Q Open, 2022, **2**, 1–22
https://doi.org/10.1093/qopen/qoac029
Advance access publication date: 28 October 2022
Article

OXFORD

Orphan crops and the vulnerability of rural livelihoods: The case of enset in Ethiopia

Ashenafi Duguma Feyisa [1,3,*], Yann de Mey [2] and Miet Maertens [3]

[1]Department of Economics, Arba Minch University, 4400 Arba Minch, Ethiopia
[2]Business Economics Group, Wageningen University and Research, 6705 Wageningen, the Netherlands
[3]Division of Bioeconomics, KU Leuven, 3000 Leuven, Belgium

*Corresponding author: Arba Minch University, Department of Economics, 4400 Arba Minch, Ethiopia. ashenafi.feyisa@yahoo.com

Received: May 6, 2022. **Accepted:** September 29, 2022

Abstract

This study examines the role of enset or false banana, an orphan crop with high resilience to extreme environmental conditions, high nutritional value, and long storability, in the livelihood of rural households in Ethiopia. With its specific characteristics, enset could reduce households' vulnerability but this is poorly understood as orphan crops typically receive little research attention. We analyze the contribution of enset to household income, food security, and vulnerability to shocks. We use data from a comprehensive household survey, covering 684 rural households in Southern Ethiopia. We rely on the sustainable livelihoods framework to guide the empirical analysis and use a stepwise regression approach combined with a control function method to limit endogeneity bias. We find that household income slightly improves with enset cultivation, but food security does not. Yet, enset plants significantly reduce the negative impact of shocks on food security. Households with enset plants are less vulnerable to shocks and perceive less risk.

Keywords: False banana, Forgotten crops, Food security, Resilience to shocks, Climate change

JEL codes: Q13, Q12, Q18

Introduction

Orphan crops are crops that are important locally or traditionally but are not used on a large scale; they are also referred to as forgotten crops, underutilized crops, indigenous crops, or neglected crops (African Orphan Crops Consortium 2013; Tadele 2019). Such crops are often linked to a cultural heritage and produced locally in traditional production systems with seed-saving and few external inputs (Padulosi 2017; Tadele 2019). They receive very little attention from policymakers, donors, researchers, extension agencies, and plant breeders (Massawe et al. 2015; Padulosi 2017). Yet, the potential contribution of orphan crops to food security (due to their high nutritional value), sustainable food production systems (due to their ability to re-diversify farming systems), and climate change adaptation (due to their resilience to extreme environmental conditions) is increasingly recognized (Naylor et al. 2004; Andersen 2012; Padulosi 2017; Mabhaudhi et al. 2019; McMullin et al. 2021; Siddique et al. 2021), resulting in an emerging research and policy interest in these types of crops. The establishment of the African Orphan Crops Consortium, which aims at a greater integration of orphan crops into African food systems, a decade ago testifies of recent efforts to promote orphan crops (Hendre et al. 2019). Most research on orphan crops focusses on plant biology and genetic improvement (e.g. Lemmon et al. 2018; Tena 2019; Jamnadass et al. 2020), biodiversity and agronomy (e.g. Borrell et al. 2020; e.g. Sahle et al. 2018; Ulian et al. 2020) and nutrition (e.g. Nurfeta et al. 2009; Forsido et al. 2013; Tamrat et al. 2020). In addition, research attention is concentrated on a few crops, including, for example, common bean, orange-fleshed sweet potato, leafy vegetables, and millet in Africa (McMullin et al. 2021). Evidence on the role of orphan crops in the livelihood strategies of farm-households is rare, despite their potential importance for income, food security, and insurance against growing climate uncertainty.

In this paper, we focus on the role of Enset (*Ensete Ventricosum)*—commonly known as false banana, Ethiopian banana, or Abyssinian banana (African Orphan Crops Consortium 2013)—in the livelihood of rural households in Southern Ethiopia. Enset is a perennial plant with diverse species (Tsegaye & Struik 2001; Tsehaye & Kebebew 2006) from the Musaceae family that is native to large parts of Eastern and South-eastern Africa. However, it is only cultivated in a domesticated form in Ethiopia, where it is a staple food crop for an estimated 15 to 20 million people[1] (BMGF 2019; Borrell et al. 2019). Enset is stated to be able to withstand adverse climate conditions, such as droughts, floods, and frost, to be resistant to pests and diseases, and to reduce soil erosion through its broad leaves that intercept heavy rain (Garedew et al. 2017; Senbeta et al. 2022) but its performance varies across regions (Quinlan et al. 2015) and evidence remains limited. The enset crop matures after two to three years but can last up to 12 years in the field and can be harvested (by felling) at any time of the year (Tsegaye & Struik 2001). Enset requires intensive processing, but food products derived from enset contain high concentrations of carbohydrates and minerals such as calcium, potassium, and zinc, and are a source of essential amino acids such as lysine and leucine (Forsido et al. 2013; Mohammed B. et al. 2013; Tamrat et al. 2020). In Southern Ethiopia, enset is processed into different food products, usually involving some form of fermentation, and resulting in long storage periods (up to three years) (Andeta et al. 2018; Fanta & Neela 2019; Sahle et al. 2018). Besides, enset leaves can serve as animal feed, especially during dry spells when other sources of feed, such as grasses, are not available (Quinlan et al. 2015).

Enset is a multifaceted crop and could act as insurance against diverse shocks and support efforts by international development and humanitarian organizations in reducing rural livelihood vulnerability, but this is poorly understood. The current evidence base on the role of enset in rural livelihoods is limited to a description of the enset farming system, its multiple use and cultural values, and a descriptive analysis of the relation between enset cultivation and household food security (Negash & Niehof 2004). The aim of this study is to reveal the importance of enset in household income, food security, and vulnerability to shocks. We use data from a household survey, covering 684 rural households in the Southern Nations Nationality and Peoples' Region in Ethiopia and using a questionnaire with various modules on different livelihood aspects, including specific modules on enset cultivation and on past shocks and future risk perceptions. Our empirical analysis is guided by the sustainable livelihoods framework (SLF) (Scoones 1998), that has been identified as a relevant framework to empirically analyze household vulnerability and welfare (Bhandari 2013; Chandra et al. 2017; Serrat 2017).

Our paper contributes to the literature on orphan crops with innovative quantitative evidence on how enset contributes to food security and income, and its potential as an insurance against diverse agricultural shocks. The insights form this study are relevant from a policy perspective as the successful scaling-up and (re-)integration of orphan crops in developing country food systems, may benefit from knowledge about the traditional role of such crops, next to plant genetic and nutritional information.

Background

Enset *(Ensete Ventricosum Welw Cheesman)* belongs to the Musaceae family and has a wild and a domesticated population. The wild population is distributed in large parts of Eastern and South-eastern Africa, stretching from Ethiopia over eastern DR Congo, Uganda, Kenya, Tanzania, Mozambique, and Malawi to South Africa (African Orphan Crops Consortium 2013). Domesticated enset is cultivated only in Southern Ethiopia, in moist mid-altitude and highland areas at altitudes ranging between 1,400 and 3,000 meters above sea level, in the regions Addis Ababa, Gambella, Oromia, and the Southern Nations, Nationalities, and Peoples' Region (Negash & Niehof 2004). Being an orphan crop, data on enset production are scarce and as Borell et al., (2020) state, some estimates are questionable. Based on nationally representative data from the Central Statistical Agency, the number of enset cultivating farmers is estimated at 4.4 million, the enset acreage at around 300,000 ha and yearly enset production at 2.28 million metric ton[2] (BMGF 2019; Borrell et al. 2020). Moreover, enset is estimated to provide about 10 per cent of the caloric intake (Worku et al. 2017) and 20 per cent of the carbohydrate needs (BMGF 2019) at national level because it produces more calories per ha than other cereals.[3] As mentioned in the introduction, enset is considered a resilient crop with long storability in the field and in processed form.

The enset plant looks like a banana plant but does not bear edible fruits, hence the common names false banana or pseudo-banana. Enset propagates by vegetative cloning and is rarely propagated by seed (Diro et al. 2002; Negash & Niehof 2004). Enset has three main parts: the corm, the pseudostem, and the leaves. All parts are usable as food, feed, or utilities. The corm is usually boiled, and its consumption is similar to the consumption of other roots and tubers such as potatoes and taro (Negash & Niehof 2004). In our research area, the corm of enset is used to satisfy immediate food needs (it is not stored) and is locally called amicho. The pseudostem, along with chopped corm, is the source of two enset-based food products, called kocho and bulla in our research area, and produces fiber as well. *Kocho* is a fermented mixture of solid mass from decorticated pseudostem and chopped corm whereas *bulla* is extracted by dehydrating the mixture of liquid obtained from freshly decorticated pseudostem mass and chopped corm. *Kocho* is the main fermented enset product, with fermentation taking about 50 days and storage possibility up to 3 years (Andeta et al. 2018; Borrell et al. 2019). Processing enset into enset products is labor intensive and tedious. It is predominantly done by women—which is why enset is often described as a 'woman's crop' (MacEntee et al. 2013; Negash & Niehof 2004). Enset fiber is a by-product from decortications of the leave sheaths to produce *k*ocho and bulla and has a strength that is equivalent to the fiber of abaca (Mizera et al. 2017). Enset fiber is locally used to make sacks, bags, ropes, mats, and construction materials. Fresh and green enset leaves are mainly used as animal feed, sheets (e.g. during the enset scraping process), wrapping material (e.g. for bread, butter or injera), or serving plates—as is the case for banana leaves (Negash & Niehof 2004).

