ICAE 2024

32nd International Conference of Agricultural Economists
2-7 August 2024 | New Delhi | India

# Welfare Effects of Agricultural Productivity Growth – A Micro Panel Evidence from Rural Tanzania

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**Abstract**

This paper uses two waves of nationally representative household-level panel data to examine the welfare effects of agricultural productivity in rural Tanzania. Four measures of productivity and ten indicators of welfare, including multidimensional welfare, are considered. Econometric procedures that take into account potential endogeneity resulting from omitted variables bias are employed. The results show welfare-enhancing effects of agricultural productivity, though the elasticities are marginal, requiring potentially large productivity growth for substantial welfare impact. The analysis of the linkage between productivity growth and welfare transition shows that households that experience growth in productivity are more likely to make welfare-enhancing transitions. Policies that allow for expanding households access to durable goods and agricultural capital, investment in irrigation and erosion control facilities, improving households access to agricultural extension services with the needed know-how, as well as ensuring favorable biophysical environment, are vital for sustained productivity growth.

**Key words:** agricultural productivity; welfare effects; panel data; poverty reduction; welfare transitions.

**JEL Codes**: C33, I32, O13, O55, Q12, Q18

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## 1. Introduction

Agriculture continues to the be main source of livelihood for the rural poor, as well as contributing substantially to Gross Domestic Products (GDP) of many Sub-Saharan African (SSA) economies. While the share of rural-urban migration has surged in recent years, more than half of SSA population continue to live in rural areas (World Development Indicators (WDI) 2023) and are mainly smallholder producers. According to Baah et al (2023), poverty headcount in SSA using the US$ 2.15 2017 purchasing power parity (PPP) stands at about 34.9%, amounting to about 391 million people in absolute terms. In addition, more than 70% of SSA population are unable to afford a healthy diet, and food insecurity continues to be a development challenge (FAO 2021). Poverty and food insecurity are predominantly rural phenomenon in SSA (ibid). This indicates that for agrarian SSA countries, transformative policies that increase the productivity levels of the sector are vital for rural poverty reduction, income generation, food security and ensuring their sustained development.

The relevance of transformative agricultural policies are evidenced in the different agricultural development programs in SSA, including the Comprehensive Africa Agriculture Development Program (CAADP) and the New Partnership for Africa Development (NEPAD), focusing on among other things, improving the performance of the sector to ensure increased productivity. Growth in agricultural productivity could benefit the rural poor via rising wage rates (farm and non-farm employment) and price effects. Rural farming households who are net sellers (buyers) would benefit from price increases (decreases) resulting from agricultural productivity growth (Sadoulet & De Janvry, 1984; Dzanku, 2015). Urban non-farm households could also benefit from lower food prices resulting from increased production, thereby reducing urban poverty and boosting food security (De Janvry & Sadoulet, 2010; De Janvry et al., 1991). Against this background, the current study examines the welfare effects and drivers of agricultural productivity in Tanzania, a SSA country that depends on agriculture substantially.

While the development literature is replete with a number of studies examining the welfare effects of agricultural productivity growth, most of them focus on the macro- and meso-levels (Thurlow et al., 2009; De Janvry & Sadoulet, 2002, 2010; Thurlow et al., 2010; Ravallion, 2009; Datt & Ravallion, 1998; Foster & Rosenzweig, 2004; Ravallion & Datt, 2002), and a few at the micro-level (Darko et al., 2018; Dzanku, 2015; Sarris et al., 2006; Chegere & Stage, 2020). Darko et al. (2018) use nationally representative data to examine the welfare effects (including money and non-money metric measures) of agricultural productivity in Malawi, while and Dzanku (2015) and Sarris et al. (2006) focused on specific districts/regions in Ghana and Tanzania, respectively. There are others that look at nutrition and child development implications of agricultural productivity growth (Dillon et al., 2015; Slavchevska, 2015; Shively & Sununtnasuk, 2015; Chegere & Stage, 2020). These studies also provide little micro-evidence of the drivers of agricultural productivity, which are vital if productivity is to be boosted and potential benefits, reaped.

Most of the micro-level studies on understanding the linkage between agricultural productivity and welfare in Tanzania have been in the area of agricultural commercialization (Chegere & Kauky, 2022; Carletto et al., 2017), technology adoption (Asfaw et al., 2012; Amare et al., 2012) and nutrition (Slavchevska, 2015; Chegere & Stage, 2020). The closest studies on examining welfare impact of agricultural productivity in Tanzania is that of Sarris et al. (2006) which uses cross-sectional data and descriptive analytical procedure; Pauw & Thurlow (2010) that employs a dynamic computable general equilibrium (DCGE) and microsimulation models to simulate the poverty and nutrition effects of agricultural productivity growth; Slavchevska (2015) that looks at nutritional impact of agricultural productivity using cross-sectional data; and Chegere

& Stage (2020) using three waves of panel data to examine the linkage between agricultural production diversity, and dietary diversity and nutritional status in Tanzania.

This study extends those of Darko et al. (2018), Dzanku (2015) and Chegere & Stage (2020) by employing two waves of nationally representative panel datasets collected in 2014/15 and 2020/21 to examine the welfare effects (consumption expenditure, poverty measures, dietary diversity, caloric intake, and composite welfare) of agricultural productivity growth (value of output per hectare, maize and rice yield, and labor productivity) in rural Tanzania. This is achieved by addressing three specific objectives. First, the study estimates the magnitude and direction of the different measures of agricultural productivity on the welfare outcomes. Second, the linkage between agricultural productivity growth, welfare transitions, and consumption growth, are examined. Third, the study provides micro-insights of the drivers of crop, maize, rice, and labor productivity to allow for directing and targeting policy interventions in these subsectors to those drivers.

The study is vital for both its contribution to the empirical development economics literature and agriculture policy in Tanzania. Given the government of Tanzania's recent re-focus on agriculture with substantial budgetary allocation (Government of Tanzania (GoT), 2017), a study of this nature that employs nationally representative panel datasets to examine the welfare effects of productivity and their drivers is important and timely. Another feature that makes this study unique is the examination of how productivity growth across the two periods potentially impact households transitions across poverty status and growth in their consumption expenditure.

The analytical approaches employed in this paper allows for controlling for potential endogeneity caused by omitted variables bias. Results from the analysis indicate that agricultural productivity (value of output, labor, and maize) have welfare-enhancing effect on rural farm households in Tanzania. Specifically, a percent increase in agricultural productivity (value of output) raises household caloric intake by 0.051%, while at the same time reducing the probability of becoming food insecure by 0.36 percentage points. The results also show that agricultural productivity improves household dietary diversity, with the total number of food groups consumed increasing by 0.025%. Though the results for value of output per hectare, maize and labor productivity are consistent across all estimation procedures, the effect of rice productivity becomes significant only after controlling for household fixed effects. Further, the results show that households that experienced growth in yield and value of output are more likely to transition to non-poor status, bolstering growth in their consumption expenditure.

The rest of the paper is organized as follows. Section 2 present the Tanzania-specific context of the study. In Section 3, the methodology employed in the study is presented, while Section 4 contains data and descriptive statistics. The results and discussions are presented in Section 5. Finally, the conclusions and implications of the study are contained in Section 6.

## 2. Poverty, food security, and agriculture development in Tanzania

Tanzania has experienced tremendous improvements in macroeconomic indicators in recent years. GDP has grown from US$ 13.8 billion in 2000 to US$ 75.71 billion in 2022 (World Development Indicators, 2022). While the services sector is currently the main contributor to GDP, the agriculture sector remains the mainstay of the East African country. The agriculture sector employed about 66.2% of the labor force in 2014 and nearly 62% in 2021 (NBS, 2022a) compared to the services and industry sectors with employment shares of 30.9% and 8.0% respectively in 2021. The sector also contributes about 30% of the country's export earnings and 65% of the raw materials for the industrial sector (GoT, 2017; NBS, 2022b; 2016).

