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The contribution of smallholders' livelihood activities on income inequality and poverty: Case study from rural Tanzania

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Abstract

This study uses a unique panel dataset on micro data with 786 households over 3 years (2014, 2016 and 2018) at the community level in Tanzania, assessing the contribution of different income sources on the changes in income inequality and poverty. The results show that in contrast to other income sources, non-farm self-employment is the only source with a constant poverty-decreasing effect. The inconsistency of the different income sources over time can also be observed for the effects on income inequality. Future research is needed to grasp the effect on inequality in more detail assessing its determinants and causal relationships.

KEYWORDS
income inequality, poverty, rural development, Shapley decomposition, Tanzania

1 | INTRODUCTION

The United Nations recognizes poverty, growth and inequality as three main areas for the UN's 2030 Agenda to envisage a world free of poverty and hunger to ensure sustainable economic growth and human well-being (UN, 2015). The focus on inequality in relation to poverty reduction is driven by the assumption that high inequality will not only hamper future growth (Fosu, 2017; Thorbeck, 2013) but also reduce the conversion of economic growth into poverty reduction (Fosu, 2017; Ravallion, 1997, 2005).

The latest data about global poverty published by the World Bank (2020) show that the number of people who are living in extreme poverty (less than US$1.90 PPP 2011 per person per day) has fallen from 1.9 billion in 1990 to 689 million in 2017. Although poverty has decreased worldwide, Sub-Saharan Africa (SSA) accounts for two thirds of the global extreme poor (World Bank, 2020). Therefore, poverty is and will be a primarily African phenomenon notwithstanding the poverty rate is expected to decline from 41% in 2015 to 23% by 2030 under most scenarios (Beegle & Christiaensen, 2019; World Bank, 2020). Furthermore, the majority of the poor (83.5%) live in rural areas (World Bank, 2018), generating their income mainly from agricultural production (Nerman, 2015). Economic growth is one of the key components for reducing poverty in the long term (Dollar & Kraay, 2002; Fosu, 2017), but studies reveal that a high initial inequality reduces the poverty reduction potential of economic growth because it reduces the growth elasticity of poverty reduction (Bergstrom, 2022; Fosu, 2017; Ravallion, 2014). Initial inequality not only hampers poverty reduction through economic growth, but can also exacerbate inequality during economic growth (Atkinson & Lugo, 2010; Manero et al., 2020; World Bank, 2019). The linkages between poverty, growth and inequality are captured in the Poverty–Growth–Inequality triangle. It stated that poverty reduction is depending the growth rate as well as the level of inequality (Bourguignon, 2004). Therefore, reducing poverty should not be considered alone. The distribution of growth and thus inequality needs to be taken into account. The relationship between economic growth, poverty reduction and inequality is of particular interest for rural areas, where poverty is widespread (Manero et al., 2020). On the one hand, studies reveal that economic growth is positively correlated to poverty reduction (Dollar & Kraay, 2002; Fosu, 2017). On the other hand, this positive correlation between economic growth and poverty reduction is depending on the initial level of inequality (Ravallion, 2014). High initial inequality has been shown to hamper the poverty-reduction effect of economic growth (Fosu, 2017; Ravallion, 2014). It shows that the growth–poverty relation is not consistent and clear (Atkinson & Lugo, 2010; Brock & Durlauf, 2000; Deininger & Okidi, 2003) but it is related to inequality in particular (Fosu, 2017; Ravallion, 2014; Son, 2003). The gap between rich and poor in SSA remains one of the highest worldwide, and recent evidence reveals that inequality is a more substantial challenge in SSA than in any other region of the developing world (Bhorat et al., 2019). According to data from the World Bank, the world's eight most unequal nations (measured by the Gini coefficient) are located in SSA, but the variation of inequality levels and trends among the African nations are large (Cornia, 2019).

The theoretical foundation of the connection between economic growth and inequality was laid down by Kuznets (1955), claiming a relationship between inequality and economic growth. He did not explicitly mention the inverse U-shaped pattern of inequality and economic growth; instead, he claimed that this assumption needed further empirical investigation. It was argued that inequality increases with simultaneous economic growth up to a peak. The reduction in inequality will be observed as economic growth continues over time because of a 'trickle-down' effect. The fundamental idea of the trickle-down effect is based on the accumulation of wealth. The accumulation of wealth by the rich is thought to be beneficial for the poor because of transferring wealth from the rich to the poor (Kuznets, 1955). A study by Akinci (2018) using a panel dataset from 65 countries over the period from 1995 to 2011 shows that the increasing income of the rich increases the income of the poor and vice versa. Findings from other studies are supporting the fundamental idea of trickle-down of wealth (Anser et al., 2020; Stiglitz, 2016). Even if there is a trickle-down effect of wealth from the top to the bottom, the rich are still benefiting more from economic growth (Akinci, 2018), which makes the relationship between inequality and poverty ambiguous (McKnight, 2019). These mixed results are supported by Ravallion (2001), who reported from 50 developing countries that the annual poverty reduction is larger in countries with a coincident inequality decline, which is against the trickle-down effect. Other studies reveal that economic growth is an initial point for poverty reduction if income inequality can be held constant (Bourguignon, 2004; Deininger & Squire, 1997; Fosu, 2015, 2017; Ravallion, 2005). The common sense in the past, that is, higher inequality in poor countries leads to more poverty reduction through economic growth, appears to be wrong (Ravallion, 2014).

However, inequality is not necessarily diminishing economic growth per se; in low-income countries, the growth effect of income inequality can be positive (Brueckner & Lederman, 2018). It can set incentives for capital accumulation, which further leads to higher investments (Galor et al., 2009) and innovations (Mirelees, 2006) or increases intergenerational mobility (Lefranc et al., 2008).

Besides the complex growth–poverty relationship and the relation to changes in inequality, there is a broad common sense that the two main factors determining different rates of poverty reduction at a given rate of economic growth are the initial level of income inequality and how inequality changes over time. The higher the initial inequality within a country, the fewer poor people will benefit from economic growth, and it becomes less pro-poor growth (Balakrishnan et al., 2013; Bourguignon, 2004; Heshmati, 2006; Klasen, 2016; Ravallion, 2004). In general, high initial inequality limits the poverty reduction effect of economic growth, while growing inequality fosters poverty directly for a given level of growth (Fosu, 2017).

To sum up, the challenge is to understand the relationship between economic growth, poverty reduction and inequality for producing a development strategy that is able to foster pro-poor growth (Bourguignon, 2004). To increase the knowledge about the relationships between poverty reduction, growth and inequality, it is important to understand the contribution of different income sources to the changes in welfare as well as inequality (Azevedo et al., 2012; Heshmati, 2004). Using the Shapley decomposition approach proposed by Azevedo et al. (2012), it is possible to decompose the changes in income inequality and poverty into the respective income sources to explore the linkages between economic growth from certain income sources with inequality and the reduction of poverty. The overall objective of this paper is to identify the income sources of the rural poor, which have the potential to reduce poverty while not increasing inequality in the community, using primary household level data from Tanzania.

Tanzania is a relevant example where the relationship between economic growth, poverty reduction and inequality is becoming particularly interesting. Tanzania recorded remarkable economic growth and a decline in poverty over the last decades (World Bank, 2019). However, Tanzania's success is not without reservations. In recent years, poverty incidences have remained relatively high despite more than a decade of strong and stable economic growth (Arndt et al., 2016; Mashindano & Maro, 2011). A 10 % increase in the Gross Domestic Product (GDP) per capita results in a reduction of poverty of only 4.5%, which is low compared to other developing countries (World Bank, 2019). The inequality (measured with the Gini coefficient) was increasing from 0.353 in 1991 to 0.405 in 2017 (World Bank, 2021). The noteworthy progress in poverty reduction in Tanzania has come to an end. Data from 2017 show stagnation at a poverty headcount of 49%, while the GDP is still growing (World Bank, 2020). The mismatch between economic growth and poverty reduction can be explained by inequality (Atkinson & Lugo, 2010) Another point that makes Tanzania a valuable case study is the high share of the rural population (73%), where 80% of the population are smallholder farmers (farm size smaller than of 2.2 ha) (Rapsomanikis, 2015). The livelihood of these individuals depends mainly on agricultural production as their main income source, but diversification of income generating activities is the norm (Barrett et al., 2001). In addition to that, smallholder farmers are characterized by a high vulnerability to exogenous shocks such as droughts, floods, pests and market fluctuations (Anderson et al., 2016; Mutabazi et al., 2015).

This article contributes to the literature in three ways. First, we provide new insights into the contribution of different income sources to changes in poverty and inequality over time using a unique panel dataset. The existing data on inequality in Tanzania are usually restricted to limited rounds of methodologically different household budget surveys, and only a few of them include more than two survey rounds, ignoring trends in inequality and poverty (Maliti, 2019; Manero et al., 2020). A lot of studies have been carried out on inequality and their relationship to economic growth, but studies using panel data are still very limited (Alamanda, 2021; Hailemariam et al., 2021).

Second, the bulk of the literature on inequality and poverty focuses on macroeconomic studies derived from governmental data (Atkinson & Lugo, 2010; Ferreira & Ravallion, 2008; Fosu, 2017), and the impact of growth on inequality usually differ across communities over time (Takane & Gono, 2017). The predominant use of national wide data results in a gap on the local level, which is of particular interest to designing pro-poor growth strategies (Manero et al., 2020). Therefore, the relationship between economic growth, poverty and income inequality at the community and household level is still an under-researched topic (Ferreira & Ravallion, 2008; Manero et al., 2020; Silva, 2013). It is important to understand this relationship more precisely in order to design more effective policy measures supporting robust growth strategies (Berg & Ostry, 2011; McKnight, 2019; Ravallion, 2001), particular on community level (Manero et al., 2020).

