_j = 10 + 11 z_j + u_j
\]

The final form of the model can be modified based on the above equations (Eq. (2)) as follows;

| Waved One | Wave One | Wave Two | Wave Three |
|-----------|----------|----------|------------|
| Rural | Small towns | Rural | Small towns | Large towns | Rural | Small towns | Large towns |
| EAs | HHs | EAs | HHs | EAs | EAs | Hhs | EAs | EAs | EAs | EAs | Hhs |
| National | 280 | 3466 | 43 | 503 | 280 | 42 | 73 | 5262 | 280 | 42 | 73 | 4954 |
| Tigray | 30 | 360 | 4 | 48 | 30 | 4 | 15 | 633 | 30 | 4 | 15 | 631 |
| Afar | 10 | 120 | 2 | 24 | 10 | 2 | 1 | 159 | 10 | 2 | 1 | 159 |
| Amhara | 61 | 728 | 11 | 127 | 61 | 10 | 15 | 1077 | 61 | 10 | 15 | 1077 |
| Oromiya | 55 | 656 | 11 | 125 | 55 | 10 | 20 | 1080 | 55 | 10 | 20 | 1080 |
| Somali | 20 | 237 | 3 | 36 | 20 | 3 | 3 | 321 | 20 | 3 | 3 | 321 |
| Benishangul | 10 | 120 | 1 | 12 | 10 | 1 | 0 | 132 | 10 | 1 | 0 | 132 |
| SNNP | 74 | 885 | 10 | 119 | 74 | 10 | 15 | 1233 | 74 | 10 | 15 | 1233 |
| Gambella | 10 | 120 | 1 | 12 | 10 | 1 | 1 | 147 | 10 | 1 | 1 | 147 |
| Harari | 10 | 120 | 0 | 0 | 10 | 1 | 3 | 177 | 10 | 1 | 3 | 177 |
| Total Households | 3969 | 5262 | 4954 |

Note: HHs = households interviewed, EAs = Enumeration area numbers.
Source: Author’s calculation using ESS data 2011/12, 2013/13 and 2015/16 waves
ln $C_{ij} = Y_{00} + Y_{10}Z_{j} + (Y_{10} + Y_{11}Z_{j})x_{ij} + u_{ij} + \varepsilon_{ij}$ \hfill (3)

The right-hand side of the equation (Eq. (3)) that has three terms is the deterministic or fixed part whereas the left-hand side is the stochastic or random part of the equation.

This study applied a multilevel model for analysis where multilevel modelling is an appropriate approach if one wants to analyze hierarchically structured data with variable define at all levels of the hierarchy (Hox, 2000). When data contain variables measured at different levels, nesting of lower level units with higher level ones produces additional sources variation that violate the independence and homoscedasticity assumption. This is true with panel data, where random fluctuations can occur at repeated measurements leading to serially correlated errors (Gibbons et al., 2010). Using multilevel models also allows us to include error terms at each level, which makes it possible to track changes in variance at each level across models (Gelman, 2009). This method was applied using the following step:

Step one: Regress the log of consumption per adult equivalent of household $i$ ($n = 1, \ldots, I$) in Woreda $j$ at time $t$ using the above Eq. (3). The level is justified in the ways that one is nested in the other, as the result level-one is the time or wave indicated by $t = 1, 2, 3$; level two is households indicated by $n = 1, \ldots, I$, and level three is Woreda indicated by $j = 1, \ldots, J$. Step two: The above equation gives the mean level of consumption of the household $i$ in Woreda $j$. To determine the variance of consumption, square the residual generated in the first step and use as a dependent variable as indicated in Eq. (4).

$$
\varepsilon_{ij}^2 = \beta_0 + \beta_1 x_{ij} + \beta_2 X_{ij}Z_{j} + \varepsilon_{ij}$$ \hfill (4)

Step three: The expected log of consumption and it variance including covariate, idiosyncratic and total variance is determined with the parameters of Eq. (5).

$$
E[\ln C_{ij}/x] = \tilde{\beta}_0 + \tilde{\beta}_1 x_{ij}
$$
$$
V[\ln C_{ij}/x] = \tilde{\sigma}^2 + \tilde{\sigma}_x x_{ij}
$$ \hfill (5)

Step four: These estimates from step three can be used to determine the vulnerability of the household to covariate and idiosyncratic shocks as follows (Eq. (6)):

$$
\tilde{V}_{ij} = \tilde{P}(\ln y_{ij} < \ln z|\bar{x}) = \Phi \left( \frac{\ln z - \ln \bar{y}_{ij}}{\sigma_{\bar{y}_{ij}}} \right)
$$ \hfill (6)

Where: $\Phi(\cdot)$ denotes the cumulative density of the standard normal distribution; $\ln z$ is the log of the poverty threshold; $\ln \bar{y}_{ij}$ is log of per capita income of household predicted by Eq. (3); and $V_{t, k, j} = 1 - P(\ln y_{ij} > \ln y)$ is the expected total variance of residuals in Eq. (4).