While the agriculture sector remains the mainstay of the Tanzanian economy, productivity of the country's main staple (maize) stands at about 1.5 tons/ha (NBS, 2021b), which appears low compared to the global average of 6-9 tons/ha (FAOSTAT, 2021) with comparable production inputs. The low agricultural productivity in Tanzania could be attributed to factors which are also pertinent to the agricultural sector of many SSA countries. These include low adoption of sustainable agricultural practices, continuous cropping, and challenges brought about by climate variabilities. Agriculture in Tanzania is mainly smallholder, with very limited commercialization (Carletto et al., 2017; Chegere & Kauky, 2022). For instance, Chegere & Kauky (2022) estimate that only 36% of farmers in Tanzania sell any crop harvest.

Despite the growth in macroeconomic indicators in recent years and the different development programs instituted by the government, a substantial share of the population continues to live in poverty. For instance, the poverty headcount in 2007 at the national poverty line stood at 34.4% but decreased to 26.4% in 2018 (Ministry of Finance and Planning (MoFP), 2020). Notwithstanding this decline, marrying the poverty rates with year-specific population show that in absolute terms, the number of poor people in Tanzania increased from about 14.4 million in 2007 to nearly 15.5 million in 2018. These numbers even get larger at the international poverty line of US$ 2.15 2017 PPP (World Bank, 2020a; World Bank Poverty and Inequality platform[1]). In addition, poverty in Tanzania, like in many SSA countries, is predominantly rural; 39.1% and 31.3% of rural dwellers were poor in 2011 and 2018 respectively, compared to urban areas (with 20% and 15.8% poverty rates in 2011 and 2018, respectively) (MoFP, 2020). This emphasize the fact that poverty reduction in Tanzania should be targeted and be rural-focused.

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Similar to poverty, food and nutrition security continue to be developmental challenges to the country. For instance, the number of undernourished people increased from 10.9 million in 2004 to 13.5 million in 2021, while moderately or severely food insecure individuals soaring from 25.1 million in 2014 to 34.4 million in 2021 (FAO, 2021). Conversely, the share of children under 5 years who are stunted has seen substantial improvements over the years, from 48% in 1999 to 30% in 2022 (Ministry of Health and NBS, 2023). In absolute terms, between 2012 and 2020, the number of stunted under 5 children decreased marginally from 3.2 million to 3.1 million (FAO, 2021).

Given the contribution of the agriculture sector to the overall economy over the years, the government of Tanzania has recently made huge budgetary allocation to the sector for the implementation of the second phase of its 10-year Agriculture Sector Development Program (ASDP II). Specifically, the ASDP II sees the sector receiving TZS 13.819 trillion (US$ 5.979 billion) budgetary allocation from the government. The overall objectives of the ASDP II are to "transform the agricultural sector (crops, livestock & fisheries) towards higher productivity, commercialization level and increase smallholder farmer income for improved livelihood and guarantee food and nutrition security" (GoT, 2017). Given that productivity growth in agriculture has not been commensurate with the poverty reduction efforts in the country, it is important to understand the effective and efficient ways of ensuring that the implementation of the 10-year ASDP II is pro-poor. This is particularly important as the country recovers from the ravages of the COVID-19 pandemic that pushed a substantial share of the country's vulnerable population into poverty (Chande, 2021). The sector became the buffer of employment during the COVID-19 pandemic for most countries in SSA (Amankwah and Gourlay, 2021), and Tanzania in particular (Amankwah et al., 2023)

As part of the implementation of ASDP II, the government is targeting priority crops, including maize and rice, which other studies identify as perfect sectors for investment (Pauw & Thurlow, 2010). The government of Tanzania, in partnership with different development partners have also been implementing the Southern Agricultural Corridors of Tanzania (SAGCOT) program, which is a 20-year public-private partnership aimed at job and income creation in the agriculture sector. This is expected to be achieved by boosting agricultural productivity, food security, environmental sustainability, poverty reduction and commercialization.

## 3. Methodology

### 3.1. Conceptual framework

In a developing country like Tanzania where markets are imperfect, household production, consumption, and work decisions are non-separable and are jointly determined (Sadoulet & de Janvry, 1995). The effect of agricultural productivity on welfare is thus, examined by assuming a non-separable household model with a single primary decision maker (patriarch or matriarch) to allow for pulling resources into a unique strategy and sharing production and consumption within the household. Agricultural productivity growth impacts rural household through their effect on food, prices and income (wages). The price effect depends on whether the household is a net seller/buyer of the main staple – higher price of food item increases the welfare of net sellers who have substantial marketable surplus, while the vice versa is the case for net buyers. A rise in agricultural production could lower food prices and given that most rural households are net buyers (Chegere & Kauky, 2022; Carletto et al., 2017), lower prices could improve welfare.

In addition, a rise in agricultural productivity (quantity and diversity of production) could also make food available to the rural poor, thereby boosting their caloric intake, diversity of food consumption, and ensuring their food and nutritional security (Dillon et al., 2015; Slavchevska, 2015; Shively & Sununtnasuk, 2015; Chegere & Stage, 2020). Another important channel through which agricultural productivity could impact welfare of the rural poor is through the income pathway, via agricultural wage. Since labor is the main asset of the rural poor, a rise in agricultural production that increases agricultural wage tend to be beneficial to the rural poor.

Against this background and abstracting from Minten & Barrett (2008), Christiaensen & Demery (2006), Dzanku (2015), and Darko et al. (2018), the indirect utility function of a rural agricultural household, $V(p, w, A)$, is defined as:

$$V(p, w, A) = \max[u(q, L) \mid \pi(p, w, A, B) + wL = p.q]$$

where $u(q, L)$ is the direct utility function defined over goods $q$, and labor endowments, $L$; $\pi(p, w, A, B)$ is the profit from household farm and non-farm work, with farm profit serving as the link between production and consumption; $A$ captures agricultural productivity (value of output or total crop, maize, rice, and labor); $B$ is productivity of non-farm income generating activities; $p$ captures prices of farm output, production inputs and consumption goods; and $w$ is agricultural wage rates. The household is assumed to be a price taker, such that wages, and input and output prices are exogenous to them.

Totally differentiating $V(p, w, A)$, re-arranging terms and dividing by change in $A$ gives the following expression to allow for examining the different channels through which agricultural productivity could impacts welfare:

$$\beta = \frac{dV}{dA} = (Q - q)\frac{dP}{dA} + p\frac{dQ}{dA} + \left(L - \left(L_o + \ L_{of}\right)\right)\frac{dw}{dA}$$

where $L_o$ and $L_{of}$ are the optimal levels of farm and off-farm labor supply, respectively; $(Q - q)$ denote the difference between household production and consumption of agricultural output (reflecting net buyer $(Q - q) < 0$ and net seller $(Q - q) > 0$ status).

The overall effect of agricultural productivity growth on welfare depends on the cumulative sizes of the different components. The price effect of agricultural productivity is captured by $\frac{dP}{dA}$, the welfare effect of which depends on the level of integration of rural Tanzania into the broader regional and international markets or the net seller/buyer status of households. For net sellers, the price effect (high prices) is expected to enhance welfare (Dzanku 2015; Deaton 1997). $\frac{dw}{dA}$ captures the wage effect, which is expected to enhance welfare given that rural households generally have surplus labor, while $p\frac{dQ}{dA}$ is the monetary value of total crop harvest of a change in agricultural productivity.