Third, there is hardly any literature assessing, which income components of smallholders close or below the poverty line (e.g., agriculture, off-farm wage employment, non-farm self-employment or livestock keeping) positively promote growth at the household level (and thus the reduction of absolute poverty) and simultaneously how they influence inequality. Hence, this paper aims at contributing to this research gap by analysing whether there are sources of income that have the potential to reduce poverty at the household level and at the same time not increase inequality in the rural community. Furthermore, we are able to compare all income sources of a household creating a much-detailed picture instead of focusing on only one or few particular income generating activities.

A unique household panel dataset from rural Tanzania is used to answer the question of the livelihood activities of smallholder farmers affect the poverty and inequality level using the Shapley decomposition of changes in welfare and income inequality.

2 | DATA AND METHODOLOGY

2.1 | Study area and data collection

The United Republic of Tanzania (URT) shows a human development index (HDI) of 0.528 in 2019 and belongs to the least developed countries in East Africa at position 159 out of 189 in the world. In 2017, almost half (49.4%) of the population in Tanzania lives under the poverty line of 2011 PPP USD$ 1.90 per day. Tanzania's Gini coefficient of 0.405 in 2017 is below the SSA average of 0.451 (World Bank, 2021). Furthermore, the landscape of Tanzania is very diverse, which leads to very different local conditions concerning climate conditions (Rowhani et al., 2011) and infrastructure (Asfaw et al., 2012). This is also appropriate to the study area (Figure 1). The household panel data set used in this paper covers two distinct regions, the Kilosa district in the Morogoro region and the Chamwino district in the Dodoma region. Morogoro is characterized by a semi-humid climate with 600–800 mm annual precipitation and bimodal rain patterns (Graef et al., 2014), which leads to a more diverse agriculture system compared to Dodoma (Mnenwa & Maliti, 2010). Dodoma has a semiarid climate with an annual precipitation rate of 350–500 mm and a unimodal rainfall regime (Mnenwa & Maliti, 2010), resulting in lower agricultural productivity compared to the Morogoro region (URT, 2012). The survey comprises three panel waves that took place in 2014, 2016 and 2018. The sample size of the first wave covered 899 households, of which 820 and 786 were interviewed in the second and third waves, respectively. The analysis builds on 786 rural farming households interviewed in all three survey rounds. The reference period for each survey refers to the past year. The selection process of the households followed a two-step sampling procedure. In the first step, six villages with attributes representative of the respective districts were chosen together with local experts (Morogoro, Kilosa district: Changarawe, Ilakala and Nyali; in Dodoma, Chamwino district: Ilolo, Idifu and Ndebwe) covering 70–80% of the typically farming systems in Tanzania. The selection criteria were based on several comparable socioeconomic and agroecological features (Graef et al., 2014). In the second step, 150 households per village were randomly selected from village household lists, proportionally (~10%) to the village size (Brüssow et al., 2019; Graef et al., 2014). So that the influence of the various income activities on poverty and inequality could be analysed, the structured questionnaire included information on all income generating activities as well as consumption, assets and land use.

The authors ensure that experiments involving humans or human material were not part of the research. Experiments with animals were not part of the research. Data were collected, processed and handled in accordance with the BMBF (Federal Ministry of Education and Research—Germany) regulations and stored in an appropriate data management system for later use. The project assures that it does not violate any promises of anonymity. Summary statistics of the sample with respect to household characteristics, income generating activities as well as agricultural structure are presented in Table A1 to Table A7.

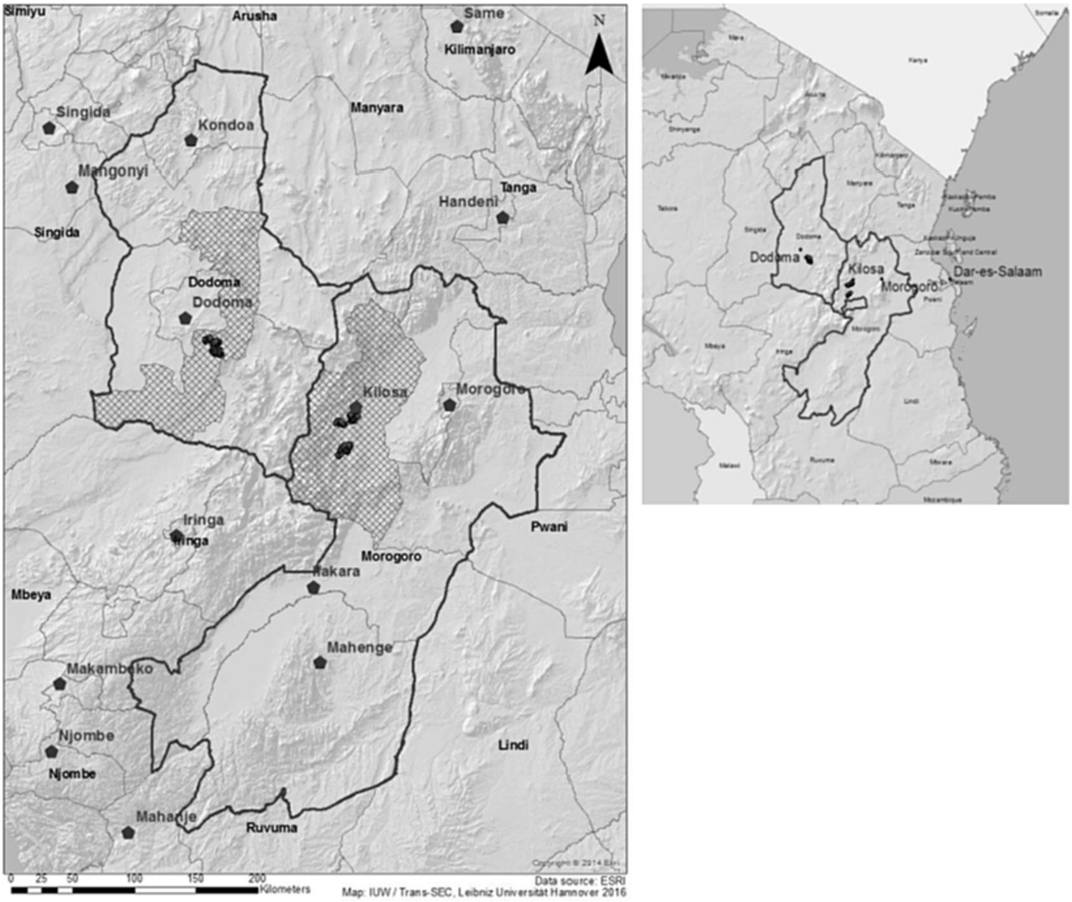

FIGURE 1 Location of Tanzania and the sample sites. The study sites are located in the Kilosa district in the Morogoro region and the Chamwino district in the Dodoma region (dashed area). *Source*: Own data.

2.2 | Variables of interests

2.2.1 | The portfolio of income generating activities: income calculation

The household income aggregation was done following the World Bank guidelines and included the following income sources (Johnson et al., 1990): (1) remittances received from friends and relatives; (2) income from land rent; (3) income from crop production; (4) income from livestock keeping; (5) income from natural resource extraction; (6) income from off-farm wage employment; (7) income from non-farm self-employment; and (8) transfer payments. Income from remittances, land rent and transfer payments accounted for only a very low amount of income and therefore collapsed to income from ‘other sources’. The final disposable household income was converted from the local currency, the Tanzanian Schilling (TZS) to 2011-based purchasing power parity (PPP) United States dollar (US$). The disposable net income was used instead of the gross income because this is the income that households have available to buy goods and services; hence, it is a better measure of living standards than gross income where costs are not reflected (Balestra & Tonkin, 2018).

Throughout the whole survey, less than 2.5% of the households reported a negative total annual income. Nevertheless, negative incomes are not uncommon in survey data and reported by many authors (Feng et al., 2006;

Möllers & Buchenrieder, 2011; Raffinetti et al., 2017). The reasons for negative incomes are manifold; e.g., crop losses due to environmental shocks can lead to negative incomes (Steffens et al., 2020), or self-employment activities may incur a loss (Raffinetti et al., 2017). The main problem that occurs in the presence of negative values is the abnormal behaviour of the Gini coefficient because the normalization principle is violated. This can lead to a Gini coefficient higher than one (Chen et al., 1982). Furthermore, the Gini coefficient is no longer a concentration measure then, and it can be only used to measure the variability with respect to the mean value (de Battisti, 2019). Another limitation of measuring inequality using Gini while including negative incomes is that it may not meet the Pigou–Dalton principle of transfer where any mean-preserving transfer (progressive or regressive) increases or decreases the measure of inequality (Shorrocks & Foster, 1987).

A very common way to solve the problem of negative income is to exclude them from inequality measures (Muller et al., 2018; World Bank, 2020). To avoid the issues mentioned above, the most common and simple practice is to drop negative values from the sample, which is also done by the World Bank's PovcalNet, but excluding negative values has serious disadvantages. First, if the number of households with negative income is high, a significant proportion of information would get lost. Second, ignoring households with negative values may lead to insufficient comparisons between different distributions (de Battisti et al., 2019). Hence, ignoring households with negative income, which are generating most of their income from agricultural activities, thus is not the optimal solution because reporting negative incomes is common and ignoring them also means ignoring key features of rural household's income (Rawal et al., 2008; Zhang et al., 2019).

Another common way to deal with negative incomes is to set them to zero. Many researchers (Burkhauser & Simon, 2010; de Battisti et al., 2019; Feng et al., 2006; Ferreira & Gomes, 2015; OECD, 2017) applied this truncation of data with negative values. The truncation can lead to a loss of information, but studies from Seidl et al. (2012) and Bray (2014) showed consistency in the results setting negative values to zero. These findings are supported by de Battisti et al. (2019) on the extent of information loss due to truncating negative values, suggesting that if the proportion of negative values is lower than 5%, setting negative values to zero leads to an acceptable corresponding unbiased Gini coefficient. This approach is also applied in this paper where less than 2.5% of the households report a negative annual income. To test the adequacy of setting negative values to zero, a sensitivity analysis was conducted (Table A8).