Vulnerability estimation is also conducted separately for different components of variance in income, namely: idiosyncratic variances $\sigma_{\varepsilon_{ij}}^2$ and $\sigma_{u_{ij}}^2$, and covariate variance $\sigma_{x_{ij}}^2$. Step Five: The optimal or benchmark vulnerability threshold is determined based on empirical literature as a result the most common vulnerability threshold used was 0.5 (Pritchett et al., 2000a,b; Guther and Harttgen, 2009; Christian and Katsushi, 2012), is adopted in this study within the three waves. Having this benchmark vulnerability threshold, the vulnerability threshold that determines the future non-vulnerable and vulnerable household is determined as follows (Eq. (7)):

$$
V_{t, k, j} = 1 - P(\ln y_{ij} > \ln y)
$$ \hfill (7)

where, $V_{t, k, j}$ is vulnerability status of the households at time $t$, $P(\ln y_{ij} > \ln y)$ is a probability of having income above or below the consumption thresholds. Thus, the estimated vulnerability threshold at time $t$ to fall below the poverty threshold at least once in the next 3 years is 0.2063 and this was consistent with the result of Christian and Katsushi (2015).

3. Results and discussion

3.1. Characteristics of sample households

Vulnerability to shocks can be attributed to a number of socioeconomic factors. These include household traits including sex, age, education, highest educational attainment in the home, total number of individuals in the household, and the proportion of dependent and employed persons in the household. Table 3 provided the summary statistics for household characteristics. The majority of the sample houses were male-headed families, with 24% of them having female heads. The average age of the sample households was 46 years, with lowest and maximum ages of 14 and 100 years, respectively. The mean age of the household was, however, 26 years old when the entire family was taken into account. A variety of socioeconomic factors play a role. This suggests that the household leader is younger than the family’s average age and that the majority of the household’s members are children. The sampled households’ average literacy rate was 39%. The sampled households had a mean of six members and a dependency ratio of 1.3%, which may be viewed from both the labor availability and expenditure perspectives. The outcome also revealed that there were on average 1.4 more female adults than male adults in the home. The outcome also revealed that each household’s average age ranged from 17 to 100.

Table 4 provides a summary of household consumption and income statistics. The average household consumed significantly more food than non-food items. In addition to being greater on average than farm incomes, off-farm incomes also had bigger standard deviations. This
suggests that household incomes included off-farm incomes as a significant portion. Compared to farm incomes, off-farm incomes were distributed more unevenly.

3.2. Socio-economic and institutional characteristics of the sample households

Household well-being is influenced by socioeconomic and institutional factors such as total land holding, cultivated land size, livestock ownership, and access to infrastructure. To determine the statistical difference between consumption quintiles, these socioeconomic and institutional characteristics were tested across consumption expenditure quintiles. The test was also carried out to determine which consumption quintile differed from others. As shown in Table 5, there is a statistically significant mean difference between consumption quintiles based on socioeconomic and infrastructure factors such as land size, cultivated land, livestock holding, distance to the nearest market, and zone capital.

In the first, second, third, fourth, and fourth consumption quintiles, the mean land size of the sample households was 1.17, 1.37, 1.49, 1.63, and 1.12 ha respectively, which is comparable to the national average of about 1.17 ha (Holden and Tilahun, 2020). According to the Tukey post hoc test, there is a statistically significant difference in mean land size between the fourth and fifth consumption quintiles.

In the first, second, third, fourth, and fourth consumption quintiles, the sampled households owned 2.19, 2.7, 2.89, 2.9, and 2.88 TLU on average. The average household owned 2.73 TLU, which was lower than the national average. The post hoc test revealed a statistically significant difference.

Table 3. Demographic characteristic of the sampled households.

| Variable                          | Mean   | Std. Dev. | Min   | Max   | Observations |
|----------------------------------|--------|-----------|-------|-------|--------------|
| 1. Sex of the Household head     | 0.243594 | 0.429272  | 0     | 1     | N = 9717     |
| Between                          | 0.42417 | 0         | 1     | N = 3239 |             |
| Within                           | 0.066268 | -0.42307  | 0.91026 |       | T = 3       |
| 2. Age of the Household head     | 46.30998 | 15.41563  | 14    | 100   | N = 9491     |
| Between                          | 15.27201 | 15.66667  | 100   |       | N = 3239   |
| Within                           | 3.231546 | 15.80998  | 92.64331 |       | T-bar = 2.93113 |
| 3. Mean age in the household     | 25.94219 | 12.44577  | 6.75  | 97    | N = 9715     |
| Between                          | 11.523  | 10.8537   | 91.33333 |       | n = 3239   |
| Within                           | 4.70391 | -17.5023  | 64.80885 |       | T-bar = 2.99938 |
| 4. Household head Literacy       | 0.393023 | 0.488447  | 0     | 1     | N = 9717     |
| Between                          | 0.435647 | 0         | 1     | n = 3239 |             |
| Within                           | 0.224877 | -0.27364  | 1.059689 |       | T = 3       |
| 5. Education level in the Household | 1.932695 | 1.420675  | 0     | 35    | N = 9717     |
| Between                          | 1.095344 | 0         | 19.66667 |       | n = 3239   |
| Within                           | 0.904868 | -13.734   | 23.9327 |       | T = 3       |
| 6. Household Size                | 5.559226 | 2.520626  | 1     | 18    | N = 9717     |
| Between                          | 2.384203 | 1         | 15.66667 |       | n = 3239   |
| Within                           | 0.818721 | -1.77411  | 11.5923 |       | T = 3       |
| 7. Total Male Adults             | 1.325924 | 1.041383  | 0     | 9     | N = 9717     |
| Between                          | 0.929917 | 0         | 8.333333 |       | n = 3239   |
| Within                           | 0.468948 | -2.00741  | 3.99259 |       | T = 3       |
| 8. Total Female Adults           | 1.413914 | 0.877374  | 0     | 8     | N = 9717     |
| Between                          | 0.761022 | 0         | 5.666667 |       | n = 3239   |
| Within                           | 0.43675 | 0         | 3.747247 |       | T-bar = 2.94687 |
| 9. Dependency Ratio              | 1.33378 | 1.082267  | 0     | 11    | N = 9374     |
| Between                          | 0.868704 | 0         | 6     | n = 3181 |             |
| Within                           | 0.653508 | -2.49955  | 8.222668 |       | T-bar = 2.94687 |