### 3.2. Empirical model and estimation approach

The empirical specification of the drivers of agricultural productivity, $A_{it}$, is given as:

$$A_{it} = \boldsymbol{M_{it}}\lambda_1 + \boldsymbol{X_{it}}\lambda_2 + \boldsymbol{H_{it}}\lambda_3 + \boldsymbol{P_{it}}\lambda_4 + \boldsymbol{G_{it}}\lambda_5 + c_i + \mu_{it}$$

Similarly, the welfare effect of agricultural productivity is examined by estimating the following empirical model:

$$W_{it} = \beta A_{it} + \boldsymbol{M_{it}}\phi + \boldsymbol{X_{it}}\psi + \boldsymbol{H_{it}}\gamma + \boldsymbol{P_{it}}\alpha + \boldsymbol{G_{it}}\eta + c_i + \mu_{it}$$

where $W_{it}$ captures the different measures of welfare, including log consumption expenditure; poverty headcount, gap and severity; food security; caloric intake; dietary diversity; composite welfare, as well as transitions in and out of poverty. $A_{it}$ is agricultural productivity measured at the household level. $\boldsymbol{M_{it}}$ is a vector of other sources of income for the household, including wage, non-farm business and remittances. $\boldsymbol{H_{it}}$ is a vector of household demographic characteristics including age and gender of household head, access to credit, and asset and livestock indices. $\boldsymbol{X_{it}}$ is a vector of agricultural production inputs including irrigation and extension access. $\boldsymbol{P_{it}}$ is a vector of prices including agricultural wage, and staple food, and inorganic fertilizer prices. $\boldsymbol{G_{it}}$ denotes household-level geo-variables, while household fixed effects and random components are captured by $c_i$ and $\mu_{it}$, respectively. $\lambda_k$, $\beta$, $\phi$, $\psi$, $\gamma$, $\alpha$, and $\eta$ are parameters to be estimated.

The effect of agricultural productivity on consumption expenditure, dietary diversity and caloric intake is estimated using the household Fixed Effects (FE) ordinary least squares (OLS) estimator given that these models are linear. In a linear model, the FE estimator controls for unobserved heterogeneity (Angrist, 2009; Wooldridge, 2010). The study employs the FE linear probability model (FELPM) for poverty and food insecurity. In the case of poverty gap and severity of poverty where there is a corner solution (gap and severity conditional on being poor), a two-part model estimator by Belloti et al. (2015) is used. The first part of the two-part model is estimated using a logit model to identify the probability of being poor, while the second part which is the intensity of poverty uses a fractional logit. The use of the two-part model allows for the probability of being poor and the intensity of poverty to be generated by different processes, but the same set of conditioning variables (Belloti et al., 2015).

In examining the effect of agricultural productivity on composite welfare, a random effects (RE) ordered probit estimator is used, assuming normality of the household specific fixed effects. The ordered probit and two-part models were estimated by incorporating means of time-varying covariates following Mundlak (1978). The effect of positive productivity growth on welfare transitions is estimated using a probit model, while the effect on consumption growth is examined using OLS.

### 3.2.1. Identification strategy - potential endogeneity of agricultural productivity in the welfare model

Even after controlling for observed characteristics and employing Mundlak (1978) and FE procedures, there is still potential endogeneity that could result from unobserved factors. One important consideration in studies of this nature is whether the unobserved factors that affect welfare are correlated with the main explanatory variable – agricultural productivity. A non-zero correlation between the error term in the welfare equation and the agricultural productivity measures could yield bias and inconsistent estimates, and misleading policy conclusions. Non-zero correlation could emanate from different sources – measurement errors especially in the main explanatory variable, omitted variables bias, and reverse causality (agricultural productivity impacts welfare, and vice versa). Given that the surveys were conducted over a 12-month period to account for seasonality (including interviewing households in the same months across waves), and collect agricultural production information after the harvest season, there is brevity in admitting that reverse causality is not an issue here, and that the direction of effect is agriculture productivity to welfare, not the other round. In addition, total planted crop area, a critical component of productivity computation, was collected using handheld Global Positioning System (GPS) device, thus measurement error is minimal in this case.

Omitted variables could, however, be a problem since both agricultural productivity and welfare are affected by factors external to the study sample. The paper uses two-stage least squares (2SLS) procedure to control for potential endogeneity emanating from omitted variables bias. While it is difficult to obtain sound instruments in small sample household surveys (Dzanku, 2015), this study uses household-level variability in long-term rainfall and nutrient retention capability of the soil in the location of the household as instruments. The variability in rainfall is defined as the difference between the total rainfall during the survey year and the long-term average (2001 – 2015). These variables are in general, strongly correlated with the different measures of agricultural productivity, but not correlated with the welfare measures. There are a number of agronomic experiments and empirical studies that establish a strong correlation between agricultural productivity and these variables (see for instance Asfaw et al., 2016; Amankwah, 2023). Thus, except for their impact on crop yield, these variables are not expected to affect welfare through any other channel. Formal tests are conducted to establish the validity of these instruments (see results in Table 3).

## 4. Data and description of variables

### 4.1. Data

This study is based on an unbalanced panel data from the fourth and fifth waves of the Tanzania National Panel Survey (NPS) conducted in 2014/15 and 2020/21 (hereafter 2015 and 2021, respectively). Each wave of the NPS is implemented over a 12-month period to account for seasonality, with households being interviewed in the same month across waves. The NPS is part of the Living Standards Measurement Study Integrated Survey on Agriculture (LSMS-ISA) Initiative of the World Bank. The surveys were implemented by the Tanzania National Bureau of Statistics (NBS) and the Office of the Chief Government Statistician (OCGS), Zanzibar, with technical assistance from the World Bank’s LSMS team. Funding for the surveys came from the Bill and Melinda Gates Foundation and the European Union. The NPS uses a multistage cluster sampling procedure and was designed to be representative at national and four analytical domains– Dar es Salaam, other mainland urban, mainland rural, and Zanzibar.

Since its inception in 2008/09, five waves of the NPS have been implemented. The original sample from 2008 was refreshed in 2015 following the 2012 population and housing census to allow for dropping a subset of the original sample and bringing in new households. Given the nature of the current study, only the refresh sample of 2015 that were re-interviewed in 2021 was used. The use of the two most recent waves was necessitated by the fact that some important variables needed for the current study were missing in the earlier NPS rounds.

The 2015 NPS refresh sample contains 3,352 households of which 3,042 were re-interviewed successfully during the 2021 survey period. One unique feature of the NPS is the tracking of split-off households, which makes the sample grow over time. Between 2015 and 2021, the sample increased to 4,164 households. Given the specific data needs of this study, however, only rural agricultural households with strictly positive value of crop harvest were included in the analysis. Following additional data cleaning and imposing these restrictions, an unbalanced panel of 2,798 households – 1,319 from 2015 and 1,506 from 2021 – was used in the analysis of the drivers of agricultural productivity and the linkage between agricultural productivity and welfare. The analysis on productivity growth and welfare transitions and consumption growth, however, uses a balanced panel of 1,014 households.

The NPS data contain rich information on household demographic characteristics, consumption expenditure, housing, assets/durables, agriculture, employment, household non-farm businesses, food security, nutrition, among others. In addition, the datasets in the public domain contain an already constructed consumption aggregates for welfare analysis. Consumer price index (CPI) from the World Bank's World Development Indicators database was used to adjust for temporal variation in consumption expenditure. The international poverty line of US$ 2.15 2017 PPP expressed in 2021 prices was used to define the poor. Climate and other geographic variables were also obtained from the available public data.

### 4.2. Description of salient variables

#### 4.2.1. Dependent variables

In order to address the research questions in this study, ten welfare variables are defined – consumption expenditure, dietary diversity, caloric intake, poverty headcount, poverty gap, poverty severity, food security, composite welfare, negative and positive welfare transitions, and consumption growth. The measure of poverty is consumption following (Deaton, 1997; Mancini & Vecchi, 2022). Consumption expenditure is the monetary value of all food and non-food consumption (including imputed rent and durables) of the household (see NBS (2021) for details on the construction of the consumption aggregates). The three measures of poverty – headcount, gap and severity – are based on Foster-Greer-Thorbecke (1984) index. This study uses daily per capita (adult equivalent) caloric intake as a measure of food security status of the household. After aggregating the calories of all food consumption from all sources (purchases, own production, and gifts), a household is considered food secure if the daily per capita caloric intake is above the 2200 kcal per capita specified by the Tanzania NBS for constructing the country's national poverty line.