To account for the economies of scale, the adult equivalent scale used by the National Bureau of Statistics of the URT and the United Nations Children's Fund (NBS, 2016), which adjusts household's welfare of certain needs based on age and sex of the household member. This allows it to compare the income of different households with different structures of household members.

Outliers are common in income data and can affect the estimation of income inequality (Safari et al., 2021). We defined outliers as values less or greater than the 1.5 interquartile range (Templ et al., 2020), and they were detected on the income source level. The advantage of the interquartile range is that it is based on values that come from the middle half of the distribution and therefore unlikely to be influenced by outliers themselves (Manikanda, 2011). There are two main approaches to handling outliers, trimming and winzorizing. Trimming drops all outliers from the distribution, while winzorizing replaces the discarded values with the most extreme possible value (Wilcox, 2005). It would not be expedient to trim the distribution, because this explicitly stated that these values are not interesting for the given purposes, but extreme and realistic values are particularly important for the measure of inequality (Tables A9 and A10).

2.2.2 | Measuring inequality: Gini coefficient

The Gini coefficient measures the degree to which a given distribution in a society differs from a perfectly equal distribution. It can range from 0 (*perfect equality*) to 1 (*perfect inequality*) (Gini, 1912; UN, 2015) and is based on the representation of the Lorenz curve, which plots cumulative income vs. cumulative population. Besides the Gini coefficient, the Theil index is another very common inequality measure. It belongs to the family of general entropy measures that are based on ratios of incomes to the mean (Cowell, 2000). Unfortunately, the Theil index, unlike the Gini coefficient, is not capped at 1. Furthermore, it is not a relative measure of inequality, and thus, the results are not always comparable across populations of different sizes or group structures (Anand & Segal, 2015). Therefore, the Gini coefficient was used in this work and it is calculated as follows:

$$G = cov(y, F(y))\frac{2}{\overline{y}},$$

where *cov* is the covariance between the income levels *y* and the cumulative distribution of the same income *F*(*y*) with the average income of $\overline{y}$.

2.2.3 | Shapley decomposition

Azevedo et al. (2012) proposed a non-parametric approach that allows decomposing the changes in welfare and inequality into income sources using the Shapley concept. The Shapley decomposition can be applied to any welfare measure based on the welfare aggregate (disposable income) providing the contribution of each component to the observed change in the indicator.

The measure of inequality θ generated by the function $\phi(.)$ depends on the cumulative density function $F(.)$ in income across the household concerning the income source y_K. The initial inequality rate is calculated as follows:

$$\theta = \phi(F(Y(y_1, y_2, ..., y_K))).$$

Following Barros et al. (2006), this method uses the benefit of the additivity property of a welfare aggregate to make a counterfactual distribution of the welfare aggregate by changing each component at a time to calculate their contribution to the observed changes in poverty and inequality. For instance, assuming the distribution of the welfare aggregate (i.e., income) for Periods 0 and 1 is known, and they were calculated using an equation based on their components (i.e., income sources). The counterfactual distribution for Period 1 can be calculated by substituting the observed level of a given income source y_K by its observed level for period 0, $\widehat{y}_K$, one at a time, until there is a completed change from Periods 0 to 1. In the next step, the inequality and poverty measure can be constructed for each counterfactual distribution, and those counterfactuals are interpreted as the inequality or poverty level that would have prevailed in the absence of a change in that indicator.

More in detail, to measure the impact of a change in the distribution of income source y_1, $\widehat{\theta_1}$ is computed, where the value for y_1 is substituted by its value in period 0, $\widehat{y}_1$:

$$\widehat{\theta_1} = \phi(F(Y(\widehat{y}_1, y_2, ..., y_K))).$$

The resulting effect due to changes in Income Source 1 is calculated by $\widehat{\theta_1} - \theta$. Similarly, the contribution of each income source to the changes in inequality is measured as follows:

$$\widehat{\theta_K} = \phi(F(Y(\widehat{y}_1, \widehat{y}_2, ..., \widehat{y}_K))) \text{ Contribution of income source } K : \widehat{\theta_K} - \widehat{\theta_{K-1}}.$$

In order to deal with the path dependency, which comes along with the stepped decomposition, all potential paths K! were decomposed, and the average of the estimates was taken (Shapley, 1988; Shorrocks, 2013).

The Shapley decomposition is very useful for understanding the driving income sources behind inequality and poverty, but it is not free of limitations. The decomposition that is calculated by eliminating each factor in succession lacks equilibrium consistency. The results are no longer an economic equilibrium but rather a result of assuming, ceteris paribus, that it would be possible to change only one factor at a time. This would not be a problem if the factors were independent from each other (Azevedo et al., 2013). This decomposition method is able to shed light on the importance of different income sources in the changes in inequality and poverty, but its main limitation is that it does not provide any information about the factors affecting the changes in the income source itself (Azevedo et al., 2012).

Another but more theoretical disadvantages arise from the lack of independence from the level of disaggregation using the Shapley approach (Sastre & Trannoy, 2002; Shorrocks, 2013). The Shapley value measures the redistributive effect contributed by each income source assuming that there is no particular order in which the different income sources must be applied and that there is no hierarchy of aggregation of them. Nevertheless, this assumption is valid because in practice different income generating activities are done at the same time. The counterfactual distributions that were generated follow every possible decomposition path; therefore, the reported Shapley–Shorrocks values are robust for each component (Barros et al., 2006).

2.2.4 | Foster-Greer-Thorbeck indicators

The Foster–Greer–Thorbeck indicators (FGT) have become a standard for international evaluations of poverty and the World Bank's PovalNet, and many other countries report them regularly (Foster et al., 2010) based on the following equation:

$$FGT_\alpha = \frac{1}{n}\sum_{i=1}^{q}\left(\frac{z-y_i}{z}\right)^\alpha,$$

where z is the poverty line, y_i is the ith lowest income (or consumption), n is the total population, q is the number of the poor (those with incomes at or below z) and $\alpha \geq 0$ is the 'poverty aversion' parameter. If α is low, then the FGT metric weights all individuals with income below the poverty line z equally. The higher the value of α gets, the greater the weight placed on the poorest individuals and this leads to three different FGT indicators (Foster et al., 1984):

i. $\alpha = 0$, the formula is reduced to $FGT_0 = \frac{q}{n}$ and the poverty headcount ratio measures the proportion of the population that lives below the poverty line in percentage. The FGT_0 is insensitive to differences in the depth and severity of poverty.
ii. $\alpha = 1$, the formula is reduced to $FGT_1 = \frac{1}{n}\sum_{i=1}^{q}\left(\frac{z-y_i}{z}\right)$ and the poverty gap index. FGT_1 measures the depth of poverty. The poverty gap index is the ratio by which the mean income of the poor falls below the poverty line. It provides an indication of the poverty level in percentage between 0% and 100%.
iii. $\alpha = 2$, the formula is $FGT_2 = \frac{1}{n}\sum_{i=1}^{q}\left(\frac{z-y_i}{z}\right)^2$ and the squared poverty gap index. FGT_2 measures the severity of poverty. It weights the poverty gap and gives higher weights on the poorest, indicating a combined measure of poverty and inequality.

3 | RESULTS

3.1 | Poverty and income inequality

The changes in income inequality as well as the incidence, depth and severity of poverty are illustrated in Table 1. The bootstrapped significance level of each value can be found in Table A11. The results show that the proportion

TABLE 1 Foster–Greer–Thorbeck indicators and the Gini coefficient.

Indicators	2014 ($n = 786$)	2016 ($n = 786$)	2018 ($n = 786$)
FGT(0)	83.8%	81.6%	71.8%
FGT(1)	52.2%	47.8%	36.1%
FGT(2)	37.5	32.9	22.2
Gini coefficient	0.549	0.543	0.466

Source: TransSEC data 2014, 2016, 2018 own calculation. FGT(0) poverty head count ratio (%), FGT(1) poverty gap index (%) and FGT(2) squared poverty gap index.

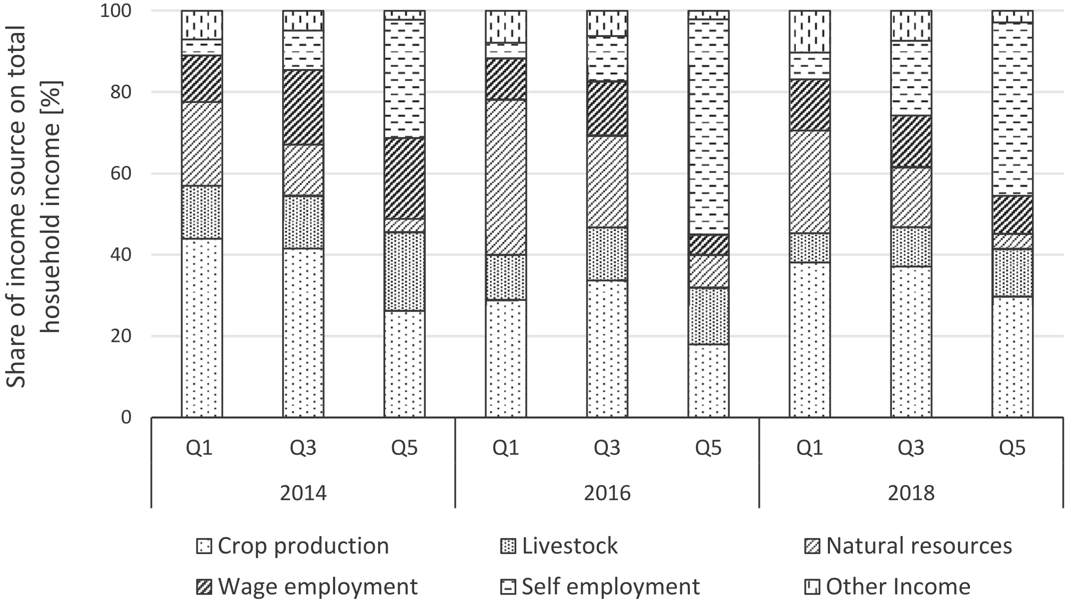

FIGURE 2 Income from different income sources as a share of total annual household income per adult equivalent (PPP USD 2010) by quintiles ($n = 786$).

of households living in poverty has fallen from 83.8% in 2014 to 71.8% in 2018. The same decreasing trend can be observed in the depth and severity of poverty. Income inequality decreased continuously from 0.549 in 2014 to 0.466 in 2018.