Sources: Author’s calculation using ESS data 2011/12, 2013/13 and 2015/16 waves.

Table 4. Summary of consumption, income and credit use of the sampled households.

| Variables                      | First Wave |          |          | Second Wave |          |          | Third Wave |          |          | Overall |          |
|--------------------------------|------------|----------|----------|-------------|----------|----------|------------|----------|----------|---------|----------|
|                                | mean       | S.D      | mean     | S.D         | mean     | S.D      | mean       | S.D      | mean     | mean    | S.D      |
| Consumption (Household)        |            |          |          |             |          |          |            |          |          |         |          |
| 1. Food Consumption            | 4485.25    | 4970.85  | 3912.45  | 31.84       | 3916.54  | 3412.32  | 4158.95    | 3931.30  |          |         |          |
| 2. Non-food Consumption        | 1057.90    | 4072.31  | 1107.12  | 130.12      | 1107.36  | 1361.46  | 1090.52    | 2595.12  |          |         |          |
| 3. Total Consumption           | 5542.34    | 6672.47  | 5019.56  | 3809.06     | 3809.06  | 4165.18  | 5249.48    | 5049.97  |          |         |          |
| Income (Household)             |            |          |          |             |          |          |            |          |          |         |          |
| 1. Farm income                 | 762.96     | 3784     | 2435.97  | 87.39       | 2164.98  | 7996.51  | 1787.97    | 7204.74  |          |         |          |
| 2. Non-farm income             | 3853.01    | 2438.8   | 3852.23  | 30          | 6539.17  | 69704.42 | 4748.14    | 43777.69 |          |         |          |
| 3. Total income                | 4615.96    | 2463.6   | 6286.20  | 1914.17     | 8704.15  | 70196.61 | 6536.11    | 44778.88 |          |         |          |
| Credit Use (1 if access,0 otherwise) | 0.284 | 0.451    | 0.42     | 0.58        | 0.179    | 0.384    |            |          |          |         |          |

Sources: Author’s calculation using ESS data 2011/12, 2013/13 and 2015/16 waves.
consumption quintiles, respectively and this is comparable to the national average of about 1.17 ha (Holden and Tilahun, 2020). The Tukey post hoc test indicates that there is a statistically significant difference in mean of land size and cultivated land between the 4th and 5th consumption quintiles. The sampled households owned 2.19, 2.7, 2.89, 2.9 and 2.88 TLU on average in the first, second, third, fourth and fifth consumption quintiles, respectively. Overall, households owned 2.73 TLU on average and this is lower than the national average. The post hoc test showed that there is a statistically significant difference in the mean of livestock holding between the 1th and other consumption quintiles.

### 3.3. Effect of vulnerability to covariate and idiosyncratic shocks

Understanding the effect of covariate and idiosyncratic shocks is very pertinent for policymaking to address the issue of rural household vulnerability. In this regard, sex, age and literacy of the household, household size, land and livestock holding, credit use, distance to road and market, income from farm and off-farm, food and non-food expenditure, exposure to shock, asset holding, extension contact, main livelihood and irrigation access were hypothesized to affect household consumption, thereby vulnerability. The analysis was conducted using a three-level mixed effect model. Before estimating the model, the study conducted a diagnostic test to arrive at the estimated model using a likelihood test. First, the OLS regression was tested against the two-level model and the two-level model was preferred. Second, a two-level model was tested against a three-level model and the three-level model was preferred. Finally, the likelihood test allows the inclusion of random coefficient for the time variable both at Woreda level and household levels. In addition to the likelihood test, the study also tests the variance-covariance matrix, group-level error and fitted values. The result of the three-level mixed model showed that education status of household head, household size, livestock holding, asset holding, distance to the nearest road, distance to the nearest market, extension contact, main livelihood, covariate and idiosyncratic shocks are the main factor which influences household consumption.