Using the food security and poverty measures and following from Dzanku (2015) and Darko et al (2018), a composite welfare variable is generated taking the value of 0 if the household is poor and food insecure, 1 if the household is non-poor and food insecure or poor and food secure, and 2 if the household is non-poor and food secure. Dietary diversity, which captures the nutritional status of the household, is defined as the total number of food groups consumed by the household in the seven days preceding the day of interview. Focusing on poverty, positive welfare transition refers to households that were poor in 2015 but became non-poor in 2021, while households that were non-poor in 2015 but become poor in 2021 are considered to have made a negative welfare transition. Change in consumption expenditure is the difference between household total consumption expenditure in 2021 and that of 2015 (see Table 1 for details on these variables).

#### 4.2.2. Explanatory variables

The main explanatory variable in this study is agricultural productivity, of which four measures are used. Given that maize and rice are the main staple crops in Tanzania, yields of these crops constitute the first two measures of productivity in this study. To account for households' production of other cash and non-cash crops, total farm output from all cultivated plots (total value of output) per hectare is also used as a measure of productivity. Finally, value of output per worker is used. The output per hectare is vital for assessing the welfare effects of new agricultural technologies and practices, while the value of output per worker measures the effect of farm and non-farm productivity (FAO, 2011; Dzanku, 2015).

For the effect of productivity growth on welfare transition, a dummy variable equal 1 if the difference in value of output per hectare between 2021 and 2015 is greater than zero, and 0 if otherwise. This is vital in understanding whether rural households that experienced positive productivity growth are more or less likely to make corresponding welfare-enhancing transitions. The choice of other explanatory variables in this study is guided by the agricultural productivity and household welfare literature (Dzanku 2015; Darko et al 2018; Dillon et al 2015; Slavchevska 2015; Shively and Sununtnasuk 2015; Asfaw et al 2012) and include household characteristics, agricultural inputs, prices, and geo-variables. Variable-specific details are presented in Table 1.

## 5. Results and discussions

### 5.1. Descriptive statistics

The descriptive statistics of the analytical variables are presented in Table 2. The descriptive results show that crop productivity, measured as the total value of output per hectare, appears to have declined between 2015 and 2021. On average, maize productivity also declined over the period. Rice and labor productivity, however, saw marginal increases between 2015 and 2021. The decline in crop and maize productivity could be due to the limited use of productivity enhancing agricultural practices (such as organic and inorganic fertilizers, irrigation, and improved seeds), rising cost of agricultural input prices, as well as limited access to agricultural extension services (only 10% of agricultural households received extension contacts during the 2021 agricultural season). The table also shows that the total area cultivated by farming households appears to have declined between 2015 and 2021, which could have contributed to the declining total crop productivity in the country, given that agricultural productivity in SSA emanates mainly from expanding area under cultivation (IFAD, 2011; OECD/FAO, 2016).

Table 2 shows further that, between 2015 and 2021, on average, welfare status of farming households in Tanzania worsened in all dimensions. For instance, average monthly per capita consumption expenditure decreased from TSh 91,000 in 2015 to TSh 79,000 in 2021 and resulting poverty headcount rising from 26% to 37% between the two periods. Similarly, the number of food groups consumed decreased over the years, though the total caloric intake appears to have increased. Using the daily per capita caloric intake, about 29% and 35% of households in 2015 and 2021, respectively, consumed less than 2,200 kcal per day and were classified as food insecure. The composite welfare index shows that, on average, about 56% of households in the pooled sample were non-poor and food secure, while 19% were poor and food insecure. Descriptive statistics of the other analytical variables are contained in respective blocks of Table 2.

## 5.2. Empirical results

The empirical results are presented and discussed in this section. The drivers of productivity, both pooled and fixed effects, are presented first, followed by the results linking productivity and welfare, including productivity growth and welfare transitions.

### 5.2.1. Drivers of agricultural productivity

The determinants of the different measures of agricultural productivity are presented in Table 3. For each productivity measure, a pooled OLS and household fixed effects models are presented. While the drivers of each of these measures differ, the determinants of each measure, in-terms of statistical significance and direction of effect, appear generally consistent across the two estimators. Households headed by females are less productive compared to those managed by males. Large household sizes are positively correlated with crop productivity, but negatively associated with labor productivity. From the pooled results, we see that except for crop productivity, households with older heads are less productive, consistent with Asfaw et al. (2016). After controlling for household fixed effects, however, households with older heads become more productive in the crop productivity model.

As expected, household ownership of durable goods, captured by the asset index constructed using principal component analysis (PCA), is positively and significantly associated with agricultural productivity. Similarly, the number of livestock owned, captured by the tropical livestock unit, drives crop and labor productivity in rural Tanzania. While agricultural capital index enhances the productivity of maize and paddy, it has no significant effect on labor productivity, after controlling for household fixed effects. Price index of staple food crops is positively and significantly related with maize productivity. In the pooled OLS model, cluster-level agricultural wage has positive significant effect on labor productivity, though it becomes insignificant after controlling for household fixed effects.

In addition, cluster-level price of inorganic fertilizer has negative and significant effect on crop, paddy and labor productivity in the pooled regression model, but becomes significant in the labor productivity model after controlling for household fixed effects. The analysis also shows negative significant relationship between total agricultural land holding and productivity of maize and paddy, but positive significant effect on crop productivity. The inverse farm size and productivity is well established in the literature (Carletto et al., 2011). For paddy production, the analysis reveals strong positive relationship with irrigation, which is not surprising given that most rice production in the country is irrigation based. These indicate the vital need for the government to continue focusing attention on the delivery of irrigation infrastructure to rural smallholder households in the country. Households with access to crop-specific extension services are more productive, emphasizing the need for high and sustained investment in agricultural extension services delivery in Tanzania.

### 5.2.2. Welfare effects of agricultural productivity

In Table 4a and 4b, the elasticities of the different measures of agricultural productivity and welfare outcomes from the 2SLS estimation are presented. The full regression model results, including other controls, are presented in Tables A6-A9. Before discussing the results, it is important to examine the identification status of the instruments. The tables show that except for the paddy productivity results, the under-identification conditions are satisfied in all models. In addition, the over-identification restriction is also satisfied in most of the models as seen from the Hansen J and corresponding p-values. Using the rule of thumb that the first stage F statistics should be greater than 10, all the models, except those of maize and paddy, pass the weak identification test as shown by the Kleibergen-Paap F statistics. The endogeneity test results indicate that crop productivity is endogenous in the consumption expenditure and poverty headcount models. Similarly, paddy productivity is endogenous with consumption expenditure, poverty headcount, food security, and caloric intake. For these, the IV results override those from the pooled and fixed effects models.

Table 5 contains the household fixed effects regression results of the impact of productivity on the different welfare measures (see Table A1 for the pooled results). The full regression model results, including other controls, are presented in Appendix A2-A5. Models 1-3 were estimated using FE OLS, while models 4 and 5 use the FELPM. The two-part model estimator was used for models 6 and 7. The results show that household welfare is improving with all measures of agricultural productivity; consumption expenditure, calories consumed, and dietary diversity are increasing with productivity, while poverty headcount, gap, severity, and food insecurity are decreasing with productivity. Although paddy productivity has no significant effect on welfare in the pooled regression (Table A1), we observe statistically significant improvements in welfare after controlling for household fixed effects. We see in general that the signs of the elasticities do not vary across the IV, FE and pooled regression results.

*Consumption expenditure and poverty effects* – All things being equal, the analysis shows the elasticity of consumption expenditure to crop and labor productivity to be 0.059 and 0.030 respectively, while that for maize and paddy are 0.073 and 0.082 respectively (Table 5, model 1). From the LPM results in model 4 of Table 5, we observe that a percent increase in crop and maize yield reduces the probability of being poor by 0.034 and 0.046 percentage points, respectively. The poverty reduction effect of crop and maize productivity are consistent with the findings of Dzanku (2015) and Darko et al (2018), while the results of labor productivity corroborate that of

Dzanku (2015). The results from the two-part model (Table 5, models 6 & 7) indicate that poverty gap and severity are decreasing across all measured of productivity.