Methods

Research area and data

Our study focuses on five districts in the Southern Nations, Nationalities, and Peoples' Region in the southern part of Ethiopia (see Fig. 1), with an altitude ranging between roughly 1,000 and 3,300 meters above sea level and suitable for enset cultivation. The region has a large ethnic diversity, including Gamo, Dorze, Dherashe, Zayise, Gidicho, and other ethnic groups. Households in the region have a diversified livelihood, including the cultivation of enset in addition to a variety of other staple food and cash crops, livestock rearing, and off- and non-farm activities.

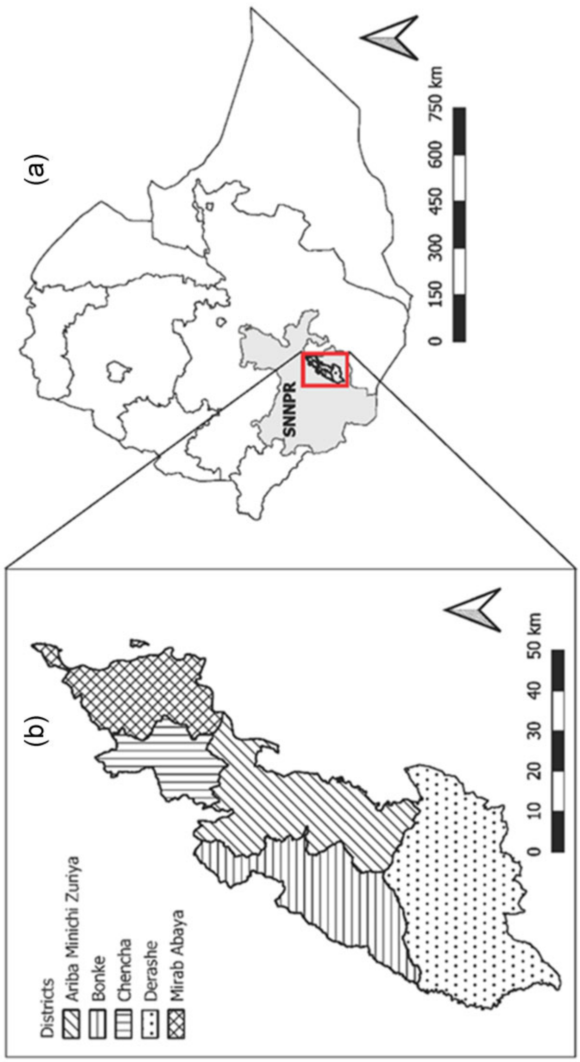

Figure 1. Map of the study area.
Source: authors' compilation.

We conducted a household survey in this region in the period August to October 2018. We used a structured questionnaire comprising modules on household demographics, crop, and livestock production, off- and non-farm employment and income, transfers, land and non-land assets, risk, and vulnerability, living conditions, and food security. We used a two-stage stratified random sampling procedure to select respondents from the five districts. In the first stage, the rural kebeles in each district were stratified based on the agro-ecological zone into lowland, midland, and highland kebeles. From each of the three strata, kebeles were selected with sampling weights proportional to the kebele population size. In total, 47 kebeles were selected, however, one kebele was not reachable by the enumerators due to a violent conflict during the survey implementation. In the second stage, we randomly selected 15 households in each of the selected kebeles. The survey was implemented with a team of trained enumerators and using computer-assisted-personal-interviewing software and tablets. The total sample used for the analysis in this paper is 684 households.[4]

Conceptual Framework

We base our analysis on the SLF that characterizes complex socio-economic interactions and emphasizes the need for livelihood strategies that allow a household to cope with and recover from stresses and shocks while maintaining or enhancing different forms of capital (Brocklesby & Fisher 2003; Scoones 1998, 2009). The SLF is a way to organize complex issues that surround the livelihoods of vulnerable people, and allows to assess the contribution of existing activities towards sustaining those livelihoods (Serrat 2017). We use it to understand the role of enset in the livelihood of rural households in Southern Ethiopia. The SLF focuses on multiple livelihood outcomes, which is in line with our interest in trying enset cultivation as an income-generating activity, a food security crop, and/or a risk coping strategy. Moreover, the SLF includes a dynamic perspective, which is important when considering the potential of enset as protection against risk and shocks. The SLF must be adapted to local circumstances and priorities (Serrat 2017), and we adapt it to specifically understand the role of enset in Southern Ethiopia (see Fig. 2).

Central in the SLF are the different forms of capital, including human, social, physical, financial, and natural capital. Ownership or user rights over these assets influence households' capability to adopt certain livelihood strategies and achieve a desirable livelihood outcome. For instance, households might strive to increase income or reduce vulnerability through income-generating and risk-coping strategies based on their experiences and expectations by applying the capabilities imbedded in their ownership or user rights of different forms of capital. In this paper, we specifically examine the role of enset cultivation as a livelihood strategy of rural households in Southern Ethiopia and we focus on household income, food security, and ex-ante vulnerability to risk as livelihood outcomes. Our main research question is whether and to which extent enset cultivation contributes to increasing household income, to achieving food security, and to reducing households' perceived vulnerability. To answer this question, we focus on the relations depicted in the SLF with full arrows while making abstraction of the relations depicted with dotted arrows, and hence take into account the different forms of capital households have, the vulnerability context in which they operate and the influence of transformation structures and processes.

The vulnerability context relates to the external environment rural households operate in and includes multiple sources of risks and shocks that households face (Mbiba et al. 2019). Agro-ecological conditions, for example, may importantly influence household income and food security through an impact on yields and determine how effective specific livelihood strategies are to realize desirable outcomes. Also, market conditions and price trends may importantly influence households' livelihood outcomes such as income and determine the effectiveness of market-based livelihood strategies. Furthermore, rural households may face multiple types of shocks, for example, related to political instability, weather variability,

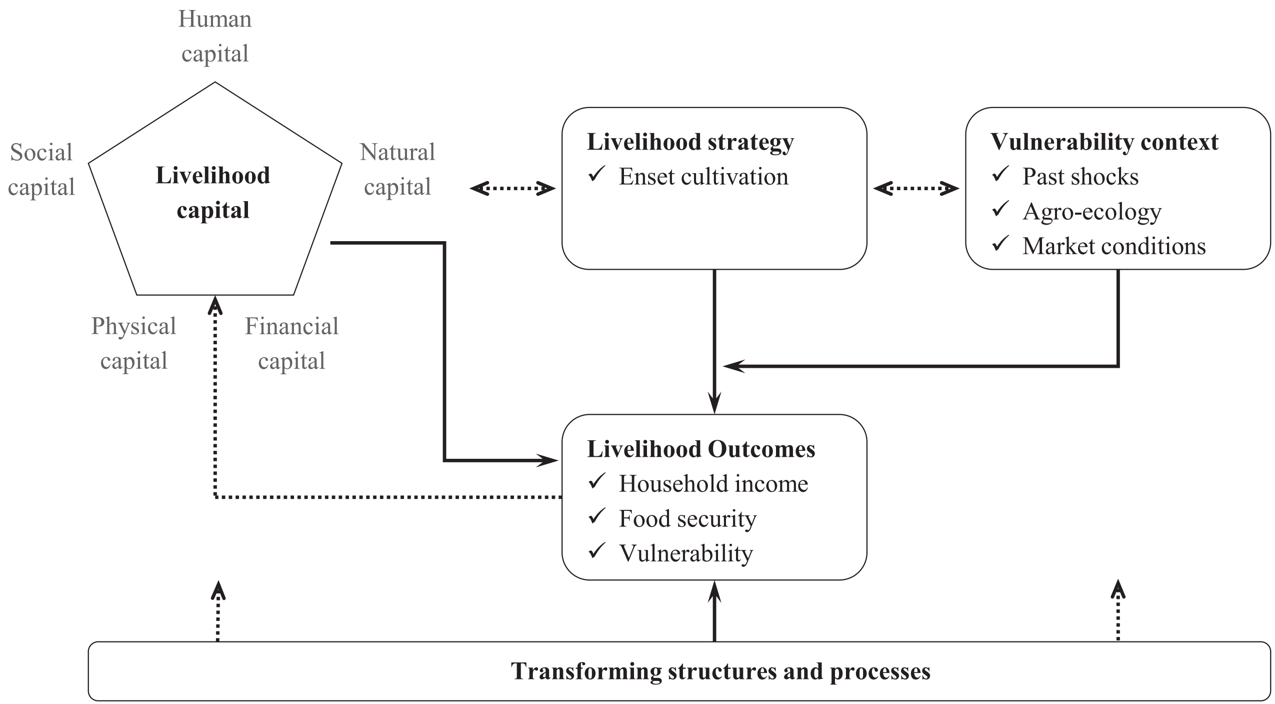

Figure 2. The Sustainable Livelihoods Framework.
Source: adapted from (Scoones 1998).

institutional change, health risks, that ex-post directly influence their livelihood outcomes or indirectly through the livelihood strategies they adopt. Finally, transforming structures and processes relate to the broader institutional, infrastructure, governance, and cultural context. Such factors fall outside the sphere of influence of individual households but can directly affect their access to capital, livelihood strategies, and resulting welfare outcomes.