3.2 | Share of income sources on the total income by quintiles

Figure 2 illustrates the share of income sources on the total income by quintiles to get a better understanding of the importance of different income sources for the households' livelihood. A detailed picture of the income structure can be found in Table A12 to Table A17.

In 2014, households in the first and third quintiles generated more than 40% of their income from crop production. It becomes less important for households from the fifth quintile. Next to crop production activities, the households in the first quintile depend mainly on natural resource extraction, livestock and income from off-farm wage employment, while income from non-farm self-employment plays a minor role. The importance of natural resources for the households' livelihood decreases over the quintiles; it becomes less essential for the households in the third quintile and almost negligible for the households in the fifth quintile. Households on the top of the income distribution generate 29% of the income from non-farm self-employment in 2014. Income from self-employment is becoming the main income source for the richest households in the sample.

From 2014 to 2016, the income share of crop production, livestock and wage employment decreases in every quintile, while the share of income from natural resource extraction rises. This leads to a shift in the first quintile, where income from crop production decreased from 44% to 29%, while the share of natural resources increased from 21% to 38%. Households in the third quintile still mainly depend on income from crop production even if it is reduced and the income share of natural resources increased. In 2014, the importance of income from crop production (26%) and non-farm self-employment (29%) was almost equal for the livelihood of households at the top of the income distribution. The share of non-farm self-employment increased to 53%, while crop production income declined to 18% in 2016.

The income patterns changed also from 2016 to 2018. Income from crop production became more important for all quintiles, while income from natural resource extraction became less important. Income from non-farm self-employment still increased for the first and third quintiles and was still the main income source for the households in the fifth quintile with 43% but declined by 10%.

To sum up, it is clear that households at the bottom of the income distribution depend mainly on crop production and natural resource extraction. This livelihood dependency is changing throughout the quintiles away from crop and natural resource extraction to income from non-farm self-employment, in a way that it is the main income source for households on the top of the income distribution. Furthermore, it is notable that the income compositions of the households are changing over time.

3.3 | Income sources accounting for the change in disposable income inequality and poverty

In the previous section, the share of the different income sources on the total annual household income per adult equivalent was presented. These results are accompanied by an analysis of the contribution of each income source to the change in disposable income inequality (measured by the Gini coefficient) and poverty (measured by the FGT indicators) (Table 2).

The decreasing trend in the Gini coefficient between 2014 and 2016 is mainly driven by income from natural resource extraction (−0.024) and wage employment (−0.019). In contrast, income from non-farm self-employment and crop production have unequilizing effects, while non-farm self-employment is the main unequilizing factor.

TABLE 2 Shapley decomposition of the changes in inequality and poverty in disposable annual household income (PPP USD 2011) per adult equivalent by income sources ($n = 786$).

	2014–2016				2016–2018			
Income sources	FGT(0)	FGT(1)	FGT(2)	Gini	FGT(0)	FGT(1)	FGT(2)	Gini
Crop production	2.1	2.3	2.1	0.010	−4.3	−5.6	−5.3	−0.017
Livestock	1.5	1.0	0.8	0.000	−1.6	−1.0	−0.7	−0.011
Natural resources	−2.3	−4.2	−4.5	−0.024	1.8	1.1	0.8	−0.002
Wage employment	1.3	1.0	0.9	−0.019	−1.8	−2.0	−1.8	−0.005
Non-farm self-employment	−4.3	−3.6	−3.1	0.033	−3.1	−3.2	−2.6	−0.036
Other income sources	−0.6	−0.9	−0.9	−0.006	−0.9	−1.1	−1.0	−0.006
Total difference	−2.3	−4.4	−4.7	−0.006	−9.8	−11.6	−10.6	−0.077

Focusing on the changes in poverty between 2014 and 2016, another picture emerges. Income from non-farm self-employment and natural resource extraction is the main reducers of poverty. Comparing the changes in the incidence and severity of poverty, it is getting clear that, particularly, the poorest households are profiting from natural resource extraction, while non-farm self-employment is supporting the richer households in the sample. All other income sources had an increasing effect on poverty in the same period. Here, crop income is increasing the poverty incidence, depth and severity the most.

In the period between 2016 and 2018, all income sources reduced income inequality. Income from self-employment accounted for almost half of the reduction, while income from natural resource extraction was the only income source with a poverty-promoting effect; all other income sources reduced poverty. The main driver behind the decreasing poverty was income from crop production and non-farm self-employment. Crop production income mainly reduces the severity of poverty indicating the poor are benefiting more, while non-farm self-employment supports richer households, therefore, the reduction is higher in the incidence compared to the severity of poverty.

To sum up, income from non-farm self-employment is the only income source that is able to decrease poverty constantly, even if the poorest households are participating less. Compared to this, income from crop income and natural resources has the highest poverty reduction potential, even if these reduction effects are not constant over time. The Gini coefficient is falling throughout the years, but the share of the different income sources is mixed. Income from natural resource extraction and wage employment decrease income inequality, while other income sources show inconsistent effects on income inequality.

4 | DISCUSSION

4.1 | Poverty and income inequality

The overall Gini coefficient in our sample varies from 0.549 in 2014 to 0.466 in 2018. The Household Budget Survey of the Tanzanian National Bureau of Statistics reports for the year 2018 using consumption expenditures with a Gini coefficient of 0.320 for the rural areas. The discrepancy between our findings and the official data could have multiple reasons: The Gini coefficient based on disposable income as used here shows usually higher values and variability than consumption (Hassine & Zeufack, 2015; Stiglitz et al., 2018). Moreover, an empirical study by Manero (2017) revealed that the Gini coefficients in Tanzania focusing on smallholder farmers ranged from 0.56 to 0.60 using income and 0.39 to 0.54 using consumption expenditures. These differences between income inequality in certain groups are supported by findings from Lusambo (2016) focusing on farmers in Morogoro highlighting a Gini coefficient of 0.82. This explicitly shows how important it is to use data on the community level to illustrate a more accurate picture of inequality and poverty. Furthermore, using macro-level data are not suitable to establish policy implications at the community level.

Regarding the poverty headcount, the values in this study area range from 83.8% to 71.8%, whereby the World Bank (2018) reports 49.4% using the poverty line of $1.90 a day (2011 PPP). Anderson et al. (2016), analysing smallholder households in Tanzania, calculated a poverty headcount of 85%. Since we wanted to shed light on the relationship between inequality and poverty and their relative changes, the absolute values (although not complete in line with other sources) are not undermining any interpretational power of the results. The decrease in the incidence, severity and depth of poverty with the concurrent decline in income inequality shows that the poor are benefiting more from growth than the richer ones, which is a key characteristic of pro-poor growth (Jumrova, 2017). The negative effect of inequality on economic growth and poverty reduction is well established (Ravallion, 2001; Deininger & Squire, 1997; Ostry et al., 2019). This underscores the misconception that focusing only on economic growth assuming that it will induce also poverty reduction can fail if inequality is neglected. Therefore, effective suitable pro-poor growth can only be achieved if inequality is taken into account.

4.2 | Household income sources and their relevance

The share of the income sources on the total annual household income per adult equivalent for households in the different quintiles is unstable over time. Nevertheless, it can claim that income from crop production is particularly important and the main income source for rural households in Tanzania, rather than self-employment income (Anderson et al., 2016; Manda et al., 2021; Reardon & Tayor, 1996; Van den Berg & Kumbi, 2006). One of the leading income source for the richest households is non-farm self-employment; usually, it is restricted to them because initial capital is needed to start their own business (Gutema, 2019), reducing barriers for poorer households could create opportunities for additional income. The poorest households show a high dependency on natural resource extraction for their livelihood (Andrews & Mulder, 2022; Lopez-Feldman, 2014), because it provides several benefits for them, e.g., a safety net in case of a shortfall in income from other sources or supporting consumption (Jagger, 2012; Nunan et al., 2022; Paavola, 2008).

The tremendous changes in the income patterns from 2014 to 2016 and from 2016 to 2018 could be explained by the negative impact of the El Niño effect in 2015 and the following normalization of climate conditions after this environmental shock. Mollet and Barelli (2016) reported that since October 2015, five regions, including Morogoro and Dodoma region, in Tanzania were extremely affected by the El Niño effect resulting in flooding of agricultural and pasture land, leading to animal disease and decreasing yields. A high proportion of the affected land was partially or even totally destroyed. The reduction in the yields of main staple crops are present in our sample as well (Table A11). Additionally to that, this loss resulted in increasing prices for animals and crops by up to 60%. Besides the changes in other income sources in our study, especially the change in income from crop production, natural resource extraction and non-farm self-employment are of particular interest. Evidence shows that weather shocks are associated with decreased yield, food consumption and lower sales of productive assets resulting in a reduction of the household's long-term welfare (Gray & Muller, 2012; Hoddinott, 2006; Hoddinott & Kinsey, 2001; Thiede, 2014). Here, natural resources act like a safety net for poor households engaged in agriculture during periods of stress (Paavola, 2008; Nunan et al., 2022;). The choice of a coping activity depends on the intensity with which the household could engage in the activity, as well as on the availability of other opportunities (Eriksen et al., 2005). It is easy for households who are already engaged in non-farm self-employment, e.g., running their own shop, to increase afford in this business, while poor households who are not engaged in self-employment are missing the necessary capital stock to start a business (Gutema, 2019). Microcredits could be one possible solution to reduce these barriers for poor households (Tundui & Tundui, 2018) and increase their ability to deal with income losses by exploring new income generating activities.