*Food security* effect – The analysis also reveals an important linkage between agriculture productivity and food security in rural Tanzania. *Ceteris paribus*, a percent increase in crop productivity reduces the propensity of being food insecure by about 0.036 percentage points, growth in maize and paddy yields leads to food insecurity reduction by 0.045 and 0.093 percentage points respectively. This is not surprising given that maize is the main staple food of Tanzania. The results show further that labor productivity does not have any significant effect on household food security.

*Dietary diversity and caloric intake effect* – We also observe positive significant relationship between all measures of productivity and dietary diversity and the per capita calories of food consumed. The elasticity of crop and maize productivity with dietary diversity is about 0.025% and 0.024%, respectively, while in the case of caloric intake, these are 0.051% and 0.061%, respectively (Table 5). The positive relationship observed in this study is consistent with that of Chegere & Stage (2020) who found agriculture production diversity to positively impact dietary diversity and nutrition status in Tanzania.

*Composite welfare* effect – From Table 6, we observe positive significant effect of crop and maize productivity on composite welfare (non-poor and food secure), while at the same time reducing the probability of a household becoming poor and food insecure. This result corroborates those of Darko et al. (2018), but in contrast to that of Dzanku (2018). Consistent with Dzanku (2018), we find evidence that composite welfare is increasing with labor productivity, an indication that while most productivity improvement focuses on land, it is vital to target labor productivity enhancing factors.

Overall, the magnitudes of the effect of productivity on welfare appears low compared to the current role of agriculture in the Tanzanian economy (the sector continues to employ majority of the labor force (NBS, 2022a)). Why is the welfare effect of agriculture productivity growth small? Probably the rural farming areas are less integrated into the broader regional and international markets and agricultural commercialization is also very low (Chegere & Kauky, 2022).

Other drivers of welfare observed in this study include household engagement in off-farm income generating activities such as operation of family business, size of livestock holdings, asset index captured by ownership of durables, smaller household size and lower dependency ratio, access to remittances and credit, and lower prices of staple foods.

### 5.2.3. Positive productivity growth and welfare transitions

The results in Table 7 show that households who experienced growth in crop productivity (value of harvest) are more likely to make a corresponding positive welfare-enhancing moves; being poor in 2015 but non-poor in 2021. In addition, positive crop productivity growth is associated with a higher likelihood of a household experiencing a corresponding outward shift in consumption expenditure. Similarly, strictly positive growth in crop yield is associated with higher growth in consumption expenditure. Maize and paddy growth are, however, not associated with welfare-enhancing moves between 2015 and 2021.

## 6. Conclusions and policy implications

This study uses two waves of nationally representative household panel data to examine the micro-level welfare effects of agricultural productivity in rural Tanzania. Three specific objectives were addressed in this study: drivers of agricultural productivity, welfare effects of productivity, and the linkage between positive productivity growth and poverty transitions. Four measures of productivity – crop, maize, paddy, and labor – were considered, while for the welfare, ten indicators – consumption expenditure, dietary diversity, caloric intake, poverty headcount, poverty gap, poverty severity, food security, composite welfare (food security and poverty headcount), negative and positive welfare transitions, and consumption growth– were used. The study employed econometric approaches that address potential endogeneity emanating from omitted variables bias.

The results show that almost all measures of agricultural productivity have welfare-enhancing effect on rural households in Tanzania: increasing consumption expenditure, dietary diversity, and caloric intake, while at the same time reducing poverty and food insecurity. The productivity growth analysis reveals that households that experienced positive growth in crop productivity are more likely to make welfare-enhancing move between the two periods. While the study in general shows positive relationship between agricultural productivity and welfare in all dimensions, the elasticities are very marginal, requiring potentially large increases in productivity for any substantial welfare gains.

That notwithstanding, the study provides important drivers of productivity that are relevant for policy-targeting for sustainably shoring up productivity in the country for potential welfare gains. These include policies geared toward expanding households' access to durable goods and agricultural capital, investment in irrigation facilities, improving households access to agricultural extension services with the needed knowhow, as well as ensuring favorable biophysical environment. It is important that agricultural policy interventions in rural Tanzania, especially in the context of the ASDP II implementation, target these drivers.

It is important to mention that though the COVID-19 pandemic may have contributed to the results observed in this paper, it is not possible to establish a causal relationship between the COVID-19 pandemic and these results. While 2020/21 NPS was implemented during the COVID-19 pandemic, the time lag between the two waves (2014/15 and 2020/21) makes it impossible to distinguish the impact of the pandemic from the long-term structural changes in the country. Although previous waves of the NPS could be a great source of data to help explain these, the samples are not the same due to a new sample that was introduced in 2014/15 wave, which was later re-interviewed in 2020/21. Thus, as more future rounds of the NPS data on the same households become available, future studies could consider deciphering the micro-level impacts of COVID-19 on agricultural productivity and welfare in rural Tanzania.

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**Table 1**. Description of variables

| Variable | Definition |
|---|---|
| **Agricultural productivity variables** | |
| Crop productivity | Total value of crops harvested per hectare ('000 TSh/ha) |
| Maize yield | Total quantity of maize harvested per hectare (Kg/ha) |
| Paddy yield | Total quantity of paddy rice harvested per hectare (Kg/ha) |
| Labor productivity | Total value of crops harvested per labor man-days ('000 TSh/man-days) |
| **Welfare measures** | |
| Consumption expenditure | Real consumption per adult equivalent ('000TSh) in 2021 prices (28 days) |
| Poverty headcount | 1 if the household was poor |
| Poverty gap | FGT (1984) poverty gap index |
| Poverty severity | FGT (1984) poverty severity index |
| Dietary diversity | Number of food groups consumed within the last 7 days at 2021 |
| Caloric intake | Kilo calories of food consumed per adult equivalent ('000) |
| Food insecurity | 1 if the daily per capita caloric intake is less than 2,200 kcal |
| Poor insecure | 1 if the household is poor and food insecure |
| Npoor secure | Non-poor and food secure |
| Positive poverty trans | 1 if the individual was poor in 2015 but became non-poor in 2021, and 0 if the individual was poor in both 2015 and 2021 |
| Negative poverty trans | 1 if the individual was non-poor in 2015 but became poor in 2021, and 0 if the individual was non-poor in both 2015 and 2021 |
| **Household Characteristics** | |
| Household size | Number of persons in the household |
| Dependency ratio | Share of dependents in the household |
| Gender | 1 if the household head is female |
| Age | Age of the household head in years |
| Education | 1 if the household head has completed at least secondary school |
| Wage work | 1 if the household head has a wage job |
| Non-farm work | 1 if the household head worked in a family business |
| Credit | 1 if the household had access to credit |
| Remittance | 1 if the household received international remittance |
| TLU | Tropical livestock unit |
| Asset index | Asset index constructed using principal component analysis (PCA) for household durables |
| Agric capital index | Agriculture capital index constructed using PCA and agriculture implements |
| **Agriculture Inputs** | |
| Erosion control | 1 if the household has erosion control facility on at least one of their plots |
| Irrigation | 1 if the household irrigated at least one of their cultivated plots |
| Extension | 1 if the household received extension services for crop production |
| Land area | Total area cultivated by the household during the agricultural year (ha) |
| **Prices** | |
| Fisher price | Within survey Fisher price index |
| Agric wage EA | Cluster-level agricultural wage |
| Fertilizer price EA | Cluster-level price per Kg of inorganic fertilizer (NPK, Urea) |
| **Geo-variables** | |
| Distance to road | Distance from house to the nearest road (Km) |
| Distance to market | Household distance to nearest major market |
| anntot_avg | Average 12-month total rainfall for July-June (2001-2015) |
| anntot_rainfall | 12-month total rainfall in July-June, starting July of the year preceding the survey year |
| Nutrient retention | Nutrient retention capacity of the soil in the community (1 = no constraint, 4= very severe constraint) |
| Tropical warm | 1 if the household lives in tropical warm agroecological zone and 0 if they live in tr |