In general, the interplay between livelihood capital, livelihood strategies, and the remaining components in the SLF determines livelihood outcomes (Scoones 1998). Depending on those outcomes, households may build up, maintain, or deplete their stocks of natural, physical, financial, human, and social capital. Households can learn, accumulate, modify, and adjust based on experience and insights gained over time (Pandey et al. 2017). A drawback of this paper is the use of cross-sectional data, which does not allow to explicitly consider dynamic processes (dotted arrows), and we, therefore, focus on the direct and static relations between the different SLF components (full arrows) to explain the role of enset. Yet, we use a novel method to consider households' experience with past shocks ex-post and households' perception towards risk and vulnerability in the future ex-ante, and thereby add a dynamic dimension to our empirical analysis. We go beyond a static assessment of current household income and food security, through an ex-post assessment of how past shocks influence current household income and food security and an ex-ante assessment of the vulnerability to income shocks and food insecurity in the future. We thereby provide a more holistic assessment of households' economic wellbeing (Ibok et al. 2019) and how enset influences this. Because of its specific characteristics in terms of storability, resistance to adverse conditions, and being a multipurpose crop, enset might specifically render households less vulnerable to different types of shocks and future risks.

Stepwise Econometric Model

We focus on estimating the relations depicted in the SLF with full arrows (Fig. 2), and use a stepwise econometric approach in which we consecutively add the different SLF components. This results in the following set of regression equations to understand enset as a livelihood strategy and its role in household income, food security, and vulnerability as livelihood outcomes:

$$Y_i = \alpha_0 + \beta_1 enset\ plants_i + \delta_1 village\ FE_i + \varepsilon_i \quad (1)$$

$$Y_i = \beta_0 + \beta_2 enset\ plants_i + \delta_2 villag\ FE_i + \gamma_1 LC_i + u_i \quad (2)$$

$$Y_i = \delta_0 + \beta_3 enset\ plants_i + \delta_3 villag\ FE_i + \gamma_2 LC_i + \varphi_1 past\ shocks_i + v_i \quad (3)$$

$$Y_i = \gamma_0 + \beta_4 enset\ plants_i + \delta_4 villag\ FE_i + \gamma_3 LC_i + \varphi_2 past\ shocks_i + \sigma_1 enset\ plants_i \times past\ shocks_i + w_i. \quad (4)$$

In these Equations (1 to 4), Y_i represents, for household i, the different livelihood outcome indicators related to income, food security, and vulnerability, that are assessed in separate regressions and explained further below. The main explanatory variable of interest is *enset plants,* a count variable for the number of enset plants a household has. We use a stepwise econometric model, consecutively adding different components of the SLF, to evaluate the contribution of enset-growing to household income, food security, and vulnerability while gradually controlling for transforming structures, livelihood capital, and past shocks in Equation (1) to (3). *VillageFE* are village or kebele fixed effects that capture differences in transforming structures and processes. The kebele is the smallest administrative sub-division in Ethiopia, and the fixed effects therefore capture differences in institutions, infrastructure, and governance. The vector *LC* represents different forms of livelihood capital and includes family size, dependency ratio, age, and literacy of the household head (human capital variables); membership in an *iddir*[5] (social capital variable); membership in an *equib*[6] (financial capital variable); and land size, livestock-holdings, and access to irrigation (physical and natural capital variables). The vulnerability context is partially captured by village fixed effects, as these control for differences in agro-ecological and market conditions, and by the variable *past shocks* measuring households' exposure to and impact from past shocks (explained in the next sub-section). To specifically investigate the role of enset as a risk coping strategy and possible indirect effects, we include an interaction term between the variables *enset plants* and *past shocks* as indicated in Equation (4). The parameters β, γ, φ, σ, and δ are parameters to be estimated, and ε_i, u_i, v_i, and w_i are error terms.

Two variables are used for each livelihood outcome indicator. First, we use total household income and per capita household income as income-related outcome indicators. Total household income is calculated as the sum of net income from crop production, livestock rearing, and off-farm businesses, from wages and salaries, and from public and private transfers during the last 12 months prior to the survey. Per capita income is calculated as total income divided by family size measured in adult equivalent units.[7] Second, we measure food security at the household level with two standard indicators developed by the Food and Nutrition Technical Assistance program (Maxwell et al. 2014): the months of adequate household food provisioning (MAHFP) and the household food insecurity access scale (HFIAS). The variable MAHFP reflects, over a 12-month period, the months in which the respondents indicate to have enough food to satisfy the needs of the household (see Table A3 in the online Appendix for the survey questions from which the variable is derived). The variable HFIAS is an index, theoretically ranging from 0 to 27, constructed based on nine survey questions on how often households experienced problems with access to sufficient quantity and quality of food in the past four weeks (see Table A2 in the online Appendix). The HFIAS indicator reflects access to food with higher values indicating a lower food security while the MAHFP indicator reflects stability in access to food with higher values indicating a higher food security. Third, we measure vulnerability in an innovative way using two indicators reflecting households' perceived risk and perceived vulnerability to future adverse events. This is explained in more detail, along with the construction of the variable *past shocks*, in the next sub-section.

Estimation Technique

We estimate Equations (1), (2), (3), and (4) for total household income and per capita household income, for months of adequate household food provisioning (MAHFP) and household food insecurity access scale (HFIAS), and for households' perceived risk and vulnerability. We estimate Equations (1) to (4) using OLS regressions and additionally estimate Equation (4) using a control function (CF) or two-stage-residual-inclusion approach (Wooldridge 2015). The main variable of interest, *enset plants*, and its interaction with *past shocks* is potentially endogenous due to unobserved heterogeneity in households' decision to cultivate enset or due to reverse causality between enset cultivation and perceived risk and vulnerability. Households who expect high future risk might plant more enset to buffer that risk (Quinlan et al. 2015). We try to limit potential bias and obtain consistent estimates through the CF approach (Wooldridge 2015). We use this approach rather than the more classical two-stage-least-squares (2SLS) approach to allow for the inclusion of the interaction term with the endogenous explanatory variable in Equation (4).

In the first stage (reported in Table A4 in appendix), we use two instrumental variables, *ethnicity* and *cultural adherence*, along with other independent variables in Equation (4) (*LC*, *past shocks* and *FE*) to estimate the variable *enset plants*. The residual from this first stage regression is then included in the estimation of Equation (4). Because of collinearity between the instrumental variables and some village dummies, we use *district FE* instead of *village FE* in the CF model. To assure robustness of the results to using *district FE* instead of *village FE*, we additionally estimate Equation (4) using OLS and *district FE*.

The IVs, *ethnicity*, and *cultural adherence*, are measured as dummy variables. The first takes the value of one when the household is from the Gamo or Dorze ethnic group, who are commonly known to be enset cultivating ethnic groups (Assefa & Hans-Rudolf 2017), and zero otherwise. The second takes the value of one if the respondent assessed him or herself as being very highly adherent to culture and zero otherwise. Cultural adherence was assessed during the survey using a five-point Likert scale question with answers ranging from very low to very high adherence to culture. These IVs are relevant because enset is a traditional subsistence crop in the Gamo highlands, where the Gamo and Dorze ethnic groups predominantly reside (Assefa & Hans-Rudolf 2017) and because enset is known to be a crop that is important from a socio-cultural perspective (Tsehaye & Kebebew 2006). The IVs plausibly satisfy the exclusion restriction and exogeneity condition. After controlling for differences in livelihood capital and location, the livelihood strategies in the region, apart from the cultivation of enset, do not vary much across ethnic and cultural groups. Ethnicity is exogenously determined, and the strong cultural value of enset cultivation reduces the likelihood of confounding factors in the first-stage relation between enset cultivation on the one hand, and ethnicity and cultural adherence on the other hand. Testing the validity of the IVs is difficult in the CF approach. We therefore additionally estimate Equation (3) (the full model without the interaction term) using classical 2SLS estimation and test for under-identification, weak identification, and overidentification restrictions. We find Kleibergen-Paap Wald F statistics that are well above the corresponding Stock-Yogo values, implying strong IVs. We fail to reject the null hypothesis of overidentification at a 5 per cent significance level for all outcome indicators, which is an indication of exogeneity of the IVs (see appendix Table A13).