From 2016 to 2018, the income from crop production becomes more important for the top and bottom households of the income distribution, switching back from natural resources and self-employment, respectively. For the richest households, the shift from self-employment to crop production is not so high, meaning that the share of crop income increases but self-employment is still the main income source. It is crucial to differentiate between a principle and a complementary business. The expansion of an existing business, e.g.. running a shop, can become a principal status and will continue after the shock, while a smaller and easier to implement business, e.g., selling cooked products, would be typically a complementary coping strategy and will be dropped if the shock is overcome (Eriksen et al., 2005). Additionally, smallholder farmers enjoy and find great satisfaction in farming; a transition away from farming is therefore done more by necessity rather than joy (Anderson et al., 2016). Shifting back to farming could be a logical subsequent step if crop production is able to ensure a sufficient livelihood. Farmers usually tend to do activities that they perceived to be favourable (Obayelu et al., 2017). It is essential to know which self-employment activities are driven by necessity or joy with a direct implication for the inequality level. Further research needs to be done for evaluating the driving factors beyond our observed shifts. These changes in income patterns have strong implications for the contribution of the different income sources to changes in income inequality and poverty. Nevertheless, this study was not collecting data on the satisfaction level of farmers working in farming activities. Satisfaction can only provide an explanation for the results and should therefore be examined more closely.

4.3 | Income sources accounting for the change in disposable income inequality and poverty

Income from non-farm self-employment is the only income source with a constant decreasing effect on the incidence, severity and depth of poverty in our study. It is well established that starting an own business could be one possible pathway out of poverty (World Bank, 2019). In contrast to this, our findings show that the effect of non-farm self-employment on income inequality is not constant over time. These mixed results are in line with the literature. On the one hand, non-farm self-employment can reduce inequality if all households are able to take up a business (Sujithkumar, 2008). On the other hand, it can also increase inequality if poor households are excluded from starting their own business because of entrance barriers, such as a lack of initial capital (Awoyemi & Adeoti, 2006; Gutema, 2019). Studies reveal that the relationship between entrepreneurship and income inequality follows the inverted U-shaped Kuznets curve (Ragoubi & El Harbi, 2018; Xie et al., 2022). In other words, increasing inequality while growing entrepreneurial activities can be seen as normal to some extent. This claims the question of how it is possible to flatten the curve to avoid an unsustainable level of inequality. One solution would be to reduce the entrance barriers for poor households for taking up a business because, usually, they do not have the required capital to start a business (Gutema, 2019). Nevertheless, non-farm self-employment can play a critical role, especially for the poor because in contrast to agricultural income, non-farm self-employment is not closely linked with landholdings (Dias et al., 2019; Sujithkumar, 2008), and the labour force is more equally distributed among households than land (van den Berg & Kumbi, 2006). Furthermore, Reardon and Tayor (1996) stressed the point that the distributional effect of non-farm self-employment also depends on the resource endowments, meaning that it has a unequilizing effect on poor and risky agricultural zones while having an equalizing effect in the productive agro-climatic zone with a dynamic agriculture structure. Nevertheless, the government can play an active role to promote self-employment to reduce poverty by enhancing entrepreneurial skills via knowledge increase through training and building institutional capacities focusing on individuals who want to establish or expand a business (Ifeoma et al., 2018). All individuals in society must have the same conditions to start a business; otherwise, self-employment can be exclusive leading to higher inequality.

The effect of crop income on poverty and income inequality varies over time. It can have an equalizing effect on income distribution (Alamgir et al., 2021; Babatunde, 2008; Reardon & Tayor, 1996), while other studies show the unequilizing effect of crop income (Awoyemi & Adeoti, 2006; Sujithkumar, 2008). Income from crop production is crucial because high crop income implies higher liquidity and can be seen as a starting point for investments in non-farm businesses (van den Berg & Kumbi, 2006). Furthermore, crop income needs to be taken into account, because the livelihood of the poor depends mainly on crop income, which implies a high vulnerability to environmental shocks with potential yield-reducing effects (Reardon & Tayor, 1996). Respecting the assumed impact of El Niño in our case study, the adoption of climate-smart agricultural techniques could be a possible solution to prevent the poorest from falling into poverty and the resulting increase in inequality. The adoption rate of climate-smart agriculture for rural smallholder farmers is low because farms often face a lack of inputs, such as land, human resources, equipment, infrastructure and finance (Mugabe, 2019). Reducing these barriers can be one solution for increasing the resilience of farmers to environmental shocks and can lessen the inequality-promoting effect as well as the negative effect on poverty induced by environmental shocks. The findings from our study suggest the importance of the relationship between environmental shocks and inequality for further research. This is getting more important knowing that climate change will lead to more frequent and server climate shocks, such as drought or floods. This is supported by Cappelli et al. (2021) using panel data from 149 countries between 1992 and 2008, showing that natural disasters are hitting countries with high levels of income inequality more.

Income from natural resource extraction is showing a continuously decreasing inequality trend, which is in line with the literature (Andrews & Mulder, 2022; Fisher, 2004; Lopez-Feldman et al., 2007). These findings imply that natural resource extraction is especially important for the poor (Avom et al., 2022). In addition to that, not only the poor are depending on natural resources but rather less educated young male-headed households with poor access to markets as well as female-headed households because of lacking alternative income sources (Andrews & Mulder, 2022). Therefore, natural resources can be seen as an important income generating activity, making rural communities more equal (Jagger, 2012). The impact on poverty is diverse; our results show that if natural resources have a poverty reduction potential, then the poor, in particular, participate in natural resource extraction stressing the importance of natural resources as an income-generating activity (Lopez-Feldman, 2014). However, the use of natural resources is not risk free. Communities in developing countries tend to overuse natural resources, which leads to the depletion of these resources (Massoi, 2019) In other words, poor farmers with no opportunities to take up other income generating activities could accidentally destroy their livelihood, which can promote inequality and poverty.

Further research has to be done on the reasons and resulting implications that can be observed in the strong changes in households' income structure in our case study. One possible explanation could be the El Niño effect in 2015 that caused the high loss of yields mentioned above (Mollet & Barelli, 2016). It would be important to focus on a particular income source to understand the changes and underlying factors in detail. Furthermore, it can be seen that the strong changes in income patterns have direct implications for inequality and poverty. Therefore it is not possible to designate one particular income source as primarily worthy for income inequality and poverty.

5 | CONCLUSION

In this study, we provide new empirical evidence on the contribution of different income sources on the changes in poverty and income inequality. Our analysis builds on a household panel survey of traditional smallholder farmers in Tanzania between 2014 and 2018.

First, we provide evidence on the extent of inequality and poverty as well as the contribution of different income sources to them over time using panel data. Our results show that the level how different income sources influencing inequality and poverty is not stable over time. It stresses the point that research on the relationships between poverty reduction and inequality should be undertaken in more than only one period in time in order to create sustainable policy measures.

Second, our results show the discrepancy between micro and macro-level data about income inequality and poverty. Their magnitude can be much higher on the community level compared to national or regional wide data. This is not surprising but needs to be taken into account when it comes to effective policy implications.

Finally, we contributed to the debate about income sources and their respective influence on the changes in income inequality and poverty. We detect three main income sources with a strong impact on inequality and poverty, positively or negatively. The results from this study suggest that income from crop production, natural resource extraction and non-farm self-employment require a closer examination. Crop income is the main income source for most households, while the households on top of the income distribution generate the highest share of their income from non-farm self-employment. In contrast to this, income from natural resource extraction is much more important for the livelihood of the poor. The changes that can be observed over time call for further research. It would be essential to know what exactly leads to the observed changes and how policy measures can support beneficial income sources in term of income inequality and poverty. Furthermore, entrance barriers to alternate income generating activities must be reduced especially for the poor, to allow income diversification that is not driven by necessity but rather by joy.

The main limitation of this study is the limited scope. It is difficult to claim that our findings are generalizable to whole Tanzania or even beyond, although our sample covers 70–80% of the typical farming systems in Tanzanian. Further, the analysis is focusing on descriptive statistics to estimate which income sources are of particular interest when it comes to income inequality and poverty. Future research will focus on the factors that are influencing a certain income source to know how policy measures should handle each of these income sources.

Our findings shed light on some debated questions regarding income inequality and poverty. The main policy implication is that political and institutional measures were taken to increase income with a strong pillar on non-farm self-employment next to farming activities, while stabilizing or even reducing inequality, this would be a great lever to fuel future growth in developing countries. Further research has to be done on evaluating the causalities between poverty reduction and inequality resulting from non-farm self-employment.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author, Gregor Mager. The data are not publicly available due to restrictions, e.g., their containing information that could compromise the privacy of research participants.

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APPENDIX A

TABLE A1 Sample characteristics of the quintiles.