The education status of the household head is positively determined by household consumption which enables households to have access to information, skill and practices. This highlights the significance of education; a finding is consistent with the findings of Abrahm and Bauer (2012), Birhan and Tesfahun (2017), Teka et al. (2019) and Kebede et al. (2019). Total household size is negatively determined household consumption as a larger household size means lower consumption. This implies that as the household size increase, its consumption declines. This is due to fact that larger household size is associated with higher sharing of resources. The result is in line with the finding from Lanjouw and Ravallion (1995), Bogale and Shimelis (2009) and Berisia and Heshmati (2016).

Livestock holding is an important determinant of households’ consumption as livestock holding increase the probability of households’ consumption will raise. Gemechu et al. (2016), Abafti and Kim (2014) and Mitiku et al. (2012) showed that a household having higher livestock ownership creates more livestock products such as milk, milk products, meat, and better income from the sale of both live animal and livestock product. This highlights the positive effect of livestock on the household’s consumption; hence, this household has the potential of less vulnerable to shocks due to the consumption smoothing role of livestock. Similarly, asset holding is an important determinant of household consumption. The asset considered in this category is plow full sets, horse/donkey carts, wheelbarrows, boreholes, spray pumps, brewing trough, distilling equipment, fishnets, diesel pumps, water tanks, beehives, trailers, graders, ax, slathers, hand hoes, spades, storage facilities, water tanks, bicycles, and radios.

The study found asset holding has a positive effect on the households’ consumption. This result is confirmed with the previous studies (Woldeyohanes et al., 2017; Bachewe et al., 2016; Berloff and Modena, 2013). The study also revealed that distance to the nearest market negatively determines the household’s consumption. It is obvious that when the distance to the nearest market decreases, the household’s access to price information will increase which discourages the market orientation behavior of the households. This is because the distance to the nearest market affects a household’s decision to engage in crop and livestock sales. This result is in line with the previous studies of Yonatan (2020) and Gemechu (2018). The agricultural extension contact has a positive effect on household consumption as the agricultural extension contact increases the households’ access to agricultural practices, methods and information will be raised. This has a positive contribution to agricultural production and hence a positive effect on household consumption. This result is confirmed with the previous studies (Nkgbe et al., 2018; Hussein and Janekarnkij, 2013; Nugasse et al., 2013; Gregory and Sewando, 2013). The households’ consumption will improve through promoting non-farm and off-farm rural livelihood diversification strategies (Dinku, 2018; Andualem et al., 2021).

The main livelihood negatively influences household consumption. This implies that the household who are mainly crop-based livelihood has lower consumption than other based livelihoods such as livestock, non-farm. This is because diversified livelihood enables households to have better income, enhance better consumption; this finding is consistent with the finding of Davis et al., 2014; Loison, 2015; Udoh and Nwibo, 2017; Gebre et al. (2018). The result also showed that both shocks (covariate and idiosyncratic) were found to have a negative

### Table 5. Test of equality of means of socio-economic and institutional characteristics.

| Variables            | Overall         | Consumption Quintile |
|----------------------|-----------------|----------------------|
|                      | 1st             | 2nd                  | 3rd                  | 4th                  | 5th                  | F-stat     |
| Land size (ha)       | 1.35            | 1.17                 | 1.37                 | 1.49                 | 1.63                 | 1.12       | 2.22**    |
|                      | (6.43)          | (2.88)               | (3.31)               | (3.31)               | (8.44)               | (3.40)     |
| Cultivated land (ha) | 1.391           | 1.18                 | 1.38                 | 1.55                 | 1.67                 | 1.16       | 2.34*     |
|                      | (6.30)          | (2.83)               | (3.24)               | (10.45)              | (7.85)               | (2.18)     |
| Livestock Holding (TLU) | 2.73          | 2.19                 | 2.7                  | 2.89                 | 2.90                 | 2.88       | 11.88***  |
|                      | (3.57)          | (2.59)               | (3.72)               | (3.53)               | (3.62)               | (4.11)     |
| Distance to main road (km) | 16.41       | 16.37                | 16.37                | 16.52                | 16.82                | 15.99      | 0.38      |
|                      | (21.98)         | (18.93)              | (21.10)              | (22.68)              | (23.55)              | (22.92)    |
| Distance to Pop. Center (km) | 40.49      | 40.89                | 39.51                | 40.54                | 40.07                | 41.33      | 0.66      |
|                      | (33.66)         | (28.31)              | (30.02)              | (34.06)              | (36.04)              | (37.75)    |
| Distance from nearest Market (km) | 66.37     | 84.26                | 65.28                | 61.76                | 61.96                | 60.62      | 73.47***  |
|                      | (50.55)         | (59.70)              | (46.66)              | (46.96)              | (94.84)              | (47.01)    |

Note: ***0.01% significant level: standard Deviation in the parenthesis based on pooled mean difference; mean differences by each wave. Source: Author’s calculation using ESS data 2011/12, 2013/13 and 2015/16 waves
influence on household consumption. Households that are less exposed to shocks have higher consumption than exposed ones. The study also found that covariate shocks are a relatively larger and more significant effect on households’ consumption than idiosyncratic shocks. This result is consistent with the findings of Carter (1997), Dercon and Krishnan (2000), and Sarris and Karfiks (2010).