As a robustness check for the food security indicators, MAHFP and HFIAS, we run Poisson regressions and probit regressions, respectively (Tables A11 & A12 in online appendix). The MAHFP food security indicator is a count variable ranging from 0 to 12 months of adequate food provisioning in the household, and a Poisson regression is a more appropriate estimation technique in this case. There are several households whose HFIAS score is zero (see Fig. A1 in online appendix for the variable distribution), indicating that these households never experienced food insecurity in the past four weeks in any of the nine components of the food insecurity scale. We transform the HFIAS score into a binary variable equaling one if the household is food secure or has a zero HFIAS score, and zero otherwise. We run a set of probit regressions for this indicator.

Measuring Shocks, Risk, and Vulnerability

We follow a novel approach, building on the method proposed by Brown et al. (2018) and Meraner and Finger (2019), in measuring risks and shocks considering three dimensions: frequency, impact, and level of control towards a particular source of risks and shocks. In addition, we explicitly disentangle between the ex-post dimension of experiencing shocks in the past and the ex-ante dimensions of being vulnerable to future risks. First, we identified the most important sources of risks and shocks in the research area through expert interviews in all selected villages, and classified them based on the agricultural risk literature (Barrett 2011; Hardaker et al. 2015; Komarek et al. 2020). We identified twenty-one specific sources of risks and shocks[8] that households face(d) and classified them into five categories: production risk, marketing risk, institutional risk, financial risk, and personal or health risk (see Table A1 in the online Appendix). These sources of risk vary between being idiosyncratic or household-specific (e.g. personal or health risk), and covariate or correlated among households in the same neighborhood, village, or region (Barrett 2011).

Second, specific questions on the occurrence and impact of the twenty-one identified sources of risks and shocks were included in the risk and vulnerability module of the questionnaire. In an ex-post manner, we asked respondents about the occurrence of the twenty-one shocks in the past three years based on a 5-point Likert scale ranging from rarely (1) to very often (5), and about the impact of those twenty-one shocks on household income and food security based on a 5-point Likert scale ranging from no impact (1) to a very large impact (5). Likewise, in an ex-ante manner, we asked respondents about their perception towards the likelihood of the twenty-one risks in the next three years, and about their perception towards the impact of those twenty-one risks on household income and food security, based on the same 5-point Likert scales. In addition, we asked respondents about how they evaluate the household's ability to control the impact of the twenty-one future risks, based on a 5-point Likert scale ranging from no control (1) to very high control (5).

Third, based on the answers to these questions on risks and shocks, we calculated the variables *past shocks*, *perceived risk*, and *perceived vulnerability*. The variable *past shocks* for household i is calculated as given in Equation (5), with FR_j the frequency of a specific shock j occurring in the past three years and IM_j^p the impact of the occurrence of shock j on household income and food security, both measured on a 5 point Likert scale (as explained above). This results in an index for past shocks that increases with the severity of exposure to risk in the past, and theoretically ranges from 1 to 25.

$$past\ shocks_i = \frac{\sum_{j=1}^{21} FR_j^p * IM_j^p}{\sum j} \tag{5}$$

The outcome variables *perceived risk* and *perceived vulnerability* for household i are calculated as given in Equations (6) and (7), with FR_j the expected frequency (likelihood) of a specific source of risk j in the next three years, IM_j the expected impact of the source of risk j on household income and food security, and CT_j the perceived level of control over the impact of risk source j in the coming three years. All three variables, FR_j, IM_j and CT_j are measured on a 5 point Likert scale (as explained above) but the scale of CT_j was reversed in order for a higher (lower) perceived control to lead to a lower (higher) perceived vulnerability. Both indices theoretically range from 1 to 25. The higher the value of *perceived risk*, the more risk the household perceives for the future. The higher the value of *perceived vulnerability*, the more vulnerable the household perceives itself to future risk exposure.

$$perceived\ risk_i = \frac{\sum_{j=1}^{21} FR_j * IM_j}{\sum j} \tag{6}$$

$$perceived\ vulnerability_i = \frac{\sum_{j=1}^{21} FR_j * CT_j}{\sum j} \tag{7}$$

We are aware of potential differences in the degree of perception between households when responding, for example, 'very often' or 'very large'. However, our interest is not in an objective measure of shock occurrence and impact but rather in the subjective importance.

Results and Discussion

Descriptive Statistics

Enset cultivation is common in our research area and is practiced by 73 per cent of the sampled households. The extent of enset cultivation differs across the districts and is most intensive in Chencha (97 per cent of sampled households) and Bonke (94 per cent), followed by Arba Minch Zuriya (62 per cent), Derashe (40 per cent), and Mirab Abaya (24 per cent). The enset-cultivating households have on average 5 plots and 372 enset plants (Table 1).

Table 1. Summary statistics on enset cultivation, processing, and marketing for enset-cultivating households (N = 500)

Variables	Mean	St. dev.	Min	Max
Enset cultivation				
Total number of plots	5.40	4.44	1	23
Number of plots with enset	1.33	0.79	1	8
Enset grown in the home-garden (% of households)	97	17	0	100
Number of enset plants in the home-garden	297.38	406.98	0	3,800
Number of enset plants on all plots	371.56	463.52	2	3,800
Number of immature enset plants (<2 years)	139.49	239.74	0	3,000
Number of mature enset plants (>2 years)	232.06	313.43	0	2,600
Number of enset plants between 2 and 4 years	141.54	197.36	0	1,670
Number of enset plants between 4 and 6 years	64.90	110.33	0	1,000
Number of enset plants between 6 and 8 years	18.96	52.348	0	620
Number of enset plants above the age of 8 years	6.66	31.19	0	400
Weighted number of enset plants	179.94	235	0.5	1,950
Harvested enset plants during the last 12 months	60.18	91.66	0	558
Standing enset plants sold during the last 12 months	0.43	5.26	0	100
Labor type in enset harvesting and processing				
Use of hired and exchange labor (% of households)	22	41	0	100
Use of female family labor (% of households)	71	27	0	100
Enset products and marketing				
Production of *kocho* during the last 12 months (kg)	206.71	488.63	0	5,625
Selling *kocho* during the last 12 months (kg)	37.25	310.33	0	5,625
kocho fermentation period (month)	1.76	2.68	0	12
Production of *bulla* during the last 12 months (kg)	21.23	47.32	0	600
Selling *bulla* during the last 12 months (kg)	6.21	30.08	0	420
Production of enset fiber during the last 12 months (kg)	5.76	12.87	0	140
Selling enset fiber during the last 12 months (kg)	0.86	3.88	0	36
Enset income				
Enset income during the last 12 months (*ETB*)	914.85	3522.85	0	72,800
Share of enset income in total household income (%)	9.24	16.07	0	83.26

Source: derived and calculated from survey data.

Yet, there is a large variability in the number of enset plants households have, ranging from 2 to 3,800 (see also Fig. A1 in the online Appendix). Enset plants are mostly grown in the home-garden, in the surrounding of the house in combination with trees and other crops (Jacobsen et al. 2018), which might be an indication of the value that people attach to enset or a need for close management (Tsegaye & Struik 2001; Negash & Niehof 2004). The age breakdown of the enset plants (Table 1) shows that households in the research area rarely leave enset in the field for more than 6 to 8 years, which might be an indication of high time preferences. Sometimes mature enset plants are sold while still standing in the field, but this is only a small minority of plants. The large majority of enset-cultivating households rely on female family labor to harvest and process enset, documenting earlier derived statements on enset being a 'women's crop' (MacEntee et al. 2013). Different products are derived from the processing of enset, including *kocho* (taking into account an average fermentation period of 53 days), *bulla* and fibers, but only a small share of these products are marketed, which relates to an underdeveloped enset value-chain, as reported by BMGF (2019). Enset seems to be grown mainly for household subsistence. Our calculations reveal that enset accounts on average for 9 per cent of total household income, including cash and subsistence income.