Variables	2014 Q1 (*n* = 158)	2014 Q2 (*n* = 157)	2014 Q3 (*n* = 157)	2014 Q4 (*n* = 157)	2014 Q5 (*n* = 157)	2016 Q1 (*n* = 158)	2016 Q2 (*n* = 157)	2016 Q3 (*n* = 157)	2016 Q4 (*n* = 157)	2016 Q5 (*n* = 157)	2018 Q1 (*n* = 158)	2018 Q2 (*n* = 157)	2018 Q3 (*n* = 157)	2018 Q4 (*n* = 157)	2018 Q5 (*n* = 157)
Gender hhh (% male)	70	83	73	87	82	75	71	76	77	81	65	74	75	75	81
Age hhh (years)	51.63 (1.38)	50.87 (1.22)	49.91 (1.38)	47.37 (1.30)	46.31 (1.40)	53.54 (1.33)	53.30 (1.31)	50.69 (1.24)	49.73 (1.38)	48.83 (1.30)	56.06 (1.41)	52.90 (1.21)	52.35 (1.33)	53.29 (1.29)	48.64 (1.13)
Education hhh (years of schooling)	4.04 (0.28)	4.15 (0.26)	3.81 (0.27)	4.89 (0.28)	5.11 (0.27)	4.18 (0.27)	4.25 (0.26)	4.35 (0.28)	4.45 (0.27)	5.43 (0.28)	3.97 (0.28)	3.79 (0.27)	4.41 (0.27)	4.32 (0.27)	4.91 (0.28)
Hh size nucleus	5.53 (0.18)	5.18 (0.18)	5.04 (0.19)	4.65 (0.17)	3.86 (0.15)	5.71 (0.19)	4.88 (0.15)	4.85 (0.16)	4.30 (0.17)	3.94 (0.15)	5.04 (0.15)	4.7 (0.16)	4.47 (0.18)	4.42 (0.17)	4.00 (0.16)
Hh size adult equivalent	4.48 (0.15)	4.23 (0.15)	4.07 (0.15)	3.77 (0.14)	3.12 (0.12)	4.77 (0.17)	4.08 (0.13)	4.02 (0.13)	3.50 (0.14)	3.26 (0.13)	4.19 (0.13)	3.96 (0.13)	3.69 (0.15)	3.67 (0.14)	3.30 (0.13)
Cultivatable land (ha)	0.78 (0.06)	0.73 (0.05)	0.92 (0.16)	0.91 (0.05)	1.08 (0.10)	0.96 (0.08)	0.89 (0.06)	0.82 (0.05)	0.92 (0.05)	1.35 (0.17)	0.6 (0.04)	0.76 (0.05)	0.73 (0.05)	0.85 (0.05)	0.96 (0.05)
Hh engaged in ... (%)															
Crop production	94	97	97	97	97	95	97	97	97	98	97	99	97	99	100
Livestock	50	65	62	75	76	68	81	89	83	85	73	80	83	89	82
Natural resources	72	79	78	80	77	96	100	98	96	97	98	98	97	97	92
Wage employment	20	26	30	25	26	30	41	39	34	35	49	48	50	48	54
Self-employment	11	15	30	25	48	11	25	29	46	66	23	44	45	65	65
Other Income	20	26	30	25	26	30	41	39	34	35	49	48	50	48	54

Note: Mean values and standard errors (in parentheses) of different household characteristics and share of households engaged in different income sources.

TABLE A2 Cultivated area in ha for different crops and income quintiles in 2014.

	1st quintile (n = 158)		2nd quintile (n = 157)		3rd quintile (n = 157)		4th quintile (n = 157)		5th quintile (n = 157)	
Type of crop	***n***	**Mean**	***n***	**Mean**	***n***	**Mean**	***n***	**Mean**	***n***	**Mean**
Maize	95	0.76 (0.07)	101	0.76 (0.10)	102	0.80 (0.07)	113	0.87 (0.06)	113	1.14 (0.12)
Millet	72	0.89 (0.08)	87	1.09 (0.13)	79	0.92 (0.08)	60	1.07 (0.09)	62	1.12 (0.23)
Sunflower	29	0.59 (0.10)	22	0.55 (0.10)	33	0.49 (0.05)	31	0.74 (0.13)	40	0.73 (0.12)
Groundnut	60	0.65 (0.07)	71	0.72 (0.12)	61	0.76 (0.11)	55	0.72 (0.07)	56	1.04 (0.18)
Simsim	31	0.68 (0.11)	41	0.70 (0.10)	54	0.59 (0.07)	73	0.80 (0.06)	76	1.02 (0.13)
Sorghum	31	0.71 (0.09)	42	0.65 (0.07)	35	0.88 (0.10)	33	0.76 (0.09)	29	0.95 (0.17)
Bambara nut	23	0.44 (0.10)	29	0.50 (0.09)	33	0.70 (0.18)	25	0.52 (0.13)	26	1.07 (0.39)
Rice	6	0.70 (0.29)	7	0.41 (0.17)	9	0.72 (0.24)	21	0.51 (0.07)	19	0.70 (0.13)
Cowpeas	9	0.51 (0.16)	13	0.42 (0.09)	11	0.45 (0.08)	10	0.73 (0.28)	18	0.72 (0.22)
Pigeon peas	9	0.84 (0.40)	9	0.89 (0.65)	5	0.38 (0.21)	10	0.59 (0.11)	12	0.56 (0.10)
Other crops	153	0.75 (0.04)	156	0.82 (0.07)	157	0.78 (0.04)	157	0.84 (0.05)	155	1.12 (0.09)

Note: Mean values and standard errors (in parentheses) of area (ha) under cultivation for different crops for different income quintiles.

TABLE A3 Cultivated area in ha for different crops and income quintiles in 2016.

	1st quintile ($n = 158$)		2nd quintile ($n = 157$)		3rd quintile ($n = 157$)		4th quintile ($n = 157$)		5th quintile ($n = 157$)	
Type of crop	*n*	Mean	*n*	Mean	*n*	Mean	*n*	Mean	*n*	Mean
Maize	86	0.75 (0.05)	80	0.65 (0.05)	85	0.67 (0.04)	97	0.69 (0.04)	95	0.84 (0.05)
Millet	75	0.94 (0.07)	92	0.86 (0.05)	81	0.78 (0.06)	72	0.96 (0.07)	64	0.97 (0.08)
Sunflower	47	0.64 (0.09)	60	0.49 (0.05)	55	0.45 (0.04)	59	0.56 (0.06)	52	0.73 (0.12)
Groundnut	43	0.50 (0.08)	56	0.45 (0.05)	53	0.43 (0.04)	56	0.49 (0.05)	55	0.64 (0.06)
Simsim	39	0.66 (0.13)	52	0.51 (0.04)	47	0.60 (0.06)	62	0.60 (0.05)	51	0.86 (0.09)
Sorghum	15	0.71 (0.14)	20	0.51 (0.08)	25	0.63 (0.08)	19	0.51 (0.07)	15	0.70 (0.12)
Bambara nut	22	0.38 (0.06)	22	0.33 (0.05)	30	0.35 (0.04)	24	0.32 (0.08)	28	0.36 (0.05)
Rice	11	0.44 (0.07)	14	0.40 (0.05)	20	0.57 (0.09)	25	0.50 (0.07)	34	0.74 (0.10)
Cowpeas	5	0.33 (0.22)	4	0.30 (0.06)	6	0.27 (0.06)	5	0.59 (0.19)	11	0.35 (0.06)
Pigeon peas	30	0.64 (0.08)	40	0.52 (0.06)	41	0.65 (0.09)	51	0.52 (0.04)	55	0.81 (0.10)
Other crops	155	0.73 (0.04)	156	0.61 (0.03)	156	0.60 (0.03)	156	0.65 (0.03)	155	0.79 (0.04)

Note: Mean values and standard errors (in parentheses) of area (ha) under cultivation for different crops for different income quintiles.

TABLE A4 Cultivated area in ha for different crops and income quintiles in 2018.

	1st quintile (*n* = 158)		2nd quintile (*n* = 157)		3rd quintile (*n* = 157)		4th quintile (*n* = 157)		5th quintile (*n* = 157)	
Type of crop	***n***	**Mean**	***n***	**Mean**	***n***	**Mean**	***n***	**Mean**	***n***	**Mean**
Maize	89	0.63	95	0.76	92	0.69	91	0.60	97	0.86
		(0.04)		(0.05)		(0.05)		(0.05)		(0.07)
Millet	60	0.68	70	0.76	63	0.86	88	0.93	65	1.09
		(0.05)		(0.06)		(0.11)		(0.06)		(0.10)
Sunflower	55	0.42	50	0.43	67	0.43	74	0.51	73	0.64
		(0.05)		(0.04)		(0.03)		(0.05)		(0.08)
Groundnut	40	0.37	44	0.36	56	0.39	73	0.49	58	0.59
		(0.03)		(0.03)		(0.03)		(0.06)		(0.08)
Simsim	9	0.48	20	0.51	17	0.43	14	0.42	19	0.53
		(0.10)		(0.07)		(0.06)		(0.06)		(0.11)
Sorghum	53	0.58	48	0.54	45	0.74	61	0.73	51	0.92
		(0.07)		(0.05)		(0.07)		(0.09)		(0.12)
Bambara nut	12	0.27	19	0.27	19	0.28	34	0.44	28	0.32
		(0.07)		(0.04)		(0.05)		(0.11)		(0.04)
Rice	29	0.43	32	0.36	35	0.48	26	0.48	36	0.73
		(0.07)		(0.05)		(0.05)		(0.07)		(0.08)
Cowpeas	25	0.21	23	0.33	28	0.32	23	0.26	24	0.49
		(0.03)		(0.05)		(0.05)		(0.04)		(0.10)
Pigeon peas	24	0.28	25	0.33	25	0.48	20	0.35	28	0.53
		(0.05)		(0.05)		(0.12)		(0.08)		(0.09)
Other crops	155	0.53	157	0.58	154	0.59	156	0.63	155	0.78
		(0.02)		(0.02)		(0.03)		(0.03)		(0.04)

Note: Mean values and standard errors (in parentheses) of area (ha) under cultivation for different crops for different income quintiles.

TABLE A5 Annual yields (kg) for different crops and income quintiles in 2014.