**Table 2**. Descriptive statistics

| Variable | Pooled | | 2015 | | 2021 | |
|---|---|---|---|---|---|---|
| | Mean | Sd | Mean | Sd | Mean | Sd |
| **Agricultural productivity variables** | | | | | | |
| Crop productivity | 617 | 915 | 671 | 935 | 570 | 896 |
| Maize yield | 1,258 | 1,719 | 1,265 | 1,752 | 1,252 | 1,690 |
| Paddy yield | 361 | 1,367 | 276 | 1,344 | 436 | 1,383 |
| Labor productivity | 2.45 | 5.03 | 2.20 | 4.77 | 2.68 | 5.23 |
| **Welfare measures** | | | | | | |
| Consumption expenditure | 84.29 | 64.24 | 90.73 | 59.41 | 78.64 | 67.71 |
| Poverty headcount | 0.32 | 0.47 | 0.26 | 0.44 | 0.37 | 0.48 |
| Poverty gap | 0.09 | 0.17 | 0.06 | 0.14 | 0.11 | 0.19 |
| Poverty severity | 0.04 | 0.09 | 0.02 | 0.07 | 0.05 | 0.11 |
| Dietary diversity | 7.54 | 1.71 | 7.57 | 1.67 | 7.51 | 1.74 |
| Caloric intake | 3.22 | 4.56 | 3.08 | 2.31 | 3.35 | 5.86 |
| Food insecurity | 0.32 | 0.47 | 0.29 | 0.45 | 0.35 | 0.48 |
| Poor insecure | 0.19 | 0.40 | 0.15 | 0.36 | 0.23 | 0.42 |
| Npoor secure | 0.56 | 0.50 | 0.61 | 0.49 | 0.51 | 0.50 |
| Positive poverty trans | 0.43 | 0.50 | | | | |
| Negative poverty trans | 0.33 | 0.46 | | | | |
| **Household Characteristics** | | | | | | |
| Household size | 5.85 | 3.47 | 5.64 | 3.29 | 6.04 | 3.61 |
| Dependency ratio | 1.04 | 0.99 | 0.98 | 0.93 | 1.10 | 1.04 |
| Gender | 0.27 | 0.44 | 0.26 | 0.44 | 0.27 | 0.45 |
| Age | 48.25 | 15.08 | 46.91 | 14.94 | 49.42 | 15.10 |
| Education | 0.05 | 0.21 | 0.04 | 0.20 | 0.05 | 0.22 |
| Wage work | 0.17 | 0.38 | 0.18 | 0.38 | 0.17 | 0.38 |
| Non-farm work | 0.15 | 0.36 | 0.17 | 0.37 | 0.13 | 0.34 |
| Credit | 0.11 | 0.31 | 0.15 | 0.35 | 0.08 | 0.27 |
| Remittance | 0.26 | 0.44 | 0.33 | 0.47 | 0.20 | 0.40 |
| TLU | 2.36 | 5.53 | 2.32 | 5.52 | 2.39 | 5.54 |
| Asset index | -1.42 | 1.39 | -1.40 | 1.41 | -1.43 | 1.36 |
| Agric capital index | 0.08 | 1.20 | 0.03 | 0.96 | 0.13 | 1.37 |
| **Agriculture Inputs** | | | | | | |
| Erosion control | 0.15 | 0.36 | 0.19 | 0.39 | 0.11 | 0.31 |
| Irrigation | 0.02 | 0.15 | 0.03 | 0.17 | 0.02 | 0.13 |
| Land area | 5.39 | 14.20 | 6.65 | 17.53 | 4.29 | 10.32 |
| Extension | 0.12 | 0.32 | 0.14 | 0.35 | 0.10 | 0.29 |
| **Prices** | | | | | | |
| Fisher price | 0.96 | 0.03 | 0.94 | 0.02 | 0.97 | 0.02 |
| Agric wage EA | 9,924 | 14,986 | 4,682 | 3,384 | 14,519 | 19,138 |
| Fertilizer price EA | 1,294 | 785 | 1,211 | 339 | 1,367 | 1,021 |
| **Geo-variables** | | | | | | |
| Distance to market | 82.37 | 48.05 | 81.48 | 48.09 | 83.17 | 48.01 |
| Distance to road | 20.04 | 20.06 | 19.91 | 19.93 | 20.16 | 20.17 |
| Tropical warm | 0.49 | 0.50 | 0.47 | 0.50 | 0.50 | 0.50 |
| Rainfall deviation | -294 | 310 | -20 | 114 | -536 | 210 |
| Nutrient retention | 1.69 | 1.03 | 1.69 | 1.05 | 1.68 | 1.02 |
| anntot_avg | 882 | 232 | 842 | 226 | 918 | 232 |
| anntot_rainfall | 1,177 | 421 | 861 | 262 | 1,453 | 330 |