A recent study in Ethiopia also showed that covariate and idiosyncratic shocks have the highest share of households’ vulnerability to poverty and covariate shocks play a larger relative role in drought-prone lowland areas (Skoufas et al., 2021). This is because idiosyncratic shocks affect only the members of an individual household as opposed to covariate shocks, which involve entire communities (Frankenberger and Nelson, 2013). Rural households in Ethiopia as a culture of supporting each other during a difficult time for idiosyncratic shocks, relatively covariate shocks have a higher impact.

### 3.4. Vulnerability status and income dynamics of the households

The results of the vulnerability profile were presented in Table 6 where this result was computed based on the estimated three-level mixed model, income mobility classification, and operation assessment of vulnerability stated under Eq. (7). The result revealed that 25.65 percent of the households were classified as vulnerable were approximately 20 percent of the household were highly vulnerable and 6 percent of the households were moderately vulnerable. In addition, 18.82 and 10.28 percent of the households were vulnerable to unobserved covariate and idiosyncratic shocks, respectively. This result is consistent with the result

Table 6. Vulnerability profile of the household by income mobility status.

| Vulnerability Status | Income mobility Status of the households | Downward | Immobility | Upward | Total |
|----------------------|----------------------------------------|----------|-----------|--------|-------|
| **Based on fixed effect** |                                        |          |           |        |       |
| Not Vulnerable       |                                        | 3.08     | 1.93      | 2.13   | 7.13  |
| Moderately Vulnerable|                                        | 37.63    | 26.47     | 25.82  | 89.92 |
| Highly Vulnerable    |                                        | 0.95     | 1.24      | 0.75   | 2.95  |
| **Based on the Random effect** |                                    |          |           |        |       |
| Total shocks         |                                        | 31.05    | 21.40     | 21.89  | 74.35 |
| Not Vulnerable       |                                        | 3.47     | 2.23      | 1.80   | 7.30  |
| Moderately Vulnerable|                                        | 3.27     | 2.23      | 1.80   | 7.30  |
| Highly Vulnerable    |                                        | 4.02     | 3.86      | 2.68   | 10.57 |
| **Covariate shocks** |                                        |          |           |        |       |
| Not Vulnerable       |                                        | 34.16    | 23.56     | 23.46  | 81.18 |
| Moderately Vulnerable|                                        | 3.47     | 2.23      | 1.80   | 7.30  |
| Highly Vulnerable    |                                        | 4.02     | 3.86      | 2.68   | 10.57 |
| **Idiosyncratic shocks** |                                      |          |           |        |       |
| Not Vulnerable       |                                        | 37.37    | 26.34     | 26.01  | 89.73 |
| Moderately Vulnerable|                                        | 3.47     | 2.23      | 1.80   | 7.30  |
| Highly Vulnerable    |                                        | 4.02     | 3.86      | 2.68   | 10.57 |

*Source: Author’s calculation using ESS data 2011/12, 2013/13 and 2015/16 waves.*

Table 7. Mixed-effects REML model results of determinants household consumption.

|                        | Coef. | St.Err | t-value | P-value | [95% C. Interval] | Sig   |
|------------------------|-------|--------|---------|---------|-------------------|-------|
| Sex of the household head | 0.011 | 0.030  | 0.36    | 0.722   | -0.048            | 0.069 |
| Age of the household head | 0.001 | 0.001  | 0.83    | 0.405   | -0.001            | 0.002 |
| Education Status       | 0.119 | 0.024  | 5.05    | 0.000   | 0.073             | 0.166 |
| Land size              | 0.004 | 0.004  | 1.19    | 0.236   | -0.003            | 0.012 |
| Livestock holding      | 0.035 | 0.003  | 11.02   | 0.000   | 0.029             | 0.041 |
| Household size         | -0.066| 0.005  | -12.85  | 0.000   | -0.076            | -0.056|
| Distance to nearest Market | -0.003| 0.000  | -13.87  | 0.000   | -0.004            | -0.003|
| Distance to major road | 0.002 | 0.001  | 3.53    | 0.000   | 0.001             | 0.003 |
| Irrigated use          | -0.002| 0.004  | -0.46   | 0.646   | -0.011            | 0.007 |
| Assets                 | 0.070 | 0.005  | 13.49   | 0.000   | 0.06              | 0.08  |
| Credit use             | 0.000 | 0.000  | -0.24   | 0.81    | 0.000             | 0.000 |
| Extension contact      | 0.087 | 0.023  | 3.82    | 0.000   | 0.132             | 0.043 |
| Idiosyncratic shock    | -0.055| 0.028  | -1.95   | 0.051   | -0.111            | 0.000 |
| Covariate shock        | -0.136| 0.023  | -6.01   | 0.000   | -0.092            | -0.181|
| Dependency Ratio       | 0.000 | 0.001  | 0.71    | 0.479   | -0.001            | 0.001 |
| Main livelihood        | -0.127| 0.044  | -2.89   | 0.004   | -0.214            | -0.041|

*Source: Author’s calculation using ESS data 2011/12, 2013/13 and 2015/16 waves.*

Note: *0.1 and **0.05% and ***10% significant level, respectively: standard Deviation in the parenthesis based on pooled mean difference; mean differences by each wave.

