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# EFFECTS OF RESILIENCE CAPACITY IN REDUCING FOOD INSECURITY AMONG INFORMAL MINERAL MINERS IN TIGRAY REGION, ETHIOPIA

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**ABSTRACT**

The study examined effects of resilience capacity in reducing food insecurity among informal mineral miners in Asgede Tsimbla and Chila districts. Data was collected from a survey of 534 sampled households. Both descriptive and econometric analyses were used to examine effects of resilience capacity on food insecurity, including *resilience capacity index. The study found out that* 55.4% and 20.56% of miners in Asgede Tsimbla and Chila faced calorie deficiency respectively. The econometric result showed crippling idiosyncratic and covariate shocks adversely impacting food insecurity, whilst deteriorating resilience capacities worsens food insecurity. *Food insecure households possessed fewer resources and benefitted less from resilience capacities.* Household characteristics, land rent out, indebtedness and less proximity to towns affects food insecurity. Non-farm income, remittances, and literacy helped to address it. *The study posits expanding nonfarm economy, linking miners to markets, formalizing informal mining practices and measures to enhance environmental sustainability and sustainable development are essential.*

**Keywords**: informal mineral mining, minerals, miners, resilience building, food insecurity, informality, practices

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## INTRODUCTION

Informal mining, commonly known as artisanal and small-scale mining (ASM), has been deeply embedded in global mineral extraction since ancient times. Archaeological evidences indicate that its presence across various civilizations, where gold and other precious stones were extracted through rudimentary methods (Ofosu et al., 2022; Weldegiorgis et al., 2018). The practice has been prevalent in many regions across the globe, often driven by individuals or small groups aimed at extracting valuable minerals such as gold, diamonds, and gemstones (World Bank, 2021; Hilson, 2002). Over the millennia, informal mining practices have evolved in response to changing socio-economic and technological landscapes, shaping both local economies and global mineral supply chains. It is predominantly categorized in the informal economic sector where workers around the world who use their hands, basic tools and low-tech equipment to extract vital minerals from the crust of earth (ILO, 2009).

Ethiopia is believed to have huge potentials of minerals, and substantial workforce is engaged informally in the mining sector (Stollreiter and Traub-merz, 2023; Tadese, 2015). Indeed, mining dates back to prehistory and spanned into the famous civilizations of Punt, Da'amat, and Axumite eras (Gebreselassie, 2020). Although somehow cautious, Wolbert SMIDT and Gebremichael (2012) also indicated that gold mining had been practiced during the Axumite kingdom and they used to export it to different places. During the medieval ages and to date, the mining sector entails to be the sphere where informal and formal mining practices co=exist for differing purposes and with their own distinctive features. According to IGF (2017), over 450,000 Ethiopians were engaged in the informal mining sector supporting over 2.25 million lives. Despite this, however, the share of t industry to the GDP has been less than 1% as per recent years.

The link between informal mining and food security is seemingly driven by the confluence of multiple factors. Mining activities may generate direct or indirect employment opportunities and provide better access to income for rural households living in remote areas. The practice necessitates infrastructural growth as there appears a need to link mining sites and markets with which miners and the minerals extracted are benefited from such a linkage. Miners are extracting minerals that allows the growth in household income which is likely to promote food security among informal miners. In contrast, mining activities may increase the vulnerability of rural livelihoods by prompting large scale agricultural land dispossession and subsequent loss of food production and environmental costs, pollution or water shortage, raising living expenses, and structural labor market shifts (Hilson, 2002). Empirics extensively documented the augmentative role of artisanal mining on poverty reduction in sub-Saharan Africa (Adranyi et al., 2023; Baffour-Kyei et al., 2021; Huntington and Marple-Cantrell, 2022; Wegenast and Beck, 2020). Nevertheless, the protective role of building resilience capacity in protecting informal miners from food insecurity is at best scanty.

A critical observation of the historical evolution of informal mining practices reflects a complex interplay of economic, social, and environmental factors with both positive contributions and adverse effects. Regardless of the myriad of challenges, such as environmental degradation, labor exploitation, and conflicts over resource ownership, informal mining practice substantially contributes to enhancing resilience capacity for food security. Despite a wealth of literature exploring the relationship between mining and agriculture and its implications for food security, a significant gap remains in scrutinizing the role of building resilience capacity on enhancing food security. The potential impacts of informal mining on food security in Ethiopia remain rarely understood.

Tigray is one of the mineral rich regions in Ethiopia. The mining practices encompass a range of activities, including traditional informal mining and larger-scale operations. To date, informal mining is an extensively occupied sector in the

region. Although practiced in a hazardous manner, this sector is a source of alternative employment for many (Hagos et al., 2016 Birhane, 2017; Gebreselassie, 2020). Informal mining is predominantly practiced in the Northwestern and Central Zones of the region.

Despite the significance of informal mining in employment creation, livelihoods and contributions to economic growth and subsequent challenges to this sector are myriad. The sector in addition to being labeled informal, it also lacks vivid characterization worldwide that lead to standardized and robust interventions. Little attention is given to scientifically characterizing informal mining practices and miners. This article discovers the characteristics of informal mining practices and miners by taking two districts in two zones of Tigray, Ethiopia as case studies. The study utilizes quantitative and qualitative primary data collected through survey, interviews, discussions and observations. The article reinforces some established thinking such as informal mining being a source of direct employment and short-term livelihoods, adverse effects and the need for formalization of the sector. The added value of this article lies in its effort to characterize the practice itself and the miners (those involved in the practice). It clearly stipulated both and their implications. By doing so, the article contributes in furthering the literature on informal mining practices.

## THEORETICAL REVIEW

Mineral mining, irrespective its dimensions as being formal or informal, is linked to economic growth and development in a lens of development practice (Todaro and Smith 2020). The practice is aligned with miners' livelihoods or income, government revenue and employment opportunities. Managing these interrelated issues will be subsumed in the discussions related to the concept and theory of development in general and sustainable development in particular (Maconachie & Conteh 2021). Exploring the theoretical foundations of the concept of sustainability and sustainable development remains very complex and difficult to capture in a very concise way. An attempt to track the historical and theoretical origin of sustainability by Purvis, Mao, and Robinson (2019) makes it clear that the literature dwells too much in an interwoven fashion, but argued that the 'three-pillar' conception on 'sustainability' (sustainable development) is indicated as a dominant interpretation of the relationships and commonalities amongst them. The rational for the complexities and lack of clarity is related to various interpretations that remained to be context dependent implications.

This research draws on the ideas of the Brundtland Report (1987), by the World Commission on Environment and Development (WCED) for the theoretical expiations needed in this research. The concepts comprised in the report provide insights on how multidimensional development practice shall be managed to address the issue of sustainability in order for the scarce environmental and livelihood assets and resources be conserved and used by successive generations. It has vividly elaborated the concept of Sustainable Development as "… development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland Report 1987). The concept of 'needs', in this elaboration, is very instrumental as it helped to explain the economic status of informal mineral miners who are regarded as eking out a living with inadequate resources and poor level of living (Sultanova, 2024). The Global Multidimensional Poverty Index (2024) by United Nations Development Program (UNDP) and Oxford Poverty and Human Development Initiative (OPHI) provided statistics that regarded the rural communities in developing countries as poor. It is indicated that about 83.7 percent of poor people in the world are living in rural areas and 83.2 percent of the world's 1.1 billion multidimensionally poor people are living in Sub- Saharan Africa and South Asia and Sub - Saharan Africa alone comprise about 553 million people living in poverty (UNDP and OPHI 2024). This has indicated the aim of sustainable

development as squarely targeting at reducing poverty (Todaro and Smith 2020). In line with this, the reach examined how the three-pillars model of sustainability as part of a theoretical framework to explain the practice of informal mineral mining practices in the study areas. In so doing, the social, environmental and economic spheres or pillars are deemed to have sustainability dimensions and implications (Thompson 2017, cited in Purvis, Mao, and Robinson 2019). The research argued there exists strong alignment between mining as a development practice to have effects on the environment as it causes depletion and destruction of resources in the two case study districts (Hailemariam Meaza 2015 and Cheepurupalli 2022). The environmental impact of quarrying and informal nature of marketing minerals is in no way compatible with the current state of environmental policy and development perspective. The Social dimension of the model characterizes miners as a group of landless poor who maintain no legal licenses and without any institutional mechanisms to facilitate their engagement with the environment (Hailemariam Meaza 2015). Informality prevents commercializing minerals in formal markets and hence, makes their own income and revenue to local governments to remain very low. This process keeps economic growth to be limited and miners' resilience capacity to cope up with shocks and food insecurity very low (Cheepurupalli 2022).

The article is organized as follows: Section 2 outlines empirical strategies employed after a brief description of the data and techniques for estimating the resilience capacity index. Section 3 thoroughly discusses the major findings of the study. Concluding remarks and the policy implications are presented in the last section.