**Table 3**. Drivers of agricultural productivity

| | Pooled | | | | Fixed Effects | | | |
|---|---|---|---|---|---|---|---|---|
| Variables | Ln crop productivity | Ln maize yield | Ln paddy yield | Ln labor productivity | Ln crop productivity | Ln maize yield | Ln paddy yield | Ln labor productivity |
| Household size | 0.047*** | 0.005 | 0.018 | -0.077*** | 0.053*** | 0.003 | -0.030 | -0.040*** |
| | (0.011) | (0.009) | (0.018) | (0.010) | (0.016) | (0.011) | (0.029) | (0.015) |
| Dependency ratio | 0.046* | -0.015 | 0.034 | -0.030 | 0.041 | -0.012 | 0.012 | -0.029 |
| | (0.027) | (0.024) | (0.037) | (0.029) | (0.026) | (0.028) | (0.056) | (0.028) |
| Gender | -0.350*** | -0.044 | -0.052 | -0.068 | -0.074 | 0.011 | -0.135 | 0.061 |
| | (0.069) | (0.066) | (0.121) | (0.082) | (0.113) | (0.135) | (0.528) | (0.123) |
| Age | -0.001 | -0.006*** | -0.018*** | -0.011*** | 0.010*** | -0.005 | 0.006 | -0.004 |
| | (0.002) | (0.002) | (0.005) | (0.002) | (0.004) | (0.003) | (0.009) | (0.003) |
| Education | 0.014 | -0.176 | -0.015 | 0.131 | 0.088 | -0.078 | -0.141 | 0.003 |
| | (0.120) | (0.130) | (0.256) | (0.107) | (0.199) | (0.149) | (0.299) | (0.208) |
| Wage work | -0.298*** | -0.017 | -0.092 | -0.139* | -0.221** | -0.084 | -0.020 | -0.136 |
| | (0.073) | (0.077) | (0.116) | (0.072) | (0.101) | (0.084) | (0.214) | (0.104) |
| Non-farm work | 0.054 | -0.052 | -0.253* | 0.045 | -0.067 | 0.003 | 0.162 | -0.069 |
| | (0.072) | (0.064) | (0.151) | (0.071) | (0.087) | (0.082) | (0.211) | (0.099) |
| Credit | 0.021 | 0.021 | -0.055 | 0.076 | 0.144 | 0.077 | -0.238 | 0.128 |
| | (0.079) | (0.071) | (0.172) | (0.083) | (0.091) | (0.089) | (0.223) | (0.095) |
| Remittance | -0.111* | 0.051 | -0.162 | -0.136* | 0.074 | 0.006 | 0.057 | 0.057 |
| | (0.062) | (0.067) | (0.138) | (0.073) | (0.072) | (0.071) | (0.227) | (0.084) |
| TLU | 0.042*** | 0.008 | 0.007 | 0.040*** | 0.010 | 0.003 | -0.007 | 0.008 |
| | (0.009) | (0.007) | (0.007) | (0.008) | (0.006) | (0.008) | (0.012) | (0.006) |
| Asset index | 0.088*** | 0.126*** | 0.050 | 0.099*** | 0.081** | 0.086*** | 0.119 | 0.020 |
| | (0.027) | (0.026) | (0.060) | (0.026) | (0.040) | (0.032) | (0.087) | (0.040) |
| Ag. capital index | 0.104** | -0.011 | -0.011 | 0.112*** | 0.104** | 0.072*** | 0.172** | 0.017 |
| | (0.050) | (0.039) | (0.047) | (0.036) | (0.048) | (0.028) | (0.069) | (0.042) |
| Erosion control | 0.099 | 0.202** | 0.071 | 0.024 | 0.007 | 0.114 | -0.084 | -0.048 |
| | (0.072) | (0.083) | (0.128) | (0.085) | (0.082) | (0.080) | (0.187) | (0.086) |
| Irrigation | 0.255 | 0.534*** | 1.180*** | 0.210 | -0.143 | -0.202 | 0.516 | 0.108 |
| | (0.199) | (0.164) | (0.444) | (0.183) | (0.221) | (0.162) | (0.534) | (0.228) |
| Land area | 0.022*** | -0.013*** | -0.012*** | 0.014*** | 0.011*** | -0.005 | -0.007 | 0.009*** |
| | (0.004) | (0.002) | (0.003) | (0.003) | (0.004) | (0.003) | (0.004) | (0.003) |
| Extension | 0.224** | 0.236*** | 0.172 | 0.140 | 0.231** | 0.143 | 0.216 | 0.131 |
| | (0.093) | (0.077) | (0.170) | (0.096) | (0.094) | (0.103) | (0.169) | (0.098) |
| Fisher price | 1.961 | 3.198* | 2.984 | 3.127 | 0.779 | 3.073 | -4.427 | -0.942 |
| | (1.936) | (1.806) | (3.625) | (1.933) | (2.044) | (2.197) | (6.143) | (2.072) |
| Agric wage EA | 0.060 | 0.032 | -0.054 | 0.156*** | -0.004 | -0.046 | 0.096 | -0.073 |
| | (0.045) | (0.047) | (0.086) | (0.057) | (0.053) | (0.057) | (0.143) | (0.054) |
| Fertilizer price EA | -0.230*** | -0.102 | -0.186** | -0.365*** | 0.047 | 0.105 | -0.726** | 0.099 |
| | (0.063) | (0.071) | (0.087) | (0.084) | (0.128) | (0.124) | (0.316) | (0.124) |
| Distance to market | 0.000 | -0.001 | -0.001 | -0.002 | -0.006* | -0.000 | -0.013*** | -0.002 |
| | (0.001) | (0.001) | (0.002) | (0.001) | (0.004) | (0.004) | (0.003) | (0.004) |
| Distance to road | 0.003 | 0.002 | -0.000 | 0.001 | 0.019*** | 0.028*** | 0.023 | 0.007 |
| | (0.003) | (0.002) | (0.003) | (0.003) | (0.007) | (0.010) | (0.017) | (0.008) |
| Tropical warm | 0.131 | -0.158* | -0.001 | -0.035 | -0.082 | 0.051 | 0.025 | -0.101 |
| | (0.088) | (0.081) | (0.136) | (0.099) | (0.286) | (0.199) | (0.348) | (0.310) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Rainfall deviation | 0.001*** | -0.000 | -0.001*** | 0.000 | 0.000** | 0.000 | -0.001* | 0.001*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.001) | (0.000) |
| Nutrient retention | -0.124*** | -0.100*** | -0.186* | -0.204*** | 0.045 | 0.414** | -0.360 | 0.083 |
| | (0.040) | (0.034) | (0.106) | (0.050) | (0.130) | (0.172) | (0.408) | (0.158) |
| Round | | | | | -0.210 | 0.137 | -0.105 | 0.571*** |
| | | | | | (0.132) | (0.128) | (0.432) | (0.157) |
| Constant | 11.704*** | 4.936*** | 7.122** | -0.208 | 10.942*** | 2.514 | 16.853*** | 1.154 |
| | (2.006) | (1.737) | (3.346) | (2.013) | (2.186) | (2.379) | (6.330) | (2.332) |
| N | 2,799 | 2,418 | 486 | 2,798 | 2,799 | 2,418 | 486 | 2,798 |
| $R^2$ | 0.251 | 0.108 | 0.230 | 0.144 | 0.166 | 0.053 | 0.235 | 0.039 |
| ll | | | | | -2896 | -1999 | -317.6 | -3043 |
| F | 20.32 | 6.334 | 5.441 | 8.966 | 8.816 | 3.000 | 3.285 | 1.851 |
| p | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.010 |

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses

**Table 4a**. Effects of crop and maize productivity on welfare – 2SLS

| Variable | Consumption expenditure | Dietary diversity | Caloric intake | Headcount | Food insecure | Consumption expenditure | Dietary diversity | Caloric intake | Headcou nt | Food insecure |
|---|---|---|---|---|---|---|---|---|---|---|
| Ln crop productivity | 0.237*** | 0.055* | 0.099 | -0.205*** | -0.091* | | | | | |
| | (0.075) | (0.028) | (0.062) | (0.060) | (0.053) | | | | | |
| Ln maize yield | | | | | | 0.221 | 0.128 | 0.195 | -0.187 | -0.168 |
| | | | | | | (0.228) | (0.102) | (0.184) | (0.165) | (0.175) |
| Constant | 9.250*** | 1.167** | 6.472*** | 2.676*** | 0.811 | 11.862*** | 1.468*** | 6.867*** | 0.141 | 0.310 |
| | (1.210) | (0.471) | (1.003) | (0.987) | (0.883) | (1.191) | (0.568) | (0.989) | (0.891) | (0.949) |
| N | 2799 | 2790 | 2777 | 2799 | 2799 | 2418 | 2412 | 2400 | 2418 | 2418 |
| ll | -2189 | 51.25 | -1935 | -1783 | -1730 | -1855 | -127.9 | -1807 | -1495 | -1604 |
| Second stage F Stats. | 54.36 | 26.39 | 13.62 | 27.39 | 10.00 | 48.66 | 18.33 | 9.536 | 25.65 | 6.952 |
| P value for F Stat. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Test for overidentification* | | | | | | | | | | |
| Hansen's J Stat. | 3.123 | 0.715 | 1.039 | 4.015 | 0.641 | 0 | 0 | 0 | 0 | 0 |
| P value | 0.0772 | 0.398 | 0.308 | 0.0451 | 0.423 | . | . | . | . | . |
| *Test for underidentification* | | | | | | | | | | |
| Kleibergen-Paak LM Stat | 43.05 | 41.87 | 41.82 | 43.05 | 43.05 | 6.202 | 6.215 | 6.339 | 6.202 | 6.202 |
| P value | 4.48e-10 | 8.09e-10 | 8.32e-10 | 4.48e-10 | 4.48e-10 | 0.0128 | 0.0127 | 0.0118 | 0.0128 | 0.0128 |
| *Test for weak identification* | | | | | | | | | | |
| Kleibergen-Paark F Stat | 23.74 | 23.07 | 23.04 | 23.74 | 23.74 | 6.093 | 6.108 | 6.226 | 6.093 | 6.093 |
| *Endogeneity test* | | | | | | | | | | |
| Endogeneity Stat. | 7.542 | 1.463 | 0.342 | 8.680 | 0.731 | 0.686 | 1.190 | 0.694 | 0.921 | 0.615 |
| P value | 0.00603 | 0.226 | 0.559 | 0.00322 | 0.393 | 0.408 | 0.275 | 0.405 | 0.337 | 0.433 |

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. For maize and labor productivity, only one instrument (nutrient retention constraint) was used, while for crop and paddy productivity, the two instruments were used.