Table 2 includes summary statistics and a mean comparison between households with and without enset for past shocks, different forms of capital and the various livelihood outcome indicators. The index for past shocks is 3.69 on average, with no statistically significant differences between households with and without enset. Sampled households are rather

Table 2. Mean comparison of the vulnerability context, livelihood capital, and livelihood outcomes across households with and without enset

	Total sample		Households with enset		Households without enset		mean comparison	
	Mean	St. dev.	Mean	St. dev.	Mean	St. dev.	test statistic	Sig.
Vulnerability context								
Past shocks	3.69	2.01	3.72	1.89	3.63	2.3	–0.46	
Livelihood capital								
Family size (adult eq.)	3.65	1.18	3.61	1.15	3.76	1.26	1.37	
Dependency ratio	0.97	0.85	0.99	0.85	0.94	0.85	–0.69	
Age of household head (years)	47.65	14.97	47.94	15.13	46.85	14.53	–0.86	
Literacy of household head	0.52		0.46		0.68		2.65	***
Iddir membership	0.73		0.72		0.77		0.54	
Land size (ha)	1.46	1.42	1.4	1.32	1.6	1.66	1.48	
Livestock (TLU[1])	2.46	1.95	2.62	1.91	2.04	2.02	–3.40	***
Access to irrigation	0.17		0.06		0.45		4.48	***
Iquib membership	0.26		0.23		0.32		1.03	
Livelihood outcomes								
Total household income (ETB[2])	15,241	22,121	13,573	19,072	19,775	28,394	2.74	**
Per capita income (ETB)	4,095	5,499	3,691	4,676	5,192	7,183	2.64	**
MAHFP	9.54	2.45	9.32	2.41	10.12	2.46	3.79	***
HFIAS	6.69	5.77	7.05	5.4	5.7	6.57	–2.50	*
Perceived risk	7.96	3.47	8.08	3.44	7.62	3.54	–1.50	
Perceived vulnerability	8.66	2.86	8.84	2.76	8.19	3.07	2.51	*
Observations	684		500		184			

Mean comparison between households with and without enset is done through z tests for binary variables and t tests for other variables, Significance levels: *** $P < 0.01$, ** $P < 0.05$, * $P < 0.1$ [1]Tropical Livestock Units: 1 TLU = 1 cow or 0.3 sheep/goat. [2]ETB Ethiopian Birr: 1 ETB ≈ 0.030€/1 ETB ≈ 0.036 USD (2018).
Source: derived and calculated from survey data.

large with on average 3.65 adult equivalent members; literacy among household heads is low with 52 per cent literate; and access to farmland and irrigation is rather limited with an average farm size of 1.46 ha and 17 per cent of households connected to an irrigation scheme. We observe some statistically significant differences between households with and without enset in terms of human, physical, and financial capital indicators. Enset-cultivating households have more livestock and are less likely to have a literate household head, to have access to irrigation and to be member of an equib. Total and per capita household income are rather low, with per capita income on average below the national poverty lines of 7,190 ETB but vary substantially in the sample. Households with enset have significantly smaller incomes and are less food secure than households without enset but they have a slightly lower perceived vulnerability to future shocks. Econometric results will reveal if these differences in livelihood outcomes remain when controlling for different forms of capital, past shocks, and village fixed effects.

Econometric Results

This section discusses the results of the econometric analysis on the association between enset cultivation as a livelihood strategy and household income (summary of main results reported in Table 3, full regression results reported in Tables A5 & A6 in appendix), food security (summary of results reported in Table 4, full regression results reported in Tables A7

Table 3. Summary of econometric results for income-related outcome indicators (N = 684)

	Model 1 OLS—village FE	Model 2 OLS—village FE & LC variables	Model 3 OLS—village FE & LC variables	Model 4 OLS—village FE & LC variables	Model 5 OLS—district FE & LC variables	Model 6 CF—district FE & LC variables
Annual household income						
Enset plants (in 00)	1,600.81***	1,062.84***	1,059.02***	1,275.36**	1,136.66*	1,204.159
	(335.976)	(335.254)	(334.588)	(627.566)	(651.418)	(1,195.461)
Past shocks			–1,120.186**	–977.291	–935.495	–932.694
			(547.377)	(745.713)	(612.074)	(626.827)
Enset plants × shocks				–63.009	–97.850	–97.687
				(159.667)	(163.112)	(168.552)
First stage residual						–70.301
						(989.672)
R^2	0.182	0.296	0.304	0.304	0.233	0.233
Annual per capita household income						
Enset plants (in 00)	313.215***	232.230***	231.371***	277.121**	247.351*	295.611
	(64.822)	(63.961)	(63.729)	(132.351)	(139.378)	(336.581)
Past shocks			–251.591*	–221.374	–211.499	–209.496
			(132.532)	(175.288)	(146.120)	(148.270)
Enset plants × shocks				–13.324	–21.995	–21.879
				(32.446)	(32.879)	(33.785)
First stage residual						–50.260
						(306.710)
R^2	0.161	0.228	0.234	0.235	0.165	0.165

Models (1) to (3) relate to Equations (1) to (3), respectively. Models (4), (5), and (6) relate to Equation (4). Robust standard errors in parentheses for models (1) to (5). Bootstrapped standard errors with 500 replications for model (6). *** $P < 0.01$, ** $P < 0.05$, * $P < 0.1$

Table 4. Summary of econometric results for food security-related outcome indicators (N = 684)

	Model 1 OLS—village FE	Model 2 OLS—village FE & LC variables	Model 3 OLS—village FE & LC variables	Model 4 OLS—village FE & LC variables	Model 5 OLS—district FE & LC variables	Model 6 CF—district FE & LC variables
Months of adequate household food provisioning						
Enset plants (in 00)	0.036	0.012	0.011	–0.143***	–0.132***	–0.399***
	(0.027)	(0.027)	(0.027)	(0.055)	(0.049)	(0.117)
Past shocks			–0.300***	–0.402***	–0.403***	–0.415***
			(0.049)	(0.056)	(0.054)	(0.052)
Enset plants × shocks				0.045***	0.038***	0.037***
				(0.013)	(0.012)	(0.012)
First stage residual						0.278**
						(0.120)
R^2	0.128	0.181	0.225	0.239	0.183	0.189
Household food insecurity access scale						
Enset plants (in 00)	–0.071	0.012	0.014	0.236*	0.243**	0.688**
	(0.066)	(0.066)	(0.066)	(0.122)	(0.112)	(0.287)
Past shocks			0.732***	0.879***	0.906***	0.924***
			(0.118)	(0.139)	(0.134)	(0.133)
Enset plants × shocks				–0.065**	–0.051*	–0.050*
				(0.028)	(0.027)	(0.028)
First stage residual						–0.464
						(0.288)
R^2	0.116	0.219	0.266	0.272	0.223	0.226

Models (1) to (3) relate to Equations (1) to (3), respectively. Models (4), (5), and (6) relate to equation (4). Robust standard errors in parentheses for models (1) to (5). Bootstrapped standard errors with 500 replications for model (6). *** $P < 0.01$, ** $P < 0.05$, * $P < 0.1$.

& A8 in appendix), and perceived vulnerability to shocks (summary of main results reported in Table 5, full regression results reported in Tables A9 & A10 in appendix). We report results of the stepwise regression analysis with models (1) to (4) referring, respectively, to Equations (1) to (4), and models (5) and (6) referring to Equation (4) estimated, respectively, with OLS and *district FE* and with the CF approach. Before discussing the results in detail, we first point out that joint significance of the IVs in the first-stage regression is not rejected, implying that the IVs are relevant (see F-test in Table A4 in appendix). We test the potential endogeneity of the main variable of interest, *enset plants*, using the robust Hausman test on the coefficient of the residual included in the second stage.[9] For the food security- and risk-related outcome indicators, we can reject the null hypothesis of exogeneity (Tables 4 & 5), justifying the use of the CF approach. For the income-related outcome indicators, we fail to reject the null hypothesis of exogeneity of *enset plants* (Table 3). We therefore largely base our discussion of the results on the CF estimates for food security- and risk-related outcome indicators, as these are likely less biased, and on the OLS estimates for the income-related outcome indicators, as these are more efficient. In addition, the Poisson and probit regressions for, respectively, the MAHFP and HFIAS food security indicators, result in estimates (reported in Table A11 and A12 in appendix) that are very similar to the original estimates in terms of magnitudes, with the same levels of statistical significance across the models.

Concerning income-related outcome indicators (Table 3), we find a significant association between the number of enset plants and total or per capita household income. An additional 100 enset plants is found to be associated with an increase in total household income of about 1.0 to 1.6 thousand ETB, and an increase in per capita income of 231 to 313 ETB. Considering that total and per capita household income are on average 15,241 and 4,094 ETB, respectively, in the sample (Table 2), these are rather modest income effects of between 5.7 per cent and 10.5 per cent. The regression results for food security (Table 4) show no significant coefficients for the number of enset plants for both MAHP and HFIAS in models 1 to 3. For the vulnerability-related outcome indicators (Table 5), we find that perceived risk and vulnerability both decrease with the number of enset plants, consistently so over the different models, implying that enset plays a role in reducing households' vulnerability to shocks.