## METHODOLOGY

### Description of the Study Area

The study was conducted in two districts of the Tigray region of Ethiopia, namely *Asgede Tsimbla* and *Chila*. The districts are located in Northwestern and Central zones of Tigray respectively. They are depicted in the following GIS based maps.

***Asgede Tsimbla*** Woreda, located in the Northwestern Zone of TNRS, Ethiopia, is bordered by Medebay Zana to the East, Tahtay Koraro to the Northeast, Tselemti to the South, Wolkait to the West, and Tahtay Adiyabo and Laelay Adiyabo to the North. According to the Federal Democratic Republic of Ethiopia Population and Housing Census of 2007, the population of the study area is 135,561. As of 2016, the estimated population has increased approximately to166,062, considering the average annual population growth rate of 2.5% in the Tigray region. Covering an area of 2815.05 sq. km, the district is home to approximately 21,495 farmers, each holding an average of 1.27 hectares of land. Additionally, Asgede Tsimbla Woreda is renowned for its traditional gold mining activities, which have emerged as a significant source of gold for the National Bank of Ethiopia (Hagos et al., 2016; Gebreselassie, 2020).

***Chila*** is a hot lowland woreda located 35 kilometers northwest of the town of Axum, in the Central Zone of Tigray. The woreda has a diverse socioeconomic profile that reflects the development and living conditions of the population. The primary economic activity of the community in the woreda is agriculture. Crops such as "Dagusa" (a local variety), sorghum, corn, and occasionally "Taff" are cultivated by the residents. Apart from agriculture, the community is also involved in rearing domestic animals, goat, cattle, and others. Chila woreda is rich in natural resources, including gold, sapphire, granite, iron, and various stones. Mining activities, particularly informal mining, play a significant role in the local economy. About *400 people* are estimated to be engaged in informal mining activities in the woreda. The mining activities are conducted in a traditional manner, indicating that there might be challenges related to modern extraction methods. Miners go deep up to 10-15 meters on average and use traditional materials for mining purposes. Controlling

informal mining practices in Chila Woreda is difficult. The absence of regulations and rules poses challenges to managing and overseeing these mining activities. There is a need for regulatory measures to control and manage informal mining. Establishing rules and regulations can help mitigate the challenges associated with unregulated mining activity. Encouraging sustainable mining practices that consider environmental and social impacts would be essential for the long-term well-being of the community.

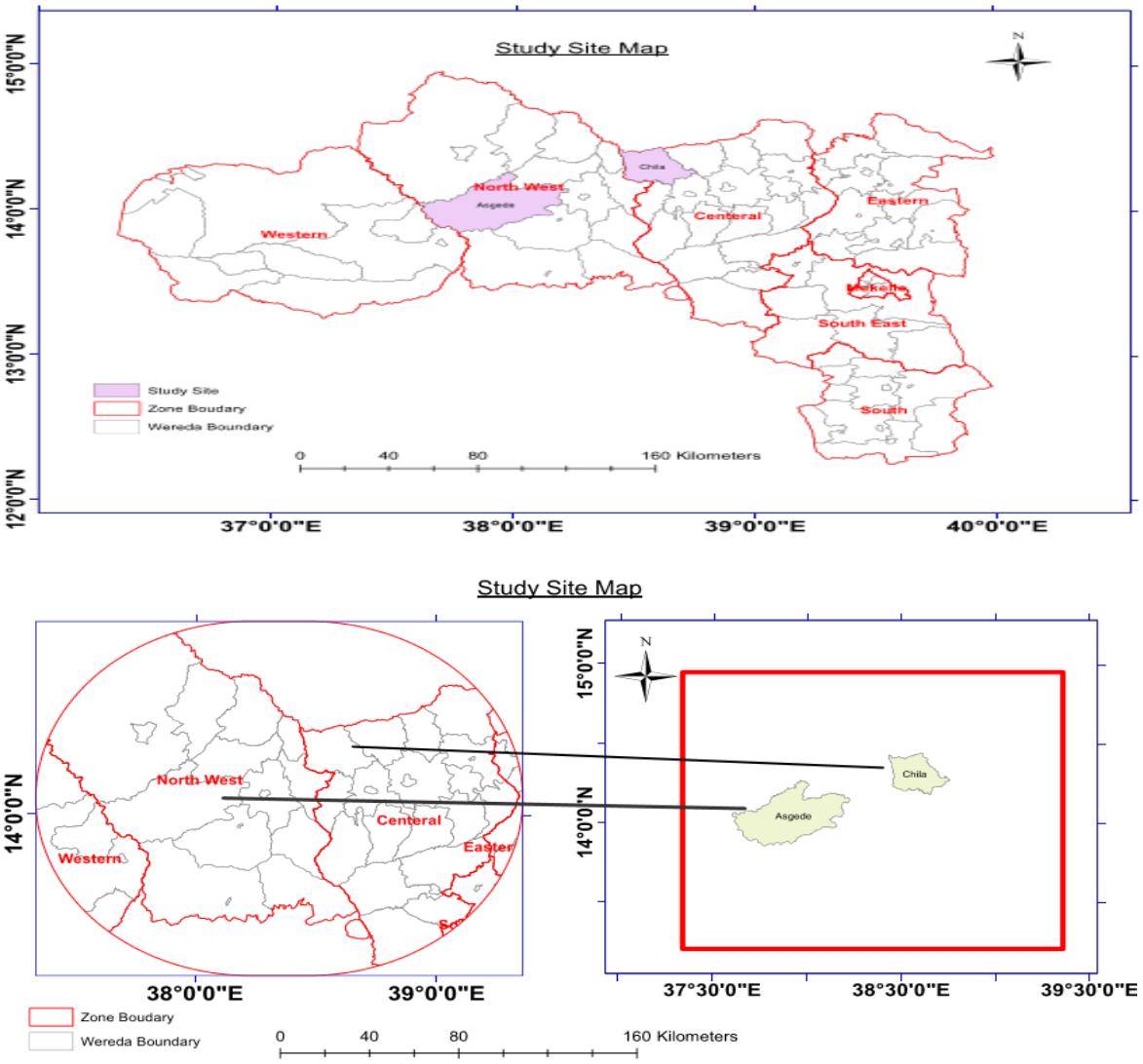


Figure 1: Map of study areas

**Method of Data Collection**

The study employed cross sectional data in quantitative approaches. A structured questionnaire was used to collect the demographic, socioeconomic and institutional characteristics involving household heads and/or their spouses from Asgede and Chila districts in Tigray region. Primary data were collected by trained enumerators who were well conversant and knowledgeable about the area using standardized and well-structured questionnaire, Key Informant Interviews (KIIs) and Focus Group Di (FGDs). The questionnaire was originally developed in English and then translated into Tigrigna language and then pre-tested on a few respondents and necessary amendments were made before starting the actual survey.

**Sample Size Determination and Sampling Strategy**

For this particular study, Kothari's (2004) formula for an unknown population was used to determine the sample size. Since the theme of the study is informal activities, it is difficult to determine the target population (informal miners) of the study precisely. For Kothari (2004), the sample size for an unknown population can be computed as follows: $n = \frac{Z^2 . p . q}{e^2}$

In this formula, the Z value of the normal curve of 95% confidence level, that is, 1.96 and the precision level of 0.05 was used. As per the advice of scholars such as Kothari (2004), since population variability is not known with confidence, 0.5 (50%) of population variability (p) was considered. Inserting the figures into the formula it is computed, as described below, and found out a sample size of 384 households.

$$\mathrm{n} = \frac{(1.96)^2 .\ 0.5\ .\ (1 - 0.5)}{(0.05)^2} = 384$$

Considering 10% contingency for non-response, a total of 420 mining households were selected from the sampling frame that was developed with the consultation of concerned bodies in the study area. The sample was distributed to two districts (Asgede Tsimbla and Chila) equally, as the population of informal miners is more or less similar. Besides, the recent (2020) restructuring of local government administration (district administration) by the Tigray regional state narrowed the population size gap between districts. The sample has also included participants who provided inputs during the focus group discussions, key informant interviews. The key selection criterion for FGD participants was being an active practitioner of informal mining in the study sites whereas the criteria to select key informants was two-fold, i.e., first the research selected the district level administrators that have mandates related to foreseeing and/or managing mining related tasks. Secondly, experts working on a position that is related to minerals and mining related roles were selected. In-depth interviews were also conducted with miners on the sites.

**Methods of Data Analysis**

**Food Insecurity Measures**

To underpin the problem of food insecurity, the concept and measurements have been evolved over the last few decades. Dated back to the World Food Conference of 1974, food insecurity began to be framed with food supply with a particular notice of food availability and price stability (Shaw, 2007). A few literatures in Ethiopia employed food availability in quantifying food insecurity: consumption measures (Maxwell, Vaitla, Tesfay, & Abadi, 2013; Souza & Jolliffe, 2016), costs required to achieve the daily minimum dietary requirement (Sileshi et al, 2019), and anthropometric indicators (Sisha, 2020).