The results of the vulnerability profile were presented in Table 6 where this result was computed based on the estimated three-level mixed model, income mobility classification, and operation assessment of vulnerability stated under Eq. (7). The result revealed that 25.65 percent of the households were classified as vulnerable were approximately 20 percent of the household were highly vulnerable and 6 percent of the households were moderately vulnerable. In addition, 18.82 and 10.28 percent of the households were vulnerable to unobserved covariate and idiosyncratic shocks, respectively. This result is consistent with the result.
already indicated in Table 7 above that covariate shocks have a slightly higher influence than idiosyncratic shocks on household consumption. This is because covariate shocks were more uncontrolled, not specific as well as direct to individual households. A study by Catherine (2008) indicated that households can smooth consumption when idiosyncratic shocks hit but appear not to smooth consumption during covariate shocks.

Let’s now look at a more detailed classification of vulnerability; it can be observed that about 10.50 percent of downward income movers and 6.80 percent of upward income movers were classified as vulnerable to both shocks. The result also showed that about 7.49 percent of downward income movers were vulnerable to unobserved covariate shocks and 5.23 percent of upward income movers were vulnerable to unobserved covariate shocks. Likewise, about 4.28 percent of downward income movers and 2.68 percent of upward income movers were vulnerable to unobserved idiosyncratic shocks. The result is consistent with the findings of Krebs et al. (2013) where shocks have a higher influence on the downward income movers.

The results of the fixed effect part presented in Table 5 did not take into account time-invariant covariates and unobserved heterogeneity effect at the Woreda level. As the result, the estimated fixed part is higher than the random part. This estimate revealed that the majority of the households (92.87%) were classified as vulnerable to covariate and idiosyncratic shocks. In terms of income mobility status, the vulnerability is higher in downward income mover (38.38%) than upward income movers (26.57). This result is consistent with the findings of Mina and Imai (2016) where almost all households are classified as vulnerable based on the fixed effect result.

4. Conclusions

A recent estimate of income inequality, poverty and other welfare indicator showed an improvement in Ethiopia. However, the observed households‘ income dynamics will be full-frledged if the investigation has incorporated the vulnerability of the household to covariate and idiosyncratic shows because rural households in Ethiopia are frequently hit by several shocks resulting in consumption instability. The overall objective of the study was to generate evidence on households’ vulnerability to covariate and idiosyncratic shocks in Ethiopia.

This study used a balanced panel data collected by the World Bank in collaboration with the Living Standard Measurement Survey-Integrated Agricultural Survey (LSMS-ISA) that were randomly drawn from nine regions through a multi-stage sampling method. The survey has three rounds collected in 2011/2, 2013/4 and 2015/6. The panel has a total of 3969, 5262 and 4954 households from one, two and three waves, respectively. However, the study restricted the sample size due to missing information and a total of 9717 households were used for analysis.

The three-level mixed effect model result showed that education status of household head, household size, livestock holding, asset holding, distance to the nearest road, distance to the nearest market, extension contact, main livelihood, covariate and idiosyncratic shocks are the main factor which influences household consumption. The result of the three-level mixed-effect model was also used to constructed the vulnerability of the household and the profile showed that both covariate and idiosyncratic have considerable influence on households vulnerability covariate shocks has relatively higher impact.

Having literate households’ heads found to have higher consumption, hence less vulnerable than illiterate household heads because education has a better opportunity to have access to information, skill and practices. Therefore, it is important to promote and support education both formal and non-formal considering the situations of rural households.

Livestock plays an important role in rural households including sources of food, energy, income and generator of development in most cases. As the livestock holding increase, the households’ source of income and consumption will also increase. Thus, policy should encourage the livestock sector to bring the required output. This can be done by improving access to facilities and institutions targeting livestock including market, health, feed and information.

Total household size has a significant and negative effect on household consumption. A household that has a larger household size has a lower probability of consumption, hence higher vulnerable. Therefore, it is very pertinent to promote, support and strength the family planning program as well as investigate the more detailed study on the merit and demerits of household size on income, consumption, and other welfare indicators.

The study also revealed that asset holding has a significant and positive effect on household consumption. The asset holding is linked mainly for agricultural production that will lead to taking a path for improving the income of the rural households. As the household’s asset holding increases, the household’s income sources, consumption smoothing and livelihood options will increase. Thus, policy should promote certain key assets that will influence the economic choice of rural households.

The finding also revealed that distance to the nearest market negatively influences the household’s consumption. Market distance has implications on the households’ decision to participate in marketing due to its role in access price information and the cost of transportation. Therefore, it is vital to promote the establishment of market place considering the rural household’s situation, promote collective action such as cooperatives and support the market infrastructures.