Our finding confirms that shocks have a significant negative effect on income, food security (i.e. a negative coefficient for MAHFP and a positive coefficient for HFIAS) and a significant positive effect on perceived risk and vulnerability. The negative association between past shocks and food security is quite strong: the estimates imply, for example, that the sample average of 3.7 for the index of past shocks is associated with an increase of 1 to 1.5 months in the length of the hunger season without adequate food provisioning. This highlights the importance of shocks and its consequences in the research area. Also, the associations between past shocks and perceived risk and vulnerability are quite strong, implying that past experience has important consequences for households' expectations towards the future. Moreover, we find a significant positive coefficient on the interaction term between past shocks and the number enset plants for MAHFP, and a significant negative coefficient on this term for HFIAS. This means that having enset plants can reduce the negative effects of shocks on household food security and implies that enset cultivation partially serves as a coping strategy for households to overcome the negative effects of shocks. This finding further corroborates the conclusion that enset plays a role in reducing the vulnerability of households in the research area. In addition, the significant interaction terms for food security outcomes document the importance of accounting for possible indirect effects in assessing the role of enset as a livelihood strategy.

Besides enset, various indicators related to different forms of livelihood capital have an influence on household income, food security, and perceived risk and vulnerability as well, as hypothesized in the SLF (see Tables A5–A10 in appendix). Concerning human capital

Table 5. Summary of econometric results for vulnerability-related outcome indicators (N = 684)

	Model 1 OLS—village FE	Model 2 OLS—village FE & LC variables	Model 3 OLS—village FE & LC variables	Model 4 OLS—village FE & LC variables	Model 5 OLS—district FE & LC variables	Model 6 CF—district FE & LC variables
Perceived risk						
Enset plants (in 00)	−0.071**	−0.076**	−0.074**	−0.155***	−0.125**	−0.702***
	(0.036)	(0.034)	(0.031)	(0.059)	(0.050)	(0.169)
Past shocks			0.706***	0.652***	0.690***	0.666***
			(0.067)	(0.079)	−0.073	(0.081)
Enset plants × shocks				0.024	0.024*	0.022
				(0.016)	(0.014)	(0.015)
First stage residual						0.601***
						(0.165)
R^2	0.139	0.202	0.324	0.326	0.285	0.298
Perceived vulnerability						
Enset plants (in 00)	−0.059**	−0.050*	−0.048*	−0.070	−0.059	−0.411***
	(0.026)	(0.027)	(0.025)	(0.044)	(0.039)	(0.141)
Past shocks			0.640***	0.625***	0.649***	0.634***
			(0.051)	(0.060)	(0.054)	(0.052)
Enset plants × shocks				0.007	0.010	0.009
				(0.013)	(0.012)	(0.012)
First stage residual						0.367***
						(0.136)
R^2	0.140	0.211	0.359	0.359	0.318	0.325

Models (1) to (3) relate to Equations (1) to (3), respectively. Models (4), (5), and (6) relate to equation (4). Robust standard errors in parentheses for models (1) to (5). Bootstrapped standard errors with 500 replications for model (6). *** $P < 0.01$, ** $P < 0.05$, * $P < 0.1$.

indicators, we find that a larger family size is associated with larger total household income, smaller per capita income, and a higher perceived vulnerability while a higher dependency ratio in the household and an older household head are associated with lower food security. Income is higher and perceived risk and vulnerability lower for households with a literate household head, documenting the positive role of education in livelihood outcomes. Social capital, measured through *iddir* membership, is positively associated with income, HFIAS, and perceived risk and vulnerability. Financial capital, measured through *equib* membership, is positively associated with food security and negatively with perceived risk and vulnerability. Physical capital in terms of land, livestock, and access to irrigation contributes positively to household income and food security. Access to irrigation reduces future risk while a larger land size is associated with increased future risk. Most of these estimated relations are intuitive and in line with expectations but some require further explanation. Landholdings are found to increase the risk and the vulnerability households perceive. This likely relates to households with more land experiencing larger absolute losses and impacts from shocks that affect agricultural land and output, such as droughts, pests, or decreasing prices, even though such households are likely more resilient to overcome the impact of these shocks. Social capital is found to increase the risk and vulnerability households perceive, which is counterintuitive and not completely understood.[10] This counterintuitive result might stem from *iddir* membership, which is a social compensation system in case of death or severe health problems of family members, being an incomplete or poor measure of social capital.

Discussion

Our results reveal a desirable role for enset in households' livelihoods in Southern Ethiopia. Enset cultivation is found to partially mitigate the adverse effects from agricultural shocks on food security and to reduce households' perceived risk and vulnerability to future threats. Yet, its direct contribution to food security and household income is limited. The latter finding may relate to the enset value chain that remains underdeveloped with labor-intensive traditional production and processing techniques, low product quality, and a complete lack of extension services and supply chain coordination. This is despite a growing demand in urban markets, where consumer prices for enset derived-products (*kocho*, *bulla*) are estimated to be 900 per cent higher than in villages where enset is cultivated (BMGF 2019). Our findings imply that enset serves as both an ex-ante adaptive and ex-post risk coping strategy, rather than an income enhancing or food security strategy. The quantitative analysis in this paper allows to nuance and update the earlier findings by Negash & Niehof (2004) who conclude, based on a descriptive analysis, that enset is a typical food security crop. Our finding that enset cultivation is primarily an adaptive risk coping strategy, is in line with earlier observations on enset being considered by rural households as a security against annual crop failure (Quinlan et al. 2015), and enset being an asset, stored in the field, that can be sold or harvested at times of distress (Tsegaye & Struik 2001).

From our findings, we can endorse the claim that orphan crops like enset have a potentially important contribution to make towards improved sustainability and climate change adaptation. The sustainability contribution that enset cultivation makes does not only stem from a re-diversification of farming and food systems—a contribution that is stressed in the literature on orphan crops in general (e.g. Meldrum & Padulosi 2017; Padulosi 2017; McMullin et al. 2021)—but also from its role in coping with shocks and risk. The use of enset as insurance against adverse shocks might be more sustainable than the alternative, more erosive coping mechanism such as building up livestock herds—a common practice in many regions in Africa (Corbett 1988)—or selling durable assets (Hoddinott 2006). In addition, the contribution that enset makes as a climate change adaptation mechanism might also go beyond its resilience to extreme weather events and environmental conditions—

again a contribution of orphan crops in general, that has been emphasized in the literature (e.g. Massawe et al. 2015; Mabhaudhi et al. 2019; Siddique et al. 2021). Due to the specific storability of enset, as a plant in the field or as a fermented food product, enset can mitigate the impact of (weather) shocks and reduce households' vulnerability to risky future (weather) events. The observed role of enset in reducing households' vulnerability to future threats further implies that enset cultivation makes households more optimistic about the future, which can further benefit productive investment in general and adoption of improved technologies in specific (Holden & Quiggin 2017). Promoting and supporting the cultivation of enset in suitable areas might be a favorable policy in sustaining rural livelihoods and supporting the resilience of rural households. For enset to contribute to upward income mobility, however, additional investments in the development of efficient enset value chains might be necessary. The growing demand for enset-derived products in urban markets (BMGF 2019) creates opportunities but for farmers to profit from these market opportunities, investments in more labor-efficient production and processing techniques, in product quality upgrading and improved storage technologies, and in some value chain coordination are likely required.

In sum, we analyze the role of enset in households' livelihood based on a comprehensive framework, extensive original survey data, rigorous regression analyses, and an innovative approach to consider risk and vulnerability. Yet, our methods suffer from some two specific data limitations. First, our cross-sectional data do not allow to capture the dynamic relation in the interplay between livelihood capital, enset cultivation as a livelihood strategy and livelihood outcomes in the SLF (Scoones 1998). With our data, we are, for example, not able to reveal whether enset plays a role in safeguarding household capital in the face of shocks. Second, the fact that we do not find a direct association between enset cultivation and food security, might partly be attributed to the food security measures we use. While the MAHFP and HFIAS indicators capture quantity and quality dimensions of food availability and access to some extent, they do not account for nutrition. Enset, given its rich nutritional content (Forsido et al. 2013; Tamrat et al. 2020), might contribute more directly to household nutrition security than to food availability and access.

Conclusion

While the potential contribution of orphan crops to food security, sustainable food production systems and climate change adaptation is increasingly recognized, their role in the livelihood strategies of farm-households is poorly understood. In this paper, we analyze the contribution of enset (or false banana) to household income, food security, and perceived vulnerability to shocks in Southern Ethiopia. We rely on the sustainable livelihood framework, original survey data, and a stepwise econometric model. We find that enset cultivation plays a limited role in directly contributing to household food security and income, but to be important in reducing households' perceived risk and vulnerability to food insecurity due to future threats, and in partially mitigating the adverse effects from past shocks on food security. Our finding sheds light on the potentials of enset as alternative source of income, ex-ante drought stress risk mitigation and ex-post food insecurity shock coping strategy. Yet, for enset cultivation to contribute to rural upward income mobility, complementary investments in the development of efficient enset value chains, including more labor-saving, efficient processing, and commercialization, are likely needed.

Conflict of interest

No conflict of interest.

Supplementary material

Supplementary data, including data and replication code, are available at *Q Open* online.

Funding

The PhD scholarship of the first author as well as the data collection and fieldwork were funded by VLIR-UOS under the Interuniversity Cooperation Program, grant number ET2017IUC35A101.