Gradually, the supply side conception has strongly been criticized by Sen (1981) for its food entitlement failure, thus introduced a food accessibility dimension. Hence, food security becomes a combination of ownership, exchange possibilities, and food availability. Following these critiques, FAO (1983) elaborated a new conception of food security built on availability, accessibility, and stability pillars. Likewise, the World Bank in its 1986 policy report emphasizes the importance of individual access to sufficient food and the transitory and chronic aspects of the problem. A few studies in Ethiopia tried to measure food security encompassing accessibility and availability dimensions (Birhanu and Zeller, 2009).

Following the 1996 world food summit, the importance of the nutritional value of the diet and the inability of a single indicator in fully capturing all aspects of food security has been emphasized. With heightened awareness and vulnerability to risks of food shortages, a more comprehensive and multidimensional approach to the concept and measurements of food

security are rapidly proliferating. Accordingly, food security as a cross-cutting and complex phenomenon, goes beyond a simple fact of food availability to encompassing pillars of availability, accessibility, utilization, and stability, each capturing different, but overlapping dimensions of the incident (Shaw, 2007). It adds the socio-cultural acceptance of food and captures the temporal dimension of all pillars.

In this study, food insecurity is measured with food energy consumption, food poverty, and multidimensional approaches. Food energy consumption and food poverty followed a standard procedure of the Cost of Basic Needs approach. The food energy consumption is estimated by multiplying the quantities of locally accepted staple food consumed by the households by the Ethiopian Health and Nutrition Research Institute[2] energy conversion factors. Average daily calorie consumption per adult equivalent is then computed by dividing each household's average daily caloric consumption by household number, adjusting for age and sex using Ethiopia Central Statistical Agency equivalence scales (CSA, 2012). Households who consumed below the minimal nutritional requirement (2200 kcal) were deemed to be food insecure, and otherwise, food secure. The food poverty, on the other hand, is computed using bundles of food items that provide nutritional threshold at the lowest cost under prevailing prices (MoFED, 2017). The cost of meeting this food energy requirement defines the food poverty line (Haughton and Khandker, 2009). Households who were able to cover the cost of this bundle were food non-poor, and otherwise, food poor. Given information on food energy and food poverty measures, aggregating summary measures of food insecurity is the next issue. The incidence, intensity, and severity of food insecurity were computed following the Foster, Greer, and Thorbecke (1984) indices. The mathematical expression of the model is specified as:

$$P_\alpha = \frac{1}{N}\int_1^q \left[\frac{Z - Y_i}{Z}\right]^\alpha ; \ \alpha \geq 0$$

where; $P_\alpha$ is the food insecurity measure, Z is the daily calorie threshold or food poverty line, $Y_i$ is daily calorie consumption per adult equivalent or food poverty of rural households, N is sample population, q is the number of food insecure, $\alpha$ is the food insecurity aversion parameter.

**Resilience Measurement**

Given the fact that resilience is a latent variable, quantifying it remains controversial. There is a rapidly growing literature in employing different modeling approaches to quickly capture and articulate resilience in policy-relevant ways. Based on the weight and meaning given to concepts, many researchers employed different multistage approaches: Factor Analysis, Principal Component Analysis, and Structural Equation Modeling (Giuseppe and Di Errico, 2018; Mekuyie et al, 2018; Tefera et al., 2017; FAO, 2016; Alinovi et al, 2010). SEM uses a factor analysis to measure the latent pillars, while simultaneously using regression to identify relationships among the latent variables (StataCorp, 2019). It is limited to the normally distributed observed variables in continuous form. Since the majority of observed variables used for estimation have mixed measurement scales, multivariate techniques are advantageous (Bennett and Bowers, 1976).

When the datasets are multidimensional and redundant while the order of variables does not have significant meaning attached to it, the analyses are often done through the standard tools for dimensionality reduction tools: Principal Component Analysis (PCA) and Treelet Transformation (TT). The previous studies employed dimensionality reduction techniques to computing Resilience Capacity Index (Giuseppe and Di Errico, 2018; Mekuyie et al., 2018; Tefera et al., 2017; FAO, 2016; Alinovi et al, 2010). This study computed resilience using a two-stage procedure. In the first stage, each

[2] The food consumption data were converted into kilocalorie using the nationally standardized food composition table manual obtained in hard copy.

pillar is measured through FA. The choice of variables adopted for estimating each pillar, on the other hand, depends on the empirics, availability of data, context analysis, and statistical properties `of the variables. Measuring the different components separately makes the model more flexible, permits the inclusion of prior information, and solves the parameter identification problem (Alinovi et al, 2010).To measure the latent pillars, relevant variables were selected based on the factor loadings and other statistical criteria. Variables having a Kaiser-Meyer-Olkin (KMO) statistic greater than or equal to 0.5 are retained. Once each pillar is estimated, they are used as covariates in the construction of the resilience capacity index. In the second stage, the resilience index is estimated using the latent pillars through FA. In this study, the resilience capacity index is computed from four pillars. Specifically, the resilience capacity of a household i is estimated as:

$$RCI_i = f(ABS_i + AST_i + AC_i + SSN_i + \in_i)$$

where the RCI of a household at time i is a function of such pillars as access to basic services (ABS), assets (AST), adaptive capacity (AC), and social safety nets (SSN), as well as time-variant and time-invariant household characteristics and responses to shocks.

**Descriptive Statistics**

The unit of analysis of this study is the household that engages in informal mining or informal mineral extraction activity and permanently lives in the selected districts (migrant households were not included due to their mobility). Descriptive statistical analysis techniques (frequencies, percentages, means, and standard deviations) and data presentation methods (tables, graphs, and charts) were used.

**Econometric Model**

To assess the effect of resilience capacity on household food insecurity among informal miners in Tigray, a limited dependent variable model was estimated. Several demographics, socioeconomic and institutional characteristics were included as potential predictors of food security. The regression results were additionally reported as marginal effects at the means of the independent variables to illustrate the change of the probability of food insecurity for a unit change in the covariates, ceteris paribus. Regression techniques were generally a powerful tool to identify what is directly associated or 'proximate' of food insecurity, but are less well able to identify deeper causes. [37] The dependent variable is binary whereby the sample household were categorized into food insecure (y = 1) and food secure (y = 0) on the basis of multidimensional food insecurity threshold. Logistic regression model is commonly recommended as an appropriate probability model in such a situation. The model is mathematically specified as;

$$\prod(x) = \mathrm{E}\left(\mathrm{Y} = \frac{1}{\mathrm{X_i}}\right) = \frac{1}{1 + \mathrm{e}^{-(\beta_1 + \beta_2 \mathrm{X_i})}}$$

Where; e the base of the natural logarithm which is approximately equal to 2.718, $X_i$ the $i^{th}$ explanatory variable, $\prod(x)$ is the probability that an individual will make a certain choice gives $X_i$ and α and β are regression parameters to be estimated. The probability that a household belongs to the food secure will be $(1 - \prod(x))$.

$$(1 - \prod(x)) = \frac{1}{1+e^{z_i}} \quad \text{Where; } \mathrm{Z_i} = \alpha + \beta_i \mathrm{X_i}$$

Therefore, to get linearity both in variable and in parameters the natural log of the odd ratio should be taken. As p goes from 0 to 1, the logit goes from – α to α. That is, although the probabilities lie between 0 and 1, the logit Z are not so. The model can be estimated through iterative maximum likelihood procedure. The coefficient of the logit model represents the change in the log of the odds associated with a unit change in explanatory variable.

$$\mathrm{Z_i} = \beta_0 + \beta_1 \mathrm{X_1} + \beta_2 \mathrm{X_2} \ldots\ldots\ldots\ldots\ldots + \beta_n \mathrm{X_n} + \mathrm{U_i}$$

Where; $Z_i$ is food insecurity status of households; $X_1$, $X_2$…… $X_n$ are the explanatory variables; $\beta_0$ is intercepted terms; $\beta_1$, $\beta_2$ ……. $\beta_n$ are the partial regression coefficients of parameters; I is the $i^{th}$ observation; and $U_i$ is the stochastic disturbance or the error term. If the disturbance term is taken in to account, the logit model becomes:

$$Z_i = \alpha + \sum \beta_i X_i + U_i$$

Multicollinearity has been checked before running the model using Variance inflation factor (VIF) and contingency coefficients (C). VIF shows how the variance of an estimator is inflated by the presence of multicollinearity. Each selected continuous variable is regressed on the other, so that the coefficient of determination ($R^2$) would be constructed. According to Gujarati [38] a variable is said to be highly collinear, if $R^2$ exceeds 0.9 or VIF exceeds 10. VIF is expressed as; $VIF = \frac{1}{1-R^2}$

On the other hand, the contingency coefficients were calculated as follows: $C = \sqrt{\frac{\chi^2}{N+\chi^2}}$

Where; C is the contingency coefficient, $\chi^2$ is chi - square and N is total sample size. The values of C range between 0 and 1, zero indicating no association between the variables and values close to 1 indicating a high degree of association, which means high degree of multicollinearity.