	1st quintile (n = 158)		2nd quintile (n = 157)		3rd quintile (n = 157)		4th quintile (n = 157)		5th quintile (n = 157)	
Type of crop	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean
Maize	95	232.98 (30.63)	101	370.26 (41.66)	102	528.76 (59.24)	113	792.46 (72.97)	113	1175.80 (151.67)
Millet	72	155.98 (21.33)	87	204.29 (19.23)	79	208.66 (22.62)	60	317.41 (53.50)	62	209.95 (29.33)
Sunflower	29	62.27 (11.45)	22	77.21 (17.85)	33	118.77 (22.74)	31	178.64 (52.31)	40	207.66 (45.24)
Groundnut	60	74.47 (15.40)	71	125.18 (22.51)	61	160.50 (33.10)	55	232.78 (44.13)	56	211.74 (41.54)
Simsim	31	33.06 (10.67)	41	141.10 (22.26)	54	145.81 (18.73)	73	263.53 (30.31)	76	373.47 (45.90)
Sorghum	31	152.29 (27.61)	42	165.46 (23.93)	35	229.66 (42.93)	33	253.45 (51.69)	29	284.52 (64.07)
Bambara nut	23	24.46 (6.83)	29	138.36 (37.89)	33	98.06 (23.06)	25	122.20 (42.01)	26	106.04 (19.96)
Rice	6	272.60 (121.08)	7	305.86 (60.34)	9	676.67 (112.92)	21	580.05 (75.18)	19	743.16 (231.65)
Cowpeas	9	96.44 (58.06)	13	83.00 (28.24)	11	130.00 (52.29)	10	140.35 (55.22)	18	255.36 (103.12)
Pigeon peas	9	115.00 (29.37)	9	84.11 (21.94)	5	76.40 (20.42)	10	112.60 (35.09)	12	237.00 (56.27)
Other crops	153	180.69 (19.18)	156	275.34 (23.44)	157	363.48 (35.36)	157	502.66 (40.20)	155	736.47 (95.18)

Note: Mean values and standard errors (in parentheses) of annual yields (kg) for different crops for different income quintiles.

TABLE A6 Annual yields (kg) for different crops and income quintiles in 2016.

	1st quintile (n = 158)		2nd quintile (n = 157)		3rd quintile (n = 157)		4th quintile (n = 157)		5th quintile (n = 157)	
Type of crop	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean
Maize	86	299.68 (49.33)	80	280.74 (40.64)	85	403.60 (44.21)	97	507.43 (74.57)	95	744.01 (97.10)
Millet	75	231.49 (22.43)	92	255.98 (18.24)	81	293.26 (29.99)	72	368.22 (32.99)	64	427.70 (50.54)
Sunflower	47	135.89 (21.92)	60	151.80 (18.15)	55	145.97 (17.14)	59	212.90 (31.19)	52	303.75 (40.77)
Groundnut	43	111.58 (22.26)	56	135.55 (18.00)	53	168.25 (29.42)	56	200.89 (24.48)	55	292.98 (39.20)
Simsim	39	90.04 (21.91)	52	106.92 (12.68)	47	159.15 (20.45)	62	181.66 (19.68)	51	274.04 (39.93)
Sorghum	15	114.60 (14.50)	20	111.80 (19.13)	25	237.08 (41.66)	19	242.21 (55.16)	15	203.06 (55.60)
Bambara nut	22	41.68 (9.53)	22	36.50 (5.39)	30	67.07 (14.72)	24	71.79 (14.41)	28	90.82 (10.98)
Rice	11	260.55 (109.37)	14	362.29 (74.31)	20	443.03 (84.29)	25	599.60 (107.66)	34	972.59 (175.09)
Cowpeas	5	78.14 (44.98)	4	125.00 (108.97)	6	44.33 (18.43)	5	198.00 (85.81)	11	75.91 (27.59)
Pigeon peas	30	132.17 (28.31)	40	139.66 (22.81)	41	231.68 (42.04)	51	207.22 (26.20)	55	312.09 (62.07)
Other crops	155	213.99 (26.09)	156	196.64 (12.63)	156	272.71 (19.16)	156	322.56 (28.53)	155	498.86 (45.05)

Note: Mean values and standard errors (in parentheses) of annual yields (kg) for different crops for different income quintiles.

TABLE A7 Annual yields for different crops and income quintiles in 2018.

	1st quintile ($n = 158$)		2nd quintile ($n = 157$)		3rd quintile ($n = 157$)		4th quintile ($n = 157$)		5th quintile ($n = 157$)	
Type of crop	*n*	Mean	*n*	Mean	*n*	Mean	*n*	Mean	*n*	Mean
Maize	89	435.18 (45.05)	95	600.96 (60.99)	92	638.22 (61.35)	91	629.98 (83.46)	97	1081.59 (133.22)
Millet	60	334.82 (30.39)	70	447.27 (45.44)	63	488.70 (52.53)	88	529.88 (45.85)	65	713.12 (59.37)
Sunflower	55	157.29 (16.01)	50	221.14 (24.52)	67	270.61 (25.38)	74	311.24 (28.03)	73	447.05 (51.94)
Groundnut	40	102.60 (12.78)	44	145.91 (23.84)	56	198.88 (18.33)	73	236.70 (28.01)	58	459.50 (66.91)
Simsim	9	80.22 (25.21)	20	133.45 (22.58)	17	159.41 (24.44)	14	144.79 (26.56)	19	315.91 (122.71)
Sorghum	53	227.32 (27.07)	48	282.43 (35.79)	45	458.13 (69.81)	61	488.01 (74.08)	51	684.30 (156.53)
Bambara nut	12	66.17 (18.71)	19	91.26 (16.38)	19	98.84 (20.51)	34	98.38 (13.64)	28	139.21 (23.69)
Rice	29	304.31 (44.37)	32	329.38 (51.09)	35	611.40 (101.45)	26	664.81 (136.19)	36	1221.53 (199.22)
Cowpeas	25	41.20 (11.02)	23	142.07 (37.24)	28	126.32 (31.87)	23	118.26 (34.24)	24	307.39 (118.57)
Pigeon peas	24	80.06 (14.02)	25	103.28 (27.03)	25	151.05 (32.94)	20	135.45 (29.31)	28	213.41 (45.08)
Other crops	155	300.11 (22.96)	157	381.40 (28.59)	154	431.44 (27.04)	156	473.97 (37.83)	155	746.23 (63.41)

Note: Mean values and standard errors (in parentheses) of annual yields (kg) for different crops for different income quintiles.

TABLE A8 Mean income (adult equivalent) sensitivity analysis by income sources ($n = 786$).

	2014 ($n = 786$)		2016 ($n = 786$)		2018 ($n = 786$)	
	Mean income including negative incomes	Mean income set negative values to zero	Mean income including negative incomes	Mean income set negative values to zero	Mean income including negative incomes	Mean income set negative values to zero
Crop production	151.17	157.09	123.81	131.13	207.66	210.63
	(8.35)	(8.09)	(8.91)	(8.68)	(12.95)	(12.86)
Livestock	70.14	85.67	58.49	70.14	51.33	72.78
	(13.80)	(11.32)	(10.59)	(10.14)	(8.87)	(7.31)
Natural resources	34.83	34.83	79.00	79.00	56.42	56.42
	(1.92)	(1.92)	(4.63)	(4.63)	(2.19)	(2.19)
Wage employment	85.99	85.99	42.23	42.23	71.16	71.16
	(15.46)	(15.46)	(5.08)	(5.08)	(8.09)	(8.09)
Self-employment	98.75	99.10	203.57	203.82	207.93	208.74
	(14.87)	(14.86)	(28.23)	(28.23)	(20.31)	(20.29)
Other income	14.17	14.17	20.58	20.58	31.89	31.89
	(2.35)	(2.35)	(2.14)	(2.14)	(2.54)	(2.54)
Total income	455.05	476.85	527.68	546.90	626.39	651.62
	(27.56)	(26.26)	(32.67)	(32.46)	(27.07)	(26.95)

Note: Mean values and standard errors (in parentheses) of different income sources in PPP USD 2011.

TABLE A9 Foster–Greer–Thorbecke indices and Gini coefficient sensitivity analysis ($n = 786$).

	2014 ($n = 786$)		2016 ($n = 786$)		2018 ($n = 786$)	
Indicators	FGT indicators and Gini including negative incomes	FGT indicators and Gini set negative values to zero	FGT indicators and Gini including negative incomes	FGT indicators and Gini set negative values to zero	FGT indicators and Gini including negative incomes	FGT indicators and Gini set negative values to zero
FGT(0)	84.4	83.8	81.7	81.6	72.3	71.8
FGT(1)	55.1	52.2	50.2	47.8	39.0	36.1
FGT(2)	51.7	37.6	37.5	32.9	27.1	22.2
Gini coefficient	0.551	0.549	0.547	0.543	0.471	0.466

Source: TransSEC data 2014, 2016, 2018 and own calculation. FGT(0) poverty head count ratio (%), FGT(1) poverty gap index (%) and FGT(2) squared poverty gap index.

TABLE A10 Shapley decomposition of the changes in inequality and poverty sensitivity analysis ($n = 786$).