Acknowledgments

We thank Kewan Mertens for his support in survey design, and Getahun Kelemework, Fassil Eshetu, and AMU-IUC Program Support Unit staff for facilitating survey implementation. We also thank Zonal, District, and Kebele level administrative bodies in Ethiopia for unreserved support during data collection.

End Notes

1 Borrell et al. (2019) estimates the number of people using enset as a staple food crop at 20 million based on a spatial identification of the enset growing regions and the total population size in these regions. BMGF (2019) uses five different estimation methods (based on expert interviews, kilocalorie calculations, and deductions based on assumptions at the national, regional, and farm-household level), with most of the resulting estimates in the range of 15 to 20 million people.

2 Borrell et al., (2020) analyses acreage trends and find that the enset acreage increased from 260,000 ha in 1996 to 335,000 ha in 2015. BMFG (2019) compares published sources with estimates based on area conversion and production calculations, and indicate the acreage to be between 300,000 and 319,000 ha and the total yearly production to be 2.28 million ton.

3 Enset is estimated to provide 4,000 calories per m^2 per year or 1.3 to 3.5 times as much as maize (BMGF 2019).

4 The original sample includes 59 kebeles and 877 households in six districts. For the purpose of this paper, the district of Konso was dropped from the sample because this falls outside the enset production zone.

5 *Iddir* is a widespread social organization in Ethiopia that supports its members during a funeral.

6 *Equib* is a local name for rotating saving and credit association (RoSCA).

7 We use the modified OECD adult equivalence scale with a weight of 1 for the first adult, 0.5 for each subsequent person above age 14 and 0.3 for children under age 14.

8 To check for potential researcher bias in identifying risk sources, we included an open question in the survey on the most important shocks (risks) households experienced (perceive). Comparing the answers to these questions with the twenty-one identified sources of risk and shocks revealed no new sources, implying that the twenty-one identified sources capture the majority of risks and shocks in the research area.

9 These tests results in the same conclusions as the endogeneity tests in the 2SLS estimations reported in table A13 in appendix.

10 Also other studies find a subordinate role of social capital in reducing rural households' vulnerability, for example, Mbiba and co-authors (2017) for rural South Africa.

References

African Orphan Crops Consortium. (2013). 'Ensete Ventricosum—African Orphan Crops Consortium'. Retrieved July 19, 2021, from ⟨http://africanorphancrops.org/ensete-ventricosum/⟩.

Andersen P. (2012). 'Challenges for Under-Utilized Crops Illustrated by Ricebean (Vigna umbellata) in India and Nepal', *International Journal of Agricultural Sustainability*, 10: 164–74. Routledge. DOI: 10.1080/14735903.2012.674401

Andeta A. F., Vandeweyer D., Woldesenbet F., Eshetu F., Hailemicael A., Woldeyes F., Ürauwels S., Lievens B., Ceusters J., Vancampenhout K. and Van Campenhout L. (2018). 'Fermentation of Enset (Ensete Ventricosum) in the Gamo Highlands of Ethiopia: Physicochemical and Microbial Community Dynamics', *Food Microbiology*, 73: 342–50. Academic Press. DOI: 10.1016/J.FM.2018.02.011

Assefa E. and Hans-Rudolf B. (2017). ‘Indigenous Resource Management Practices in the Gamo Highland of Ethiopia: Challenges and Prospects for Sustainable Resource Management’, *Sustainability Science*, 12: 695–709. Springer Tokyo. DOI: 10.1007/s11625-017-0468-7

Barrett C. B. (2011). ‘Covariate Catastrophic Risk Management in the Developing World: Discussion’, *American Journal of Agricultural Economics*, 93: 512–3.

Bhandari P. B. (2013). ‘Rural Livelihood Change? Household Capital, Community Resources, and Livelihood Transition’, *Journal of Rural Studies*, 32: 126–36. Pergamon. DOI: 10.1016/j.jrurstud.2013.05.001

BMGF. (2019). ‘Multi Crop Value Chain Phase II: Ethiopia Enset’, *Gates Open Research*, 73. F1000 Research Limited. DOI: https://doi.org/10.21955/GATESOPENRES.1115176.1

Borrell J. S., Biswas M. K., Goodwin M., Blomme G., Schwarzacher T., Heslop-Harrison J. S., Wendawek A. M., Berhanu A., Kallow S., Janssens S., Molla E. L., Davis A. P., Woldeyes F., Willi K., Demissew S. and Wilkin P. (2019). ‘Enset in Ethiopia: a Poorly Characterized but Resilient Starch Staple’, *Annals of botany*, 123: 747–66.

Borrell J. S., Goodwin M., Blomme G., Jacobsen K., Wendawek A. M., Gashu D., Lulekal E. et al. (2020). ‘Enset-Based Agricultural Systems in Ethiopia: A Systematic Review of Production Trends, Agronomy, Processing, and the Wider Food Security Applications of a Neglected Banana Relative’. *Plants People Planet*, 2: 212–28. DOI: 10.1002/ppp3.10084

Brocklesby M. A. and Fisher E. (2003). ‘Community Development in Sustainable Livelihoods Approaches—An Introduction’, *Community Development Journal*, 38: 185–98. Oxford Academic. DOI: 10.1093/cdj/38.3.185

Brown P., Daigneault A. J., Tjernström E. and Zou W. (2018). ‘Natural Disasters, Social Protection, and Risk Perceptions’, *World Development*, 104: 310–25. Pergamon. DOI: 10.1016/J.WORLDDEV.2017.12.002

Chandra A., McNamara K. E., Dargusch P., Caspe A. M. and Dalabajan D. (2017). ‘Gendered Vulnerabilities of Smallholder Farmers to Climate Change in Conflict-Prone Areas: A Case Study from Mindanao, Philippines’, *Journal of Rural Studies*, 50: 45–59. Pergamon. DOI: 10.1016/j.jrurstud.2016.12.011

Corbett J. (1988). ‘Famine and Household Coping Strategies’, *World Development*, 16: 1099–112.

Diro M., Gebremariam S., Zelleke A. and Van Staden J. (2002). ‘Growth of Enset (*Ensete ventricosum*) Suckers Under Different Horticultural Practices’, *South African Journal of Botany*, 68: 430–3. Elsevier. DOI: 10.1016/S0254-6299(15)30369-0

Fanta S. W. and Neela S. (2019). ‘A Review on Nutritional Profile of the Food from Enset: A Staple Diet for More than 25 per cent Population in Ethiopia’, *Nutrition and Food Science*, 49: 824–43. Emerald Group Holdings Ltd. DOI: 10.1108/NFS-11-2018-0306/FULL/HTML

Forsido S. F., Rupasinghe H. P. V. and Astatkie T. (2013). ‘Antioxidant Capacity, Total Phenolics, and Nutritional Content in Selected Ethiopian Staple Food Ingredients’, *International Journal of Food Sciences and Nutrition*, 64: 915–20.

Garedew B., Ayiza A., Haile B. and Kasaye H. (2017). ‘Indigenous Knowledge of Enset (*Ensete ventricosum* (Welw.) Cheesman) Cultivation and Management Practice by Shekicho People, Southwest Ethiopia’, *Journal of Plant Sciences*, 5: 6–18.

Hardaker J., Lien G., Anderson J. and Huirne R. (2015). *Coping with risk in agriculture: applied decision analysis*., 3rd ed. U.K: CABI. DOI: 10.1079/9781780645742.0000

Hendre P. S., Muthemba S., Kariba R., Muchugi A., Fu Y., Chang Y., Song B. et al. (2019). ‘African Orphan Crops Consortium (AOCC): Status of Developing Genomic Resources for African Orphan Crops’, *Planta*, 1: 989–1003.

Hoddinott J. (2006). ‘Shocks and Their Consequences Across and Within Households in Rural Zimbabwe’, *Journal of Development Studies*, 42: 301–21. Routledge. DOI: 10.1080/00220380500405501

Holden S. T. and Quiggin J. (2017). ‘Climate Risk and State-Contingent Technology Adoption: Shocks, Drought Tolerance, and Preferences’, *European Review of Agricultural Economics*, 44: 285–308. DOI: 10.1093/erae/jbw016

Ibok O. W., Osbahr H. and Srinivasan C. (2019). ‘Advancing a New Index for Measuring Household Vulnerability to Food Insecurity’, *Food Policy*, 84: 10–20. Pergamon. DOI: 10.1016/j.foodpol.2019.01.011

Jacobsen K., Blomme G., Tawle K., Muzemil S. and Yemataw Z. (2018). ‘Dietary Diversity Associated with Different Enset [Ensete ventricosum (Welw.) Cheesman]-Based Production Systems in Ethiopia’, *Fruits*, 73: 356–64. International Society for Horticultural Science. DOI: 10.17660/th2018/73.6.6

Jamnadass R., Mumm R. H., Hale I., Hendre P., Muchugi A., Dawson I. K., Powell W. et al. (2020). 'Enhancing African Orphan Crops with Genomics', *Nature Genetics,* 52: 356–60. Nature Publishing Group. DOI: 10.1038/s41588-020-0601-x

Komarek A. M., De Pinto A. and Smith V. H. (2020). 'A Review of Types of Risks in Agriculture: What We Know and What We Need to Know', *Agricultural Systems*, 178: 102738. Elsevier. DOI: 10.1016/J.AGSY.2019.102738

Lemmon Z. H., Reem N. T., Dalrymple J., Soyk S., Swartwood K. E., Rodriguez-Leal D., Van Eck J. et al. (2018). 'Rapid Improvement of Domestication Traits in an Orphan Crop by Genome Editing', *Nature Plants*, 4: 766–70. Nature Publishing Group. DOI: 10.1038/s41477-018-0259-x

Mabhaudhi T., Chimonyo V. G. P., Hlahla S., Massawe F., Mayes S., Nhamo L. and Modi A. T. (2019). 'Prospects of Orphan Crops in Climate Change', *Planta*, 250: 695–708. Springer Verlag. DOI: 10.1007/S00425-019-03129-Y

MacEntee K. K., Thompson J., Fikreyesus S. and Jihad emeru. (2013). 'Enset is a Good Thing', *Ethiopian Journal of Applied Science and Technology*, 1: 103–9.