**Definition and Hypothesis of Variables**

The dependent variable for this study was food insecurity, which is dichotomous with an expected value of 1 indicating the probability of food insecurity and 0 otherwise. Food insecurity was hypothesized to be a function of the following explanatory variables, selected on the basis of review of literature, past research findings, experts and authors' knowledge of the food insecurity in the area.

***Resilience capacity:*** Tigray is exposed to various shocks that result in food insecurity or jeopardize the lives and livelihoods of millions of households (Knippenberg and Hoddinott, 2017). A growing number of organizations respond differently to these shocks. Humanitarian assistance is critical for saving lives and livelihoods, alleviating sufferings, and maintaining human dignity. However, they often arrive late and there is increasing recognition that these types of response are reactive or redemptive in nature, short-run, costly and less sustainable. Those interventions also function in a silo. Therefore, the persistent effect of shocks that many interventions failed to address spurred the interest of resilience in the development practice. Resilience is hypothesized to ameliorate food insecurity.

***Age of the household head:*** As age of a household head increases, it is assumed that households could acquire more knowledge and experience. However, they became more risk averter and their chance to stay in persistent welfare problem increases with age. Thus, it is hypothesized that age of the household heads and food insecurity is positively correlated**.**

**Female headship:** Female headed households are more likely to experience impoverishment or transitory escape than sustained food security. However, households headed by male have more access to agricultural technologies and more security to farmland. It is hypothesized that male headed households are more likely to escape food insecurity sustainably.

**Household size:** its impact on food insecurity is mixed as revealed in the previous empirics. It is expected to affect food insecurity either ways depending on the demographic composition of the household. Its effect will be positive if larger household size means more working force (hence less dependency ratio) and negative if it implies higher dependency ratio.

**Dependency ratio:** It is obtained by dividing inactive labor force by the active ones in a household. When a large household size associated with availability of adequate economically active labor force, it could be a blessing. But a household with

more economically non active shows a high dependency ratio and it is more likely to be a burden. Therefore, dependency ratio and food insecurity are positively associated.

**Education:** Education is a portable asset that equips individuals with the knowledge of how to make a living, and stimulate economic growth as it allows people to be more productive. Hence, literate heads have better welfare and more likely to reduce food insecurity as it is associated with working outside agriculture and also obtaining skilled work.

**Size of cultivated land:** As cultivated land size increases, production factors remaining constant, the holder gets more output increases. Despite the fact that households that continuously live out of food insecurity may not have a livelihood based on land, it is hypothesized that cultivated land size is positively correlated with welfare of households.

**Remittances**: As a continuous variable, remittances reduce food insecurity through increased incomes allowing for greater investment in physical assets, education and health and also enable larger pool of knowledge**.** The values of remittance received are critically important in supporting inclusive growth and reducing food insecurity through boosting household consumption**.** It was expected that having relative economic support from abroad and urban areas within the country had positive impact in reducing food insecurity.

**Credit:** Credit serves as a means to boost production and expand income generating activities. It is a dummy variable taking the value 1, if the household takes credit 0 otherwise. Thus, a household which has access to credit does initiate investment in farm and non-farm activities and being food secure. Households who have access to credit minimize their financial constraints and buy inputs more readily. Thus, it is hypothesized that a household which has access to credit is more likely to be non-poor.

**Share of non-farm income:** it is one of the dummy regressors, which is expected to negatively impact the food security status of the households.

**Land rent out:** Renting out land under private holdings can be expressed in terms of fixed cash or sharecropping. Land rental markets facilitate land transfer from less efficient farmers with fewer resources to farmers that are more efficient. Despite its ability to enhance allocative efficiency, lack of well-paid non-farm employment opportunities in rural areas and a lack of credit to finance agricultural production, makes land renting out by poor households a major source of vulnerability, persistent food insecurity (Shifa, 2016). Thus, a household which is involved in such an informal institutional arrangement is likely to be food insecure.

**Distance to the market:** Closeness to market centers creates access to additional income via non-farm employment opportunities, easy access to information on inputs and transportation. It is thus, expected that a household having better access to market has better opportunity to achieve food security. Therefore, there is positive association between distance to the market and welfare of households.

**Tropical Livestock unit:** Households accumulate their wealth in terms of livestock. Unlike farm or non-farm income which are often inconsistent, assets provide strong buffers against shocks and stresses. In many rural areas, food security is partly about being able to accumulate the assets underpinning successful engagement in agriculture. Hence, Livestock in TLU are important routes out of food insecurity.

**Shocks:** The majority of Ethiopian rural households are vulnerable to such covariate and idiosyncratic shocks. The widespread predominance of livelihoods that are dependent on rain fed agriculture has characterized with higher vulnerability. Hence, these shocks have been found to have a significant impact on the welfare of these households.

**Income:** Farming may not be the sole source of income for rural household. Diversifying livelihoods activities and sources of income is one strategy for stepping out via risk spreading and buffering households against a range of shocks. Managing welfare problems is therefore, largely dependent on household ability to get income from farm and non-farm economic activities. Moreover, household with better income has higher propensity to enhance their welfare, boosting household consumption, and allowing for greater investment in physical assets. It is expected that higher income is positively correlated with better welfare.

**Oxen number:** Cultivation of land in Ethiopia is undertaken by oxen power for long. It allows effective utilization of land and labor resources where family labor could be spread over peak and slack periods to carry out both farm and non-farm activities. Households with relatively larger number of oxen can perform better on their farm and ultimately enhance their welfare. Thus, the number of oxen available to the household improves their welfare.

**Wage labor participation:** It is a dummy variable and is expected to positively impact the welfare of rural households. Households that are better endowed with farming resources such as oxen and farming skills are more likely to get access to more land and labor through factor markets, while households that are less endowed with these resources are more likely to rent out their land and participate in non-farm jobs. Hence, it is hypothesized wage labor participation diversify income sources is negatively correlated with food insecurity.

## RESULTS AND DISCUSSION

### Food Insecurity Profiles of Informal Miners

The food insecurity indices calculated using the Foster-Greer-Thorbecke measures in terms of food calorie intake were found to be 0.546, 0.209 and 0.108 for headcount, food insecurity gap and food insecurity severity, respectively. More than half of the sample population is unable to get the minimum calorie required across the survey period. The resulting food insecurity estimates show that the percentage of food insecure is about 54.6%, which is less than the regional (77.38%) (Araya and Lee, 2024; Gebre et al., 2024; Weldemariam et al., 2022; Woldegebriel et al., 2024) and the national averages (55.4%) (Haile et al., 2022) and North Eastern Rift Valley (Getaneh et al., 2022). The finding is in line with the pervasiveness of poverty and undernutrition in Ethiopia (MoFED, 2017; World Bank, 2015). The food insecurity gap index of 0.209 implies that mean per capita calorie shortfall of the food insecure relative to the minimal daily nutritional requirement was 459.8 Kcalorie per adult equivalent per day. The squared food insecurity gap of 0.108 indicated that 10.8% of the miners were ultra-food insecure (Fig 1).

Likewise, the food insecurity indices calculated using the FGT measures in terms of food poverty were found out to be 0.237, 0.068 and 0.029 for headcount, food insecurity gap and food insecurity severity, respectively. This study used the food poverty line estimated by MoFED (2017) adjusted to the monthly food poverty line (165.41 ETB[3]). Taking 4.1 mean household sizes in adult equivalent into account, miners experiences 44.28 ETBs mean monthly aggregate income shortfall relative to the food poverty line. Looking at the weighted sum of food poverty gaps as a proportion of the food poverty line depicted that 15 rural households were ultra-food poor (Fig 1).

[3] Ethiopian Birr is a domestic currency.

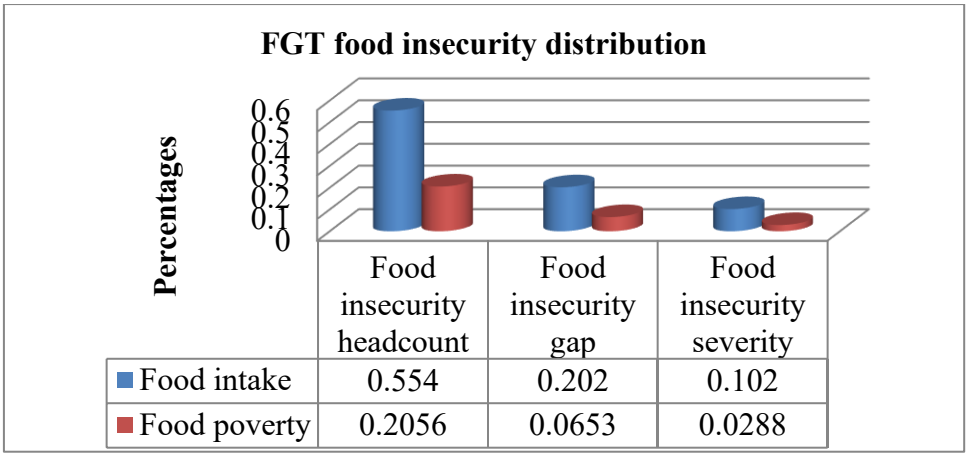


Figure 1: FGT indices
Source: survey data

The disparities in terms of woreda, as seen in table 1, revealed that Asgede Tsimbla achieved higher incidence, intensity, and ultra-food insecurity. The breakdowns of results by categories that move beyond the headcount draw insights of food insecurity. Accordingly, households headed by literates and better-off ones are substantially less food insecure. However, households headed by males and ages between 35 to 70 years were more inadequately fed than female heads and ages below 35 and above 70 years. With the exception of gender, the ordering of categories is robust to the choice of food insecurity measures.