Whereas, agricultural extension services were found to have a significant and positive effect on household consumption. It is believed that agricultural extension has a positive contribution to agricultural production and productivity due to its role in accessing agricultural practices, methods and information on agriculture-related activities. Therefore, it is recommended that the current extension system should be strengthened and supported by finance, training and monitoring.

The finding of this study also showed that crop-based main livelihood negatively influences household consumption. This is because non-diversified livelihood enables households to have lower income, enhance lower consumption. Therefore, it is important to promote and support households diversify income through non-farm and off-farm rural livelihood diversification strategies.

Regarding exposure to covariate and idiosyncratic shocks, the study found that it has a negative and significant effect on upward income mobility as well as on consumption. Rural households face several misfortunes where they are exposed to economic, social, environmental and political shocks that repeatedly affect agricultural production and economic activities which will reinforce expose downward income mobility.

Thus, rural household in Ethiopia has suffered from frequent covariate and idiosyncratic shocks. Through the implementation of a social protection strategy that may include shock prevention, ex ante social insurance, and ex post social assistance, the government and the international aid community can lessen the detrimental consequences of these shocks on the food security of vulnerable. Social protection enables disadvantaged groups to better manage their shocks and contributes to the connection between development and alleviation.

Declarations

Author contribution statement

Yalfal Temesgen: Analyzed and interpreted the data; Wrote the paper.
Mengistu kejeta: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data.
Aleign Ademe: Contributed reagents, materials, analysis tools or data.

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Data availability statement

Data associated with this study has been deposited at https://www.worldbank.org/en/programs/lsm.

Declaration of interest's statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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References

Abafit, J., Kim, K., 2014. Determinants of household food security in rural Ethiopia: an empirical analysis. J. Rural Dev. 37, 129–157.
Abrahm, A., Bauer, S., 2012. Poverty Dynamics and Vulnerability: Empirical Evidence from Smallholder Northern Highlands of Ethiopia’ Paper Presented at the International Association of Agricultural Economists (IAAE) Triennial Conference. Fofo Iguazu, Brazil.
Andahkie, E., Endris, E., Yildiz, F., 2021. Review on livelihood diversification and food security situations in Ethiopia. Cogent Food Agric 7, 1.
Asfaw, S., Shiferaw, B., Simtowe, F., Lipper, L., 2012. Impact of modern agricultural technologies on smallholder welfare: evidence from Tanzania and Ethiopia. Food Pol. 37, 283–295.
Bacheew, F.N., Berhane, G., Minten, B., Taffesse, A.S., 2016. Non-farm Income and Labor Markets in Rural Ethiopia. ESSP Working paper No. 90.
Bedek, S.B., Vanhove, W., Wordola, M.G., Natarajan, K., Van Damme, P., 2020. ‘Vulnerability to climate change among mixed-dependent smallholders in three districts of Ethiopia’ Environ. Dev. Sustain 22, 603–718.
Berloffa, G., Modena, F., 2013. Income shocks, coping strategies, and consumption smoothing: an application to Indonesian data. J. Asian Econ. 24, 158–171.
Bersisâ, M., Hohtamâ, A., 2016. Poverty and Wellbeing in East Africa a Multi-Faceted Economic Approach. Springer International Publishing Switzerland.
Birhan, S.D., Tesfahun, A.K., 2017. Rural households’ vulnerability to poverty in Ethiopia. J. Poverty 22, 1–15.
Bogale, A., 2012. Vulnerability of smallholder rural households to food insecurity in Eastern Ethiopia. Food Secur. 4 (4), 581–591.
Bogale, A., Shimelis, A., 2009. Household level determinants of food insecurity in rural areas of Dire Dawa, eastern Ethiopia. Afr. J. Food Nutr. Sci. 9, 9.
Calvo, C., Dercon, S., 2013. Vulnerability to individual and aggregate poverty. Soc. Choice Welfare 41 (4), 721–740.
Carer, M., 1997. Environment, Technology and the Social Articulation of Risks in West Africa.
Catherine, P., 2008. Examining the Impact of Idiosyncratic and Co-variate Shocks on Ethiopian Households’ Consumption and Income Source.
Chaudhuri, S., 2002. Empirical Methods for Assessing Household Vulnerability to Poverty. mimeo, Department of Economics, Columbia University, New York.
Chaudhuri, S., 2003. Assessing Vulnerability to Poverty: Concepts, Empirical Methods and Illustrative Examples. mimeo, Department of Economics, Columbia University, New York.
Christiaensen, L., 2000. Measuring Vulnerability and Food Security: Case Evidence from Mali, Department of Agricultural, Resource and Managerial Economics, Cornell University, Ithaca.
Christian, D., Katsushi, I., 2015. Estimation of vulnerability to poverty using a multilevel longitudinal model: evidence from the Philippines. J. Dev. Stud. 53, 1–27.
Mitiku, A., Fufa, B., Tadesse, B., 2012. Empirical analysis of the determinants of rural households food security in Southern Ethiopia. Issue No. 6.
Kebede, E., Goujon, A., Lutz, W., 2019. Stalls in Africa’s fertility decline partly result from disruptions in female education. Proc. Nat. Acad. Sci. 116 (8), 2891–2896.
Klassen, S., Lichtenfeld, T., Pove, F., 2015. Feminization of vulnerability? Female headship, poverty, and vulnerability in Thailand and Vietnam. World Dev. 71, 36–53.
Krafft, S., Hueselsbuech, C., Brooks, B., Kaufmann, B., 2013. Pastoralism: a critical asset for food security under global climate change. Animi. Front. 3, 42–50.
Kreb, T., Krishna, F., William, F., 2013. Income Risk, Income Mobility and Welfare. Documento CEDE No. 2013-0.
Laniov, P., Ravallion, M., 1995. Poverty and household size. Econ. J. 105, 1415–1434.
Ligon, E., Schechter, L., 2002. Measuring Vulnerability. Berkeley, University of California.
Loano, S.A., 2015. Rural livelihood diversification in sub-saharan Africa: a literature review. J. Dev. Stud. 51 (9), 1125–1138.
Lovo, S., Veronese, M., 2019. Crop diversification and child health: empirical evidence from Tanzania. Ecol. Econ. 159, 168–179.
Mina, C., Imai, K., 2016. Estimation of vulnerability to poverty using a multilevel longitudinal model: evidence from the Philippines. J. Dev. Stud. 53, 1–27.
Nygebe, P.K., Acar, A., Abu, B.M., Utzarn, Y., Setsoua, H., Abdul-Wahab, S., 2018. Rural non-farm engagement and agriculture commercialization in Ghana: complements or competitors? In: Partnership for Economic Policy ‘Working Paper No. 2018-07.
Ngung, W., Huyenbroeck, G., Buyse, J., 2013. Household food security through cooperatives in northern Ethiopia. Int. J. Cooper. Stud. 2, 34–44.
Pritchett, L., Suryahadi, A., Sumarto, S., 2000a. Quantifying Vulnerability to Poverty: A Proposed Measure, with Application to Indonesia. World Bank. Washington, DC. WB Policy Research Working Paper 2457.
Pritchett, L., Suryahadi, A., Sumarto, S., 2000b. Quantifying Vulnerability to Poverty: A Proposed Measure, with Application to Indonesia. SMERU Working Paper.
Sarris, A., Karfakis, P., 2010. Household vulnerability in rural Tanzania. FAO Commodities and Trade Policy Research Working Paper No. 17.
Seipt, J., Padgham, J., Kulkarni, A., 2013. Capacity building for climate change risk management in Africa: encouraging and enabling research for informed decision-making. Environ. Dev. 5, 1–5.
Sen, A.K., 1997. Choice, Welfare and Measurement. Harvard University Press.
Singh, R., Works, M., Bogale, S., Callis, A., Adem, A., Irvin, B., Lim, S., Bosi, L., Venton, C., 2016. Reality of Resilience: Perspectives of the 2015–16 Drought in Puntland. IFPRI Discussion Paper No. 66.
Skoufias, E., Vinha, K., Berhe, B., 2021. Quantifying Vulnerability to Poverty in the Drought-Prone Lowlands of Ethiopia.