Massawe F. J., Mayes S., Cheng A., Chai H. H., Cleasby P., Symonds R., Ho W. K. et al. (2015). 'The Potential for Underutilised Crops to Improve Food Security in the Face of Climate Change', *Procedia Environmental Sciences*, 29: 140–1. Elsevier. DOI: 10.1016/j.proenv.2015.07.228

Maxwell D., Vaitla B. and Coates J. (2014). 'How do Indicators of Household Food Insecurity Measure Up? An Empirical Comparison from Ethiopia', *Food Policy*, 47: 107–16. Pergamon. DOI: 10.1016/J.FOODPOL.2014.04.003

Mbiba M., Collinson M., Hunter L. and Twine W. (2019). 'Social Capital is Subordinate to Natural Capital in Buffering Rural Livelihoods from Negative Shocks: Insights from Rural South Africa', *Journal of Rural Studies*, 65: 12–21. Pergamon. DOI: 10.1016/j.jrurstud.2018.12.012

McMullin S., Stadlmayr B., Mausch K., Revoredo-Giha C., Burnett F., Guarino L., Brouwer I. D. et al. (2021). 'Determining Appropriate Interventions to Mainstream Nutritious Orphan Crops into African Food Systems', *Global Food Security*, 28: 100465. Elsevier. DOI: 10.1016/J.GFS.2020.100465

Meldrum G. and Padulosi S. (2017). 'Neglected No More: Leveraging Underutilized Crops to Address Global Challenges'. Danny Hunter, Luigi Guarino, Charles Spillane P. C. M. (ed.) *Routledge Handbook of Agricultural Biodiversity*, 1st ed., pp. 298–310. Routledge.

Meraner M. and Finger R. (2019). 'Risk Perceptions, Preferences and Management Strategies: Evidence from a Case Study using German Livestock Farmers', *Journal of Risk Research*, 22: 110–35. Routledge. DOI: 10.1080/13669877.2017.1351476

Mizera C., Herak D., Hrabe P. and Kabutey A. (2017). 'Effect of Temperature and Moisture Content on Tensile Behavior of False Banana Fibre (*Ensete ventricosum*)', *International Agrophysics*, 31: 377.

Mohammed B., Gabel M. and Karlsson L. M. (2013). 'Nutritive Values of the Drought Tolerant Food and Fodder Crop Enset', *African Journal of Agricultural Research*, 8: 2326–33. Academic Journals. DOI: 10.5897/AJAR12.1296

Naylor R. L., Falcon W. P., Goodman R. M., Jahn M. M., Sengooba T., Tefera H. and Nelson R. J. (2004). 'Biotechnology in the Developing World: A Case for Increased Investments in Orphan Crops', *Food Policy*, 29: 15–44.

Negash A. and Niehof A. (2004). 'The Significance of Enset Culture and Biodiversity for Rural Household Food and Livelihood Security in Southwestern Ethiopia', *Agriculture and Human Values*, 21: 61–71.

Nurfeta A., Tolera A., Eik L. O. and Sundstøl F. (2009). 'Feeding Value of Enset (*Ensete ventricosum*), Desmodium Intortum Hay and Untreated or Urea and Calcium Oxide Treated Wheat Straw for Sheep', *Journal of Animal Physiology and Animal Nutrition*, 93: 94–104.

Padulosi S. (2017). 'Bring NUS back to the table!'. *GREAT insights*, September/October: 21–2.

Pandey R., Jha S. K., Alatalo J. M., Archie K. M. and Gupta A. K. (2017). 'Sustainable Livelihood Framework-Based Indicators for Assessing Climate Change Vulnerability and Adaptation for Himalayan Communities', *Ecological indicators*, 79: 338–46.

Quinlan R. J., Quinlan M. B., Dira S., Caudell M., Sooge A. and Assoma A. A. (2015). 'Vulnerability and Resilience of Sidama Enset and Maize Farms in Southwestern Ethiopia', *Journal of Ethinobiology*, 35: 314–36. Society of Ethnobiology. DOI: 10.2993/ETBI-35-02-314-336.1

Sahle M., Yeshitela K. and Saito O. (2018). 'Mapping the Supply and Demand of Enset Crop to Improve Food Security in Southern Ethiopia', *Agronomy for Sustainable Development*, 38: 13593. Springer-Verlag France. DOI: 10.1007/S13593-017-0484-0

Scoones I. (1998). 'Sustainable Rural Livelihoods: a Framework for Analysis'. *IDS Working Paper*. IDS. Retrieved July 31, 2021, from ⟨http://forum.ctv.gu.se/learnloop/resources/files/3902/scoones_1998_wp721.pdf⟩

Scoones I. (2009). 'Livelihoods Perspectives and Rural Development', *Journal of Peasant Studies*, 36: 171–96.

Senbeta A. F., Sime G. and Struik P. (2022). 'Enset Farming System—A Resilient, Climate-Robust Production System in South and South-Western Ethiopia', *Cogent Food & Agriculture*, 8: 2074626. Cogent. DOI: 10.1080/23311932.2022.2074626

Serrat O. (2017). 'The Sustainable Livelihoods Approach'. *Knowledge Solutions*, 1: 21–6. Springer Singapore. DOI: 10.1007/978-981-10-0983-9_5

Siddique K. H. M., Li X. and Gruber K. (2021). 'Rediscovering Asia's Forgotten Crops to Fight Chronic and Hidden Hunger'. *Nature Plants*, 7: 116–22. DOI: 10.1038/s41477-021-00850-z

Tadele Z. (2019). 'Orphan Crops: Their Importance and the Urgency of Improvement', *Planta*, 250: 677–94. Springer Verlag. DOI: 10.1007/S00425-019-03210-6

Tamrat S., Borrell J. S., Biswas M. K., Gashu D., Wondimu T., Vásquez-Londoño C. A., Heslop-Harrison P. J. S. et al. (2020). 'Micronutrient Composition and Microbial Community Analysis Across Diverse Landraces of the Ethiopian Orphan Crop Enset', *Food Research International*, 137: 109636. Elsevier. DOI: 10.1016/J.FOODRES.2020.109636

Tena G. (2019). 'Sequencing Forgotten Crops', *Nature Plants*, 5: 5. Nature Publishing Group. DOI: 10.1038/s41477-018-0354-z

Tsegaye A. and Struik P. C. (2001). 'Enset (Ensete Ventricosum (Welw.) Cheesman) Kocho Yield Under Different Crop Establishment Methods as Compared to Yields of other Carbohydrate-Rich Food Crops', *NJAS - Wageningen Journal of Life Sciences*, 49: 81–94.

Tsehaye Y. and Kebebew F. (2006). 'Diversity and Cultural Use of Enset (Enset ventricosum (Welw.) Cheesman) in Bonga in-situ Conservation Site, Ethiopia', *Ethnobotany Research and Applications*, 4: 147.

Ulian T., Diazgranados M., Pironon S., Padulosi S., Liu U., Davies L., Howes M. J. R. et al. (2020). 'Unlocking Plant Resources to Support Food Security and Promote Sustainable Agriculture'. *Plants People Planet*, 2: 421–45. John Wiley & Sons, Ltd. DOI: 10.1002/ppp3.10145

Wooldridge J. M. (2015). 'Control Function Methods in Applied Econometrics', *Journal of Human Resources*, 50: 420–45. University of Wisconsin Press. DOI: 10.3368/jhr.50.2.420

Worku I. H., Dereje M., Minten B. and Hirvonen K. (2017). 'Diet Transformation in Africa: The Case of Ethiopia', *Agricultural Economics (United Kingdom)*, 48: 73–86. John Wiley & Sons, Ltd. DOI: 10.1111/agec.12387