The profiles of food insecurity inequality categorized among indicators are depicted in table 1 The Gini coefficient is found to be 0.367. This implies that food security loss because of inequality in the distribution of calorie intake is 36.7% of consumption level if overall calorie intake had been equally distributed. For countries with unequal distribution, the Gini coefficient typically lies between 0.5 and 0.7, whereas, for countries with relatively equitable distribution, it is in the order of 0.2 to 0.35 (Todaro and Smith, 2012). Inequalities among regions such as Amhara, SNNP, and Others, and better-off households are not far from zero, showing the existence of relative egalitarianism. Atkinson and Generalized entropy indices were also used to calculate the proportion of total calories that would be required to achieve an equal level of food security at present if calories were perfectly distributed. An Atkinson index of 0.116 suggests that we could achieve the same level of calorie consumption with 88.4% of the calorie. The Generalized Entropy index of 0.268 revealed that the food energy intake is more likely equally distributed across everyone in the society.

**Table 1: The Extent of Food Intake and Inequalities for Households**

| | Food insecurity | | | Generalized entropy index | Gini index | Atkinson index |
|---|---|---|---|---|---|---|
| | $(\alpha = 0)$ | $(\alpha = 1)$ | $(\alpha = 2)$ | | | |
| All households | 0.541 | 0.202 | 0.104 | 0.268 | 0.367 | 0.116 |
| Education | | | | | | |
| Illiterate | 0.560 | 0.208 | 0.106 | 0.249 | 0.360 | 0.111 |
| Literate | 0.507 | 0.191 | 0.100 | 0.297 | 0.378 | 0.125 |
| Region | 0.638 | 0.22 | 0.103 | 0.25 | 0.336 | 0.103 |
| Asgede Tsimbla | | | | | | |
| Chila | 0.56 | 0.618 | 0.267 | 0.521 | 0.748 | 0.237 |
| Gender | | | | | | |
| Female | 0. 497 | 0.177 | 0. 087 | 0.250 | 0. 361 | 0. 111 |
| Male | 0.552 | 0.208 | 0.107 | 0.272 | 0.368 | 0.117 |
| Age | | | | | | |
| < 35 | 0. 529 | 0.191 | 0. 096 | 0.343 | 0. 389 | 0. 137 |
| 35 - 70 | 0. 547 | 0.206 | 0.106 | 0.239 | 0.358 | 0.108 |
| > 70 | 0.527 | 0.198 | 0.102 | 0.263 | 0.371 | 0.117 |
| Income | | | | | | |
| < 4000 | 0. 548 | 0. 207 | 0. 107 | 0.309 | 0. 384 | 0. 129 |
| 4000 - 7500 | 0.496 | 0.166 | 0.076 | 0.243 | 0.361 | 0.110 |
| > 7500 | 0. 514 | 0. 169 | 0.076 | 0.209 | 0.339 | 0.097 |

Source Survey data

Tables 2 depicted the distributions of food insecurity and inequality measures among household characteristics and groups. The results for the majority of household characteristics are generally as expected. Households with characteristics correlated with lower poverty rates also have lower food insecurity under all the measures. Disaggregating FGT measures regionally revealed a considerable disparity in that Tigray and Oromia recorded the lowest score, whereas SNNP and Amhara were more food insecure. Furthermore, households headed by literates, young, better-off ones, and females were less at risk of food insecurity.

In tables 2, we present our results for food insecurity inequality measures. The Gini index of 0.456 implies that the loss of welfare because of inequality in distribution is 45.6% of the welfare level if the overall income had been equally distributed. The results are also broken down in terms of household characteristics. Atkinson index of 0.182, on the other hand, suggests that we could achieve the same level of food consumption expenditure with only 81.1% of the expenditure. Moreover, the higher generalized entropy index indicates food consumption expenditure is less equally distributed across everyone in the society.

**Table 2: The Extent of Food Poverty and Inequalities for Households**

| | Food poverty ($\alpha = 0$) | ($\alpha = 1$) | ($\alpha = 2$) | Gini index | Generalized entropy index | Atkinson index |
|---|---|---|---|---|---|---|
| All households | 0.219 | 0.068 | 0.030 | 0.459 | 0.466 | 0.182 |
| Education | | | | | | |
| Illiterate | 0.237 | 0.074 | 0.033 | 0.455 | 0.443 | 0.178 |
| Literate | 0.184 | 0.056 | 0.024 | 0.463 | 0.500 | 0.187 |
| Woreda | 0.391 | 0.11 | 0.044 | 0.92 | 0.993 | 0.375 |
| Asgede Tsimbla | | | | | | |
| Chila | 0.633 | 0.177 | 0.092 | 1.341 | 1.31 | 0.516 |
| Gender | | | | | | |
| Female | 0.209 | 0.065 | 0.029 | 0.474 | 0.465 | 0.189 |
| Male | 0.221 | 0.068 | 0.030 | 0.454 | 0.465 | 0.179 |
| Age | | | | | | |
| < 35 | 0.197 | 0.064 | 0.029 | 0.491 | 0.446 | 0.184 |
| 35 - 70 | 0.226 | 0.070 | 0.031 | 0.434 | 0.472 | 0.180 |
| > 70 | 0.237 | 0.067 | 0.028 | 0.415 | 0.453 | 0.185 |
| Income | | | | | | |
| < 4000 | 0. 233 | 0. 073 | 0. 032 | 0.468 | 0.568 | 0.212 |
| 4000 - 7500 | 0.116 | 0.032 | 0.013 | 0.452 | 0.388 | 0.160 |
| > 7500 | 0.086 | 0.021 | 0. 008 | 0. 468 | 0. 333 | 0. 143 |

Source: Survey data

**Resilience Information Pack**

This section presents the of resilience structure matrix of households who are participating in informal mining practices in Tigray region. Figure 2 present the non-parametric kernel density estimates of resilience capacity of informal miners in Tigray. It reveals a clear distinction in distributions of resilience between the Woredas.

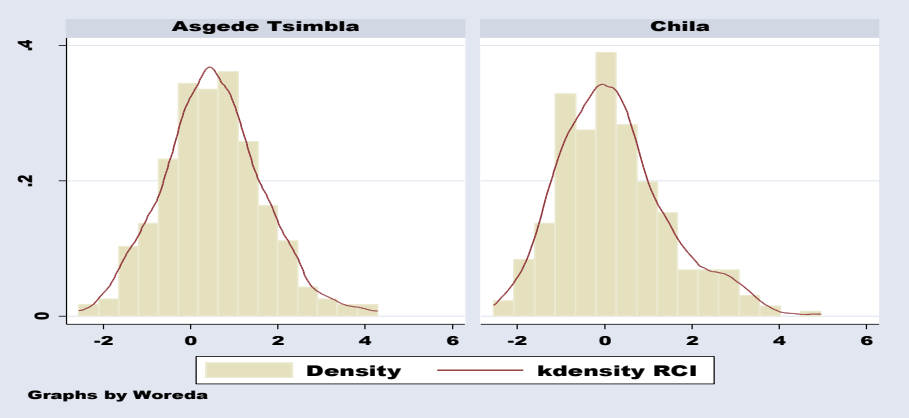


Figure 2: Kernel density
Source: Survey data

Woreda disparities strongly explain household heterogeneities in resilience capacity and its pillars. Households in Asgede Tsimbla Woredas score better than Chila. The highest score for Asgede Tsimbla is attributed to better stability, adaptive capacity, and social safety nets. However, households in the lowest-scoring Woreda, i.e., Chila, is in a disadvantaged position concerning adaptive capacity and asset ownership (Mekuyie et al, 2018) (Figure 3).