Y. Temegen et al.
Teka, A.M., Woldu, G.T., Fre, Z., 2019. Status and determinants of poverty and income inequality in pastoral and agro-pastoral communities. Household-based Evidence from Afar Regional State, Ethiopia. World Dev. Perspect. 15, 100123.

Tefaye, W., Thomas, H., Yves, S., 2015. Effect of off-farm income on smallholder commercialization: panel evidence from rural households in Ethiopia. Agric. Econ. 48 (2), 207–218.

Tessema, I., Simane, B., 2019. Vulnerability analysis of smallholder farmers to climate variability and change: an agro-ecological system-based approach in the Fincha’a sub-basin of the upper Blue Nile Basin of Ethiopia. Ecol. Process 8, 1–18.

Udoh, N.E., Nwibo, S.U., 2017. Socio-economic determinants of rural non-farm households’ income diversification in southeast Nigeria. Int. Res. J. Fin. Econ. 164, 1116–1128.

Wassie, B., 2019. Assessment of Vulnerability to Persistent Deprivation: Evidence from A Peripheral Pastoralist Population in Ethiopia. African Economic Research Consortium, Research Department. Working Papers 374.

Woldeyohanes, T., Heckelei, T., Surry, Y., 2017. Effect of off-farm income on smallholder commercialization: panel evidence from rural households in Ethiopia. Agric. Econ. 48 (2), 207–218.

World Bank, 2015. A measured approach to ending poverty and boosting shared prosperity. The World Bank, Washington DC.

Wossen, T., Berger, T., Swanikannu, N., Ramlan, T., 2014. Climate variability, consumption risk and poverty in semi-arid northern Ghana: adaptation options for poor farm households. Environ. Dev. 12, 2–15.

Yonatan, D., 2020. Off-farm activities, incomes and household welfare in rural Ethiopia. AAU. PhD Dissertation.