	FGT indicators and Gini including negative incomes								FGT indicators and Gini set negative values to zero							
	2014–2016 ($n = 786$)				2016–2018 ($n = 786$)				2014–2016 ($n = 786$)				2016–2018 ($n = 786$)			
Income sources	FGT (0)	FGT (1)	FGT (2)	Gini	FGT (0)	FGT (1)	FGT (2)	Gini	FGT (0)	FGT (1)	FGT (2)	Gini	FGT (0)	FGT (1)	FGT (2)	Gini
Crop production	1.9	2.4	2.5	0.017	−3.8	−6.2	−7.7	−0.035	2.1	2.3	2.1	0.010	−4.3	−5.6	−5.3	−0.017
Livestock	1.4	0.4	−9.0	−0.017	−1.3	0.2	2.7	0.008	1.5	1.0	0.8	0.000	−1.6	−1.0	−0.7	−0.011
Natural resources	−2.2	−4.2	−4.7	−0.030	1.3	1.2	0.9	0.000	−2.3	−4.2	−4.5	−0.024	1.8	1.1	0.8	−0.002
Wage employment	1.0	1.0	1.1	−0.016	−1.8	−2.0	−1.8	−0.006	1.3	1.0	0.9	−0.019	−1.8	−2.0	−1.8	−0.005
Non-farm self-employment	−4.2	−3.7	−3.2	0.024	−3.0	−3.3	−3.4	−0.040	−4.3	−3.6	−3.1	0.033	−3.1	−3.2	−2.6	−0.036
Other income sources	−0.5	−0.9	−0.9	−0.008	−0.8	−1.1	−1.1	−0.007	−0.6	−0.9	−0.9	−0.006	−0.9	−1.1	−1.0	−0.006
Total difference	−2.7	−4.9	−14.2	−0.029	−9.4	−11.2	−10.4	−0.080	−2.3	−4.4	−4.7	−0.006	−9.8	−11.6	−10.6	−0.077

TABLE A11 Foster–Greer–Thorbecke indices and Gini coefficient ($n = 786$).

	2014 ($n = 786$)			2016 ($n = 786$)			2018 ($n = 786$)		
Indicators	Coef.	95% Conf. interval		Coef.	95% Conf. interval		Coef.	95% Conf. interval	
FGT(0)	83.8***	0.813	0.864	81.6***	0.787	0.844	71.8***	0.685	0.750
FGT(1)	52.2***	0.500	0.544	47.8***	0.455	0.501	36.1***	0.339	0.384
FGT(2)	37.6***	0.355	0.396	32.9***	0.308	0.349	22.2***	0.205	0.240
Gini coefficient	0.549***	0.513	0.585	0.543***	0.503	0.583	0.466***	0.437	0.495

Note: Results using bootstrapped statistics (500 repetitions, 95% bootstrap confidence interval).
*p < 0.10, **p < 0.05, and ***p < 0.01.

TABLE A12 Mean income for the total sample ($n = 786$).

	2014		2016		2018	
Income sources	Mean value (PPP USD 2011)	Share on total income (%)	Mean value (PPP USD 2011)	Share on total income	Mean value (PPP USD 2011)	Share on total income
Crop production	157.09 (226.76)	32.94	131.13 (243.47)	23.98	210.63 (360.65)	32.32
Livestock	85.67 (317.30)	17.97	70.14 (284.42)	12.82	72.78 (204.84)	11.17
Natural resources	34.83 (53.79)	7.30	79.00 (129.68)	14.45	56.42 (61.51)	8.66
Off-farm wage employment	85.99 (433.31)	18.03	42.23 (142.50)	7.72	71.16 (226.84)	10.92
Non-farm self-employment	99.10 (416.73)	20.78	203.82 (791.48)	37.27	208.74 (568.82)	32.03
Other income sources	14.17 (65.78)	2.97	20.58 (59.94)	3.76	31.89 (71.16)	4.89
Total income	476.85 (736.19)	100.00	546.90 (909.93)	100.00	651.62 (755.53)	100.00

Note: Mean values and standard deviation (in parentheses) of annual household income per adult equivalent in PPP USD 2011 with percentage share on total income.

TABLE A13 Mean income for the first quintile ($n = 158$).

Income sources	2014 Mean value (PPP USD 2011)	2014 Share on total income (%)	2016 Mean value (PPP USD 2011)	2016 Share on total income	2018 Mean value (PPP USD 2011)	2018 Share on total income
Crop production	31.28 (28.52)	43.93	26.70 (27.06)	28.92	57.94 (43.77)	38.11
Livestock	9.28 (17.66)	13.03	10.21 (16.70)	11.06	10.94 (17.44)	7.19
Natural resources	14.66 (19.22)	20.60	35.24 (26.43)	38.17	38.38 (28.95)	25.25
Off-farm wage employment	8.16 (19.64)	11.46	9.41 (19.09)	10.19	19.16 (33.41)	12.60
Non-farm self-employment	2.82 (11.38)	3.96	3.51 (13.17)	3.80	9.96 (25.23)	6.55
Other income sources	5.00 (13.62)	7.02	7.25 (13.33)	7.86	15.65 (27.13)	10.30
Total income	71.20 (30.13)	100.00	92.32 (36.50)	100.00	152.02 (47.98)	100.00

Note: Mean values and standard deviation (in parentheses) of annual household income per adult equivalent in PPP USD 2011 with percentage share on total income.

TABLE A14 Mean income for the second quintile ($n = 157$).

Income sources	2014 Mean value (PPP USD 2011)	2014 Share on total income (%)	2016 Mean value (PPP USD 2011)	2016 Share on total income	2018 Mean value (PPP USD 2011)	2018 Share on total income
Crop production	72.58 (55.80)	42.92	67.74 (56.42)	33.64	101.76 (71.41)	35.06
Livestock	20.08 (34.84)	11.87	17.06 (22.27)	8.47	25.44 (38.65)	8.76
Natural resources	32.55 (36.19)	19.25	55.61 (37.88)	27.61	54.13 (44.30)	18.65
Off-farm wage employment	27.28 (44.41)	16.13	25.28 (35.19)	12.55	42.85 (62.74)	14.76
Non-farm self-employment	7.88 (23.95)	4.66	20.77 (42.73)	10.31	43.80 (66.72)	15.09
Other income sources	8.75 (21.68)	5.17	14.94 (33.58)	7.42	22.28 (40.94)	7.68
Total income	169.12 (26.36)	100.00	201.40 (30.20)	100.00	290.27 (35.97)	100.00

Note: Mean values and standard deviation (in parentheses) of annual household income per adult equivalent in PPP USD 2011 with percentage share on total income.

TABLE A15 Mean income for the third quintile ($n = 157$).

Income sources	2014 Mean value (PPP USD 2011)	2014 Share on total income (%)	2016 Mean value (PPP USD 2011)	2016 Share on total income	2018 Mean value (PPP USD 2011)	2018 Share on total income
Crop production	114.57 (96.01)	41.51	106.29 (77.35)	33.68	162.64 (107.66)	37.08
Livestock	35.65 (59.04)	12.92	41.12 (58.83)	13.03	42.37 (61.54)	9.66
Natural resources	35.00 (43.75)	12.68	71.02 (54.00)	22.50	64.44 (58.30)	14.69
Off-farm wage employment	50.60 (77.45)	18.34	42.15 (61.62)	13.35	56.02 (89.58)	12.77
Non-farm self-employment	26.75 (53.69)	9.69	35.44 (65.90)	11.23	80.84 (114.35)	18.43
Other income sources	13.42 (32.67)	4.86	19.60 (42.00)	6.21	32.28 (72.39)	7.36
Total income	276.00 (40.00)	100.00	315.63 (41.02)	100.00	438.61 (52.67)	100.00

Note: Mean values and standard deviation (in parentheses) of annual household income per adult equivalent in PPP USD 2011 with percentage share on total income.

TABLE A16 Mean income for the fourth quintile ($n = 157$).

Income sources	2014 Mean value (PPP USD 2011)	2014 Share on total income (%)	2016 Mean value (PPP USD 2011)	2016 Share on total income	2018 Mean value (PPP USD 2011)	2018 Share on total income
Crop production	197.73 (160.76)	43.25	165.50 (141.19)	32.32	227.16 (160.99)	33.39
Livestock	89.85 (127.18)	19.65	57.61 (102.30)	11.25	86.67 (140.52)	12.74
Natural resources	46.12 (70.46)	10.09	102.62 (93.14)	20.04	61.40 (58.09)	9.02
Off-farm wage employment	63.29 (125.36)	13.84	53.60 (92.86)	10.47	78.99 (144.89)	11.61
Non-farm self-employment	47.26 (104.33)	10.34	105.07 (149.23)	20.52	185.32 (196.04)	27.24
Other income sources	12.93 (39.56)	2.83	27.68 (68.97)	5.41	40.83 (98.00)	6.00
Total income	457.19 (74.66)	100.00	512.09 (75.35)	100.00	680.37 (103.36)	100.00

Note: Mean values and standard deviation (in parentheses) of annual household income per adult equivalent in PPP USD 2011 with percentage share on total income.

TABLE A17 Mean income for the fifth quintile ($n = 157$).

Income sources	2014 Mean value (PPP USD 2011)	2014 Share on total income (%)	2016 Mean value (PPP USD 2011)	2016 Share on total income	2018 Mean value (PPP USD 2011)	2018 Share on total income
Crop production	370.09 (383.91)	26.19	290.06 (475.53)	17.95	504.62 (696.31)	29.68
Livestock	273.98 (661.04)	19.39	225.07 (600.60)	13.93	198.89 (403.19)	11.70
Natural resources	45.94 (72.99)	3.25	130.80 (255.12)	8.09	63.83 (94.75)	3.75
Off-farm wage employment	281.10 (933.30)	19.89	80.93 (291.79)	5.01	159.09 (461.77)	9.36
Non-farm self-employment	411.38 (857.64)	29.11	855.57 (1607.33)	52.94	725.04 (1104.01)	42.65
Other income sources	30.83 (134.48)	2.18	33.53 (99.10)	2.07	48.52 (86.62)	2.85
Total income	1413.31 (1238.11)	100.00	1615.96 (1619.28)	100.00	1700.01 (1148.24)	100.00

Note: Mean values and standard deviation (in parentheses) of annual household income per adult equivalent in PPP USD 2011 with percentage share on total income.