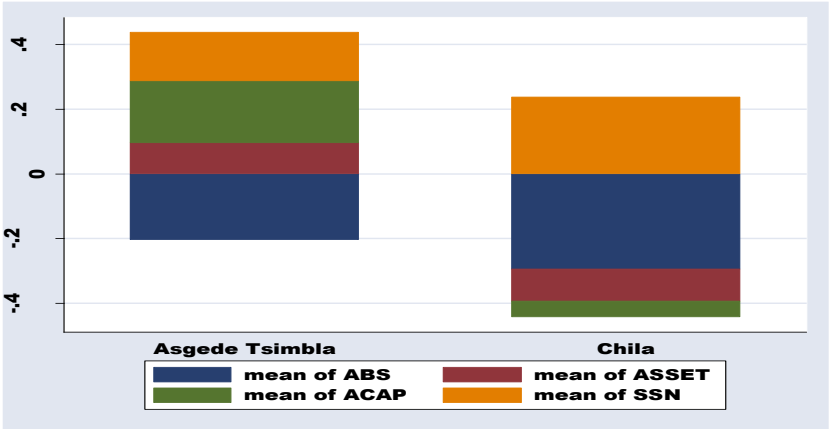


Figure 3: Distribution of resilience pillars among gender
Source: survey data

Generally, the resilience structure matrix shows that ABS and SSN are the most important pillars for resilience capacity for both male and female-headed households (Figure 4). There are relevant differences in the resilience capacity between female and male-headed households. The analysis disaggregated by gender reveals that male-headed households have a slightly greater resilience capacity due to their better level of adaptive capacity and assets consistent with Mekuyie et al (2018).

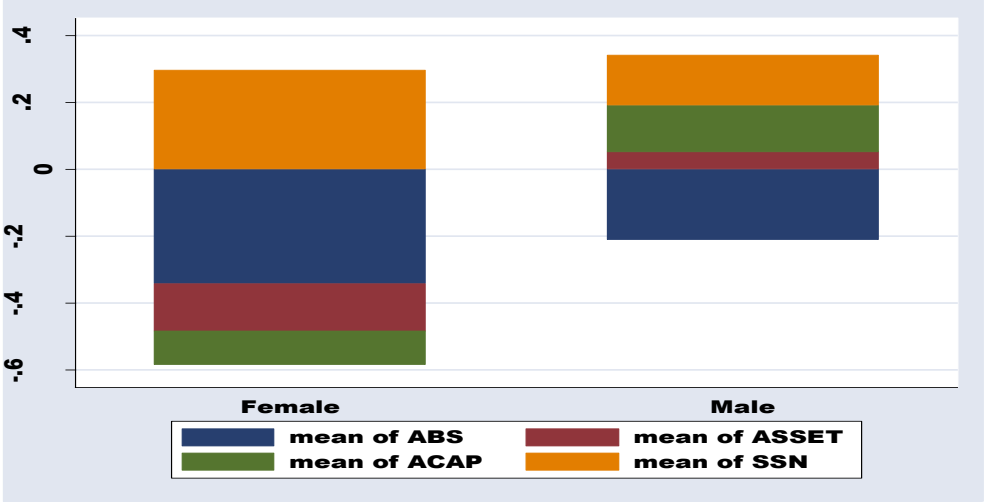


Figure 4: Distribution of resilience pillars among gender
Ource: survey data

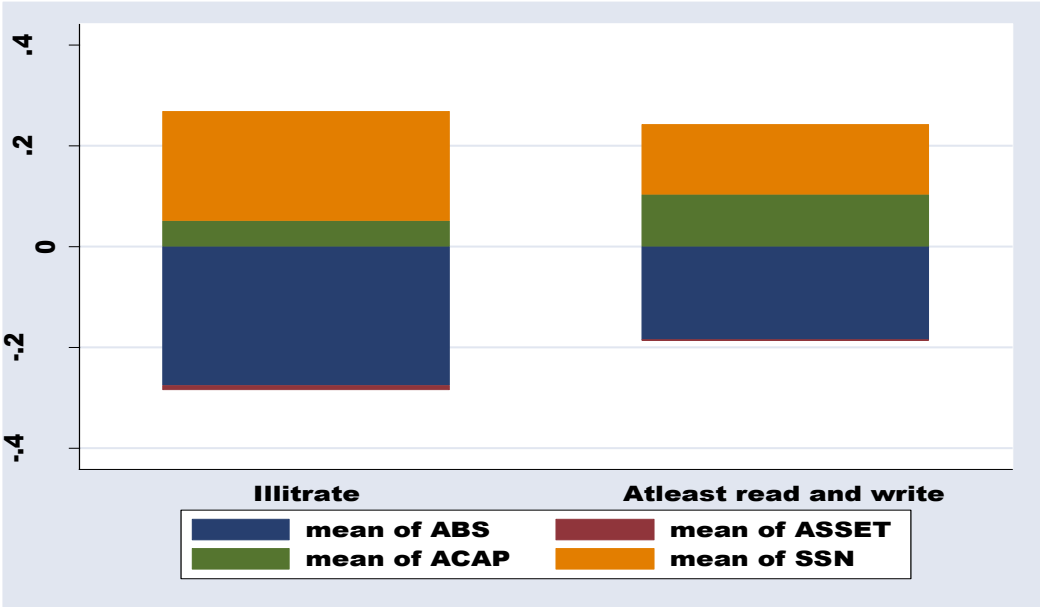


Figure 5: Distribution of resilience pillars among education
Source: Survey data

When looking at the contribution of each pillar, access to basic services is ranked as the least pertinent contributor to the resilience capacity in both Woredas. Nevertheless, possession of assets followed by social safety net and adaptive capacity also plays a vital role in building resilience capacity (Figure 6).

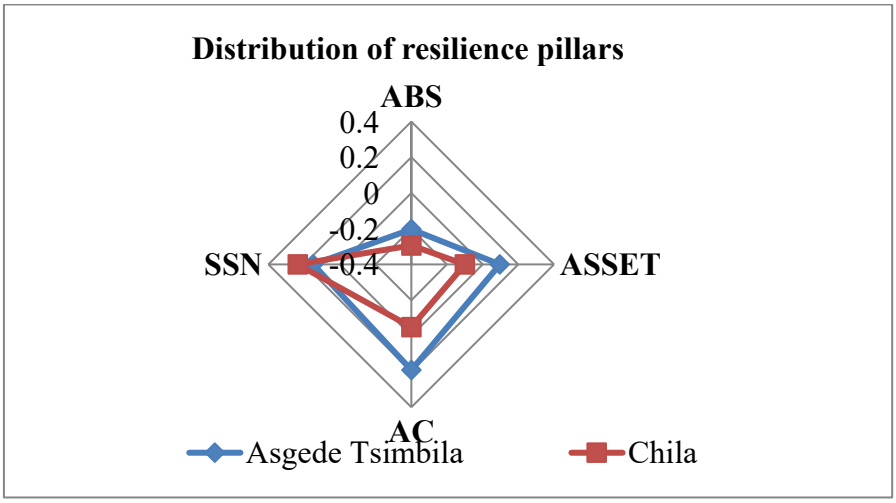


Figure 6: Distribution of resilience pillars
Source: Survey data

The proportions of both less and highly resilient households are concentrated in Asgede Tsimbla Woreda than Chila. However, the bulk of the least resilient ones are found in Chila Woreda.

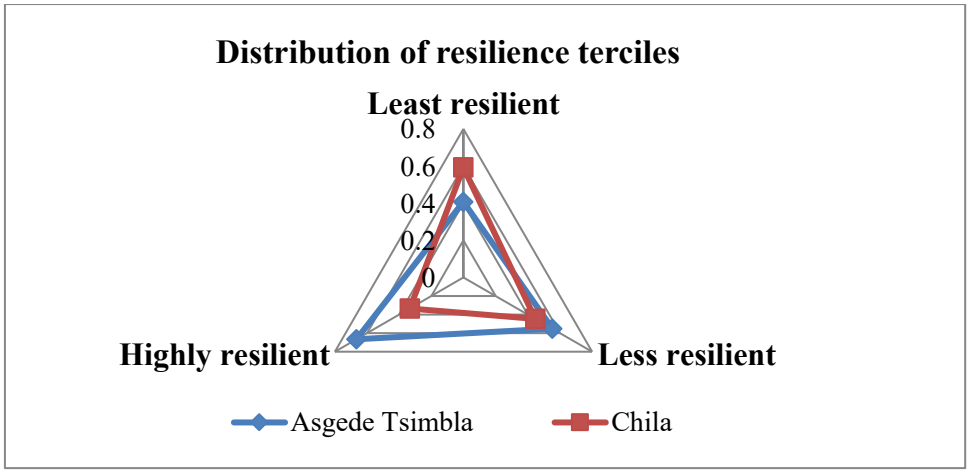


Figure 7: Resilience capacity components over years
Source: Survey data

**Descriptive Statistics**

The descriptive statistics for continuous and discrete variables were presented separately in the following two tables. For the ten continuous explanatory variables, the independent t-tests results reveal that the mean difference between food secure and insecure was significant in terms of resilience capacity, household size, idiosyncratic and covariate shocks, size of cultivated land, income, and tropical livestock unit (Table 3). However, the mean differences between the food secure and insecure were found to be statistically insignificant in terms of age of the household head, distance to the town and market.

**Table 3: Distribution of Variables Among Food Insecurity Categories**

| | Food secure (N = 245) | | Food insecure (N = 289) | | Total (N = 534) | | |
|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD | t – value |
| Resilience capacity | 0.265 | 0.047 | 0.249 | 0.019 | 0.263 | 0.045 | 71.18*** |
| Size of cultivated land | 0.474 | 0.921 | 0.425 | 0.678 | 0.467 | 0.889 | 10.78*** |
| Age of the household head | 47.49 | 15.21 | 49.49 | 15.21 | 47.78 | 15.14 | 0.1497 |
| Household size | 4.94 | 2.16 | 4.41 | 2.55 | 4.86 | 2.23 | 3.9317** |
| Distance to the market | 55.06 | 27.34 | 63.02 | 27.16 | 56.24 | 27.44 | 0.0063 |
| Distance to the town | 34.5 | 20.92 | 37.61 | 21.08 | 34.96 | 20.96 | 0.0076 |
| Income | 8495 | 15158 | 6622 | 11822 | 7866 | 14144 | 13.71*** |
| Idiosyncratic shocks | 0.242 | 0.432 | 0.184 | 0.502 | 0.223 | 0.479 | 5.437** |
| Covariate shocks | 0.75 | 1.085 | 0.43 | 0.929 | 0.704 | 1.069 | 2.96 * |
| Tropical livestock unit | 3.629 | 4.99 | 2.818 | 3.26 | 3.357 | 4.50 | 38.12*** |

Source: Survey data

Likewise, a chi-square test for the discrete variables indicated that greater proportion of food insecure were members of female heads (200), households who have access to credit (185) and participated in land rent out (179) significant at less than 1% level of probability and illiterate heads (226) (Table 4).

**Table 4: Distribution of Variables among Food Insecurity Categories**

| | Categories | Food secure (N = 243) | Food insecure (N = 301) | $\chi^2$ |
|---|---|---|---|---|
| Female headship | Yes | 61 | 101 | 3.379* |
| | No | 172 | 200 | |
| Education | Literate | 76 | 75 | 3.840** |
| | Illiterate | 157 | 226 | |
| Saving account | Yes | 102 | 137 | 0.1605 |
| | No | 131 | 164 | |
| Extension | Yes | 43 | 61 | 0.275 |
| | No | 190 | 240 | |
| Land rent out | Yes | 155 | 179 | 2.79* |
| | No | 78 | 122 | |
| Access to credit | Yes | 162 | 185 | 3.755* |
| | No | 71 | 116 | |

Source: Survey data

## ECONOMETRIC ANALYSIS

### The Effect of Resilience Capacity on Food Insecurity of Informal Miners

The stata's output of logistic regression also contains the Hosmer and Lemeshow test, -2log likelihood, LR chi$^2$, chi square and pseudo $R^2$ results. Hosmer and Lemeshow test is a goodness - of - fit test of the null hypothesis that shows whether the model adequately fits the data well or not. If the significance of the test is small (i.e., less than 0.05) then the model does not adequately fit the data. The -2log likelihood of value of the final model has no meaning in itself. It is simply the probability at which the null hypothesis would be rejected and the alternate would be accepted. LR chi$^2$ (18) is minus two times the difference between the starting and ending log likelihood. The number in the parenthesis indicates the number of degrees of freedom. The pseudo $R^2$ does not have an equivalent to the $R^2$ that is found in OLS regression; however, many people have tried to come up with one. Pseudo $R^2$ provides a quick way to describe or compare the fit of different models for the same dependent variable. Note that unlike the $R^2$ in classical regression, the pseudo statistics lack the straightforward explained variance interpretation.

Receiver Operating Characteristics (ROC) curve is a plot of the true positive rate against the false positive rate for different possible cut-off points of a diagnostic test. In a ROC curve, the true positive rate (sensitivity) was plotted in function of the false positive rate (100 - specificity) for different cut-off points. Each point represents a sensitivity/specificity pair corresponding to a particular decision threshold. The ROC curve demonstrates the trade-off between sensitivity and specificity. Any increase in sensitivity would be accompanied by a decrease in specificity. The closer the curve follows the left-hand border and then the top border of the ROC space, the more accurate the model. The closer the curve comes to the $45^0$ diagonals of the ROC space, the less accurate the model. The area under the ROC curve is found to be 0.953, which is more than 0.5 and the model is found to acceptable.

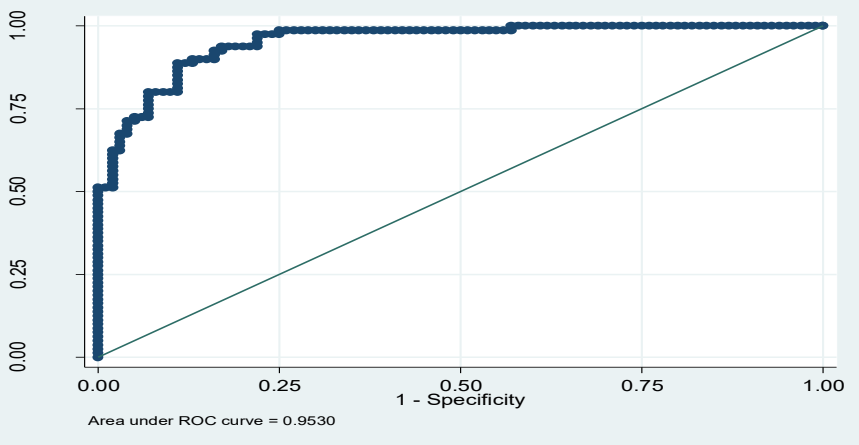


Figure 6: Receiver Operating Characteristics (ROC) Curve
Source: Survey data

Sensitivity and specificity are the two indices used to evaluate the accuracy of a test that predicts the dichotomous outcome (multidimensional poverty). They describe how well a test discriminates between cases with and without a certain condition. Sensitivity implies the proportion of true positives or the proportion of cases correctly identified by the test as not meeting a certain condition. Specificity implies the proportion of true negative or the proportion of cases correctly identified by the test as not meeting a certain condition. The position of the cut off determines the number of true positives, true negatives, false positive and false negatives. As we increase our sensitivity (true positives) and can identify more cases with a certain condition, we also sacrifice accuracy on identifying those without the condition (specificity).

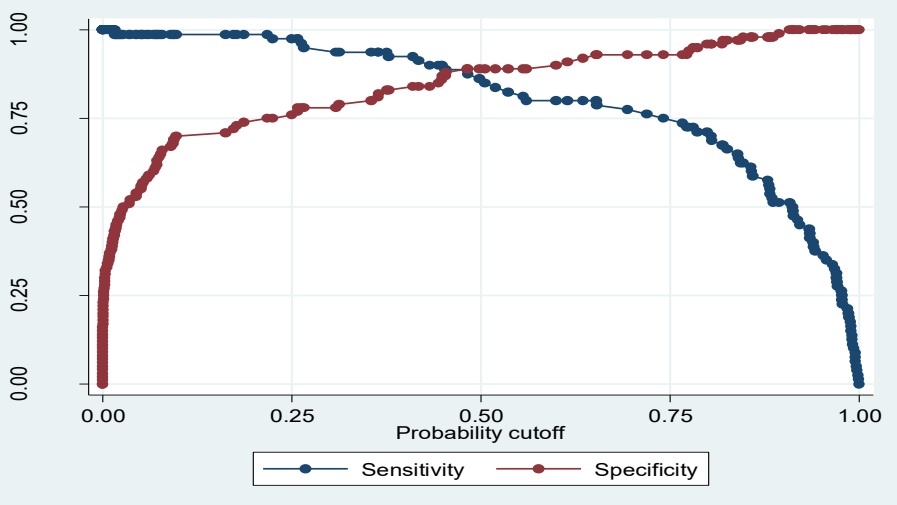


Figure 7: Sigma plot of sensitivity and specificity
Source: Survey data

Table 5 presents logistic regression model results on the effect of resilience for food insecurity of informal miners in Tigray. Miners are subject to several shocks that may occur to households, or the whole villages that may significantly deteriorate food insecurity. Our findings reveal a sturdy negative impact of covariate and idiosyncratic shocks. This findings is supported by many studies (Fuje, 2018; Gao and Mills, 2018; Woodson et al, 2016; Smith and Frankenberger, 2015; Dercon et al., 2005; Dercon, 2004). Two aspects of this result are worth mentioning. First, shocks in Tigray tend to be more recurrent, longer and more severe (Koo et al., 2019). It exacerbates living conditions, leads to greatest loss of lives, aggravates migration (Gray and Mueller, 2012), propel million people to become food insecure and make completely dependent on food aid. Second, concurrence of shocks deteriorates livelihood resources and their adaptive capacity.

In contrast, enhancing resilience is found to be a sustainable solution in reducing food insecurity. The result corroborates the earlier findings fairly well (Beyene et al., 2023; D'Errico et al., 2018; Haile et al., 2022; Matewos, 2020; Melketo et al., 2021; Murendo et al., 2020; Sibrian et al., 2021; Smith and Frankenberger, 2018). Resilience marks the ability of households to withstand and recover from shocks, and maintain their wellbeing even in the face of shocks. The interaction terms for testing the moderation hypothesis for resilience capacity and idiosyncratic shocks are negative and statistically significant. The total effect of resilience on food insecurity might be lower as idiosyncratic shocks intensified. It implies that enhancing resilience capacity protects food insecurity in the presence of shocks. Better asset endowments, adaptive capacity, social safety nets, and access to social services protect food insecurity in the presence of shocks. Promoting interventions that build resilience in informal miners is paramount.

Demographic variables seem to be more important drivers of food insecurity. Accordingly, age of the household head and household size are significantly and negatively related to food insecurity. Age of household head has ambiguous roles, with the heavy burden imposed by old ages and the benefits of having many young workers. Older household heads is associated with better food security. However, when they are too old (indicated by the squared age of the household head) food insecurity steady exacerbates. It became apparent that older heads of a household have a lower adaptive capacity and less ability to contribute to family income- generating activities. Contrary to our earlier proposition, household size is found to be correlated significantly in enhancing food security. This might partly be attributed to the presence of more economically active members with better farm skill, education and experience, and endowed with better farming resources. Likewise, education determines food security positively. Households with literate head are less at risk of welfare impoverishment.

The finding indicates also that the effects of access to credit, distance to the town, and distance to the market on food security are detrimental. Credit is a double-edged sword not only in generating incomes but also impoverishing debtors who cannot repay. Contrary to Agbola et al (2017) our results show a substantial deterioration in the resilience capacity. The contrasting effect relies on the unintended use of loans in determining welfare outcomes (Abraham, 2018; Maitrot and Niioo-Zarazza, 2017; Imai et al, 2010). Moreover, distance to the town and market accompanied with poorly developed rural road networks, not only for output sale but also for input purchase, deteriorates food insecurity.

The likelihood of renting-out land is higher among households that had at least one member who participated in informal mining or other non-farm jobs or migrated to other workplaces. Additionally, literates, those who possess more cultivable land but possess inadequate farm capital and livestock resources, and headed by a female were more likely to rent out their land (Rahman, 2010). Moreover, participation in land rental markets increases with the scarcity of land (Abay et al, 2021). The result indicated that renting-out land enhances food security. The possible justification would be participation in this informal institutional arrangement strengthens resilience through complementing income sources, improving land-use efficiency, productivity gains, and labor mobility out of agriculture (Kijima and Tabetando, 2020; Deininger et al, 2013; Jin and Deininger, 2009).

In contrast, the share of non-farm income correlates with better food security. Rural households rely on rain fed smallholder farming. Those households having greater share of their income from crops are more susceptible for shocks. In contrast, resilience capacity is enhanced if the share of non-farm income increases over time. It is widely acknowledged that wage income is the one among diversified strategies most rural households pursued to escape poverty. Participation of the largest numbers of poor people in Ethiopia in different kinds of casual agricultural work in times of peak land preparation or harvest times, temporary migratory jobs in domestic help, construction, and mining and any jobs in the lower end of quality

spectrum play the biggest role in their daily struggle. But even for households earning better farm income, wage work is a significant contributor, and can be important for income smoothing and risk diversification.

**Table 5: Binary Logit Model Results**

| | Coef. | Std. Err. | dy/dx | Std. Err. |
|---|---|---|---|---|
| **Resilience capacity index** | -54.76*** | 7.997 | -9.639*** | 1.267 |
| Age of household head | 0.646*** | 0.078 | 0.114*** | 0.013 |
| Female household head | -0.266 | 0.254 | -0.047 | 0.045 |
| Household size | 0.324** | 0.165 | 0.057** | 0.029 |
| Dependency ratio | -0.168 | 0.138 | -0.030 | 0.024 |
| **Education** | -0.070* | 0.039 | -0.012* | 0.007 |
| **Remittance** | -0.036*** | 0.011 | -0.006*** | 0.002 |
| Size of cultivated land | -0.213 | 0.135 | -0.038 | 0.024 |
| Access to credit | 0.754*** | 0.284 | 0.133*** | 0.050 |
| **Share of non-farm income** | -0.049** | 0.023 | -0.009** | 0.004 |
| Distance to the town | 0.682** | 0.300 | 0.120** | 0.053 |
| Distance to the market | 0.019 | 0.026 | 0.003 | 0.005 |
| Land rent out | 0.432*** | 0.145 | 0.076*** | 0.025 |
| Number of farm plots | 0.432 | 0.277 | 0.076 | 0.049 |
| Idiosyncratic shocks | -1.449 | 1.217 | -0.255 | 0.213 |
| Covariate shocks | 7.729** | 3.648 | 1.360** | 0.628 |
| Resilience * idiosyncratic shocks | 6.080 | 4.732 | 1.070 | 0.827 |
| Resilience * covariate shocks | -32.98** | 14.713 | -5.806** | 2.525 |
| Constants | 9.250*** | 2.155 | | |

LR $chi^2$ (18) = 182.5  Prob > $chi^2$ = 0.0000 Log likelihood = -249.3 Pseudo $R^2$ = 0.268

Note: ***p < .01, **p < .05, *p < .1, respectively.

## CONCLUSION

The research proved strong alignment of mining as a development practice to have effects on environmental sustainability in a way it causes depletion and destruction of resources in the two case study districts which in turn jeopardize rural livelihoods. The environmental impact of quarrying and informal nature of marketing minerals is in no way compatible with the current state of environmental policy and development perspective. Informal mineral miners relied heavily on their own labor and archaic technologies at hand to do the mining. They maintain no legal licenses and without any social organizations to facilitate their exploration of minerals that they sold informally to secure their basic needs. The absence of legal statues and standards that could reduce environmental destructions further weakens miners' resilience capacity to cope up with shocks that exacerbate food insecurity.

Tigray region is a hotbed of intermingled social pathologies for a long. Food insecurity took the lion's share. People who are participating in informal mining are the worst affected by food insecurity as highlighted by many studies. It has long been depicted that food insecurity appears to be a fundamental challenge as adverse shocks increase vulnerability and

inhibit progress. Hence, understanding the food insecurity impacts of shocks and other covariates, and the role of resilience in the presence of shocks, highly relevant for policymakers as major themes of this paper. This paper, therefore, explores how resilience capacity enables informal miners to cope with the adverse effects of covariates and idiosyncratic shocks on food security in Tigray. We employed a primary data collected from Asgede Tsimbla and Chila. We juxtapose the alternative food insecurity measures and compare levels and trends.

Accumulation of multiple shocks over time exacerbates living conditions and propels households into negative food security trajectory. The quest to achieve food security has suffered its worst setback because of covariate shocks. Shocks jeopardizing the welfare of informal miners do not come as a surprise as many informal miners either rely on subsistence agriculture, which is, subject to uncertainties or come from households of the lower economic ladder. The findings, however, evidenced that the resilience capacity index mitigates the negative impact of covariate shocks. We also found that growth in the share of non-farm income and remittances have potentially diversified diets and smooth food consumption during times of shock. The redeeming ability of literacy is also imperative against food insecurity. In contrast, household size and households headed by the aged reduced dietary diversity and food consumption scores.

The apparent failure to sustainably achieve food security which has suffered from a recurring cycle of shocks needs resilience as a conduit mechanism. Generally, the study evidenced that resilience is more likely to recuperate from food insecurity in the presence of shocks. However, resilience is not the only long-lasting remedy to food security. Thus, policies aimed at eradicating food insecurity would do well when focusing on enabling factors that can enhance the resilience of informal miners. Therefore, better social safety net, adaptive capacity, access to social services, and productive assets play a significant role in enhancing food security. Several interventions that aim to mitigate shocks and build resilience are needed to fight food insecurity. Likewise, an emerging line of inquiry highlighted the vital role of diversifying income sources, enhancing the rural non-farm economy and livelihood opportunities.

The conclusions and policy implications drawn from the study are in light of some caveats. One of the most likely pitfalls arises from the failures of qualitative analysis. Recently, social science research has witnessed an increasing rapprochement between qualitative and quantitative methods. To bridge this methodological divide more systematic study that integrates qualitative and quantitative approaches of the contemporary Q-squared methodology is surmountable. While efforts to achieve food security strengthen, we must recognize that the problems persist in multifaceted forms. This calls for complementary ways of measurement that recognize the limitations in all their dimensions. We also see considerable potential for combining alternative measures. Building on the strengths of each approach, it is certainly possible to design a blend of different perspectives. Above all, we encourage studies to capitalize on the advantages that multiple perspectives offer in promoting diverse and comprehensive approaches to welfare measures.

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