**Table 4b**. Effects of paddy and labor productivity on welfare – 2SLS

| Variable | Consumption expenditure | Dietary diversity | Caloric intake | Headcount | Food insecure | Consumption expenditure | Dietary diversity | Caloric intake | Headcount | Food insecure |
|---|---|---|---|---|---|---|---|---|---|---|
| Ln paddy yield | -0.488 | -0.012 | -0.468 | 0.251 | 0.283 | | | | | |
| | (0.297) | (0.070) | (0.296) | (0.154) | (0.189) | | | | | |
| Ln labor productivity | | | | | | -0.748 | 0.055* | 0.020 | -0.039 | -0.027 |
| | | | | | | (3.527) | (0.030) | (0.059) | (0.051) | (0.055) |
| Constant | 14.257*** | 1.212*** | 9.364*** | -0.579 | -0.186 | 12.787*** | 2.032*** | 8.027*** | -0.535* | -0.620* |
| | (1.547) | (0.397) | (1.605) | (1.037) | (1.170) | (4.375) | (0.178) | (0.347) | (0.300) | (0.322) |
| N | 486 | 484 | 484 | 486 | 486 | 2798 | 2789 | 2776 | 2798 | 2798 |
| ll | -492.7 | 91.26 | -485.5 | -336.4 | -382.0 | -4320 | -2.906 | -1942 | -1541 | -1728 |
| Second stage F Stats. | 4.715 | 5.086 | 1.825 | 5.795 | 1.986 | 12.09 | 25.70 | 13.29 | 35.86 | 9.648 |
| P value for F Stat. | 0 | 0 | 0.0130 | 0 | 0.00522 | 0 | 0 | 0 | 0 | 0 |
| *Test for overidentification* | | | | | | | | | | |
| Hansen's J Stat. | 2.974 | 1.141 | 3.168 | 0.332 | 1.581 | 0 | 0 | 0 | 0 | 0 |
| P value | 0.0846 | 0.285 | 0.0751 | 0.564 | 0.209 | . | . | . | . | . |
| *Test for underidentification* | | | | | | | | | | |
| Kleibergen-Paak LM Stat | 11.07 | 10.71 | 10.71 | 11.07 | 11.07 | 42.36 | 41.30 | 41.20 | 42.36 | 42.36 |
| P value | 0.00394 | 0.00471 | 0.00471 | 0.00394 | 0.00394 | 7.60e-11 | 1.30e-10 | 1.38e-10 | 7.60e-11 | 7.60e-11 |
| *Test for weak identification* | | | | | | | | | | |
| Kleibergen-Paark F Stat | 4.779 | 4.630 | 4.630 | 4.779 | 4.779 | 41.38 | 40.43 | 40.29 | 41.38 | 41.38 |
| *Endogeneity test* | | | | | | | | | | |
| Endogeneity Stat. | 6.495 | 0.0584 | 5.768 | 3.715 | 3.579 | 0.0245 | 2.530 | 0.0540 | 0.0571 | 0.00240 |
| P value | 0.0108 | 0.809 | 0.0163 | 0.0539 | 0.0585 | 0.876 | 0.112 | 0.816 | 0.811 | 0.961 |

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. For maize and labor productivity, only one instrument (nutrient retention constraint) was used, while for crop and paddy productivity, the two instruments were used.

**Table 5**. Effect of agricultural productivity on household welfare – summary of results (FE)

| Variable | Model 1<br>Consumption expenditure | Model 2<br>Dietary diversity | Model 3<br>Caloric intake | Model 4<br>Headcount | Model 5<br>Food insecure | Model 6<br>Poverty Gap | Model 7<br>Poverty Severity |
|---|---|---|---|---|---|---|---|
| Ln crop productivity | 0.059*** | 0.025*** | 0.051*** | -0.034*** | -0.036*** | -0.017*** | -0.008*** |
| | (0.013) | (0.006) | (0.013) | (0.012) | (0.012) | (0.003) | (0.001) |
| Ln maize yield | 0.073*** | 0.024*** | 0.061*** | -0.046*** | -0.045*** | -0.009** | -0.004** |
| | (0.017) | (0.009) | (0.017) | (0.014) | (0.016) | (0.004) | (0.002) |
| Ln paddy yield | 0.082** | 0.031** | 0.099** | -0.039 | -0.093** | -0.013** | -0.008*** |
| | (0.038) | (0.016) | (0.038) | (0.046) | (0.046) | (0.005) | (0.003) |
| Ln labor productivity | 0.030** | 0.012** | 0.030*** | -0.018* | -0.016 | -0.010*** | -0.005*** |
| | (0.012) | (0.006) | (0.011) | (0.010) | (0.011) | (0.003) | (0.001) |

Models 1-3 were estimated using FE OLS with logarithmic transformation of dependent variables. Models 4&5 were estimated using FE linear probability estimator, while models 6&7 employed the two-part estimator (first part used Logit and second part used GLM).

**Table 6**. Correlated random effects ordered probit estimates of agriculture productivity and composite welfare

| Variable | Estimate | Category 0 | Category 1 | Category 2 |
|---|---|---|---|---|
| Ln Crop productivity | 0.161*** | -0.037*** | -0.018*** | 0.054*** |
| | (0.022) | (0.005) | (0.003) | (0.007) |
| Ln Maize yield | 0.088** | -0.020** | -0.010** | 0.030** |
| | (0.035) | (0.008) | (0.004) | (0.012) |
| Ln Paddy yield | 0.083 | -0.018 | -0.008 | 0.026 |
| | (0.062) | (0.014) | (0.005) | (0.019) |
| Ln Labor productivity | 0.070*** | -0.016*** | -0.008*** | 0.024*** |
| | (0.023) | (0.005) | (0.003) | (0.008) |

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. Category 0 = Poor and food insecure; category 1 = non-poor and food insecure or poor and food secured; category 2 = non-poor and food secure. Estimated using Mundlak (1978) approach. The results represent the marginal effects of the probability of being in a given category.

**Table 7**. Positive productivity growth and poverty transitions

| Variable | Positive transition | Negative transition | Change in consumption | Positive transition | Negative transition | Change in consumption |
|---|---|---|---|---|---|---|
| Crop value of output growth | 0.141** | -0.048 | 0.202** | | | |
| | (0.061) | (0.034) | (0.086) | | | |
| Crop yield growth | | | | 0.056 | -0.027 | 0.245*** |
| | | | | (0.061) | (0.034) | (0.081) |
| Constant | -1.835 | -0.379 | 1.679 | -1.599 | -0.360 | 1.629 |
| | (1.474) | (0.722) | (1.326) | (1.514) | (0.722) | (1.324) |
| N | 266 | 748 | 1,014 | 266 | 748 | 1,014 |
| $R^2$ | 0.164 | 0.096 | 0.047 | 0.149 | 0.094 | 0.050 |
| ll | -166.8 | -456.2 | -1672 | -169.2 | -456.8 | -1670 |
| p | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.004 |
| F | 3.598 | 5.195 | 2.346 | 3.255 | 5.079 | 2.074 |

| Variable | Positive transition | Negative transition | Change in consumption | Positive transition | Negative transition | Change in consumption |
|---|---|---|---|---|---|---|
| Maize yield growth | 0.007 | 0.018 | 0.126 | | | |
| | (0.062) | (0.034) | (0.083) | | | |
| Rice yield growth | | | | 0.084 | -0.027 | 0.070 |
| | | | | (0.077) | (0.058) | (0.082) |
| Constant | -1.583 | -0.408 | 1.491 | -1.748 | -0.372 | 1.699 |
| | (1.511) | (0.726) | (1.309) | (1.517) | (0.722) | (1.307) |
| N | 266 | 748 | 1,014 | 266 | 748 | 1,014 |
| $R^2$ | 0.146 | 0.094 | 0.043 | 0.150 | 0.094 | 0.041 |
| ll | -169.6 | -457.0 | -1674 | -169.0 | -457.1 | -1675 |
| p | 0.000 | 0.000 | 0.005 | 0.000 | 0.000 | 0.003 |
| F | 3.341 | 5.096 | 2.021 | 3.194 | 5.078 | 2.118 |

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses

**Table A1**. Effect of agricultural productivity on household welfare – summary of results (*pooled*)

| Variable | Model 1<br>Consumption expenditure | Model 2<br>Dietary diversity | Model 3<br>Caloric intake | Model 4<br>Headcount | Model 5<br>Food insecure | Model 6<br>Poverty Gap | Model 7<br>Poverty Severity |
|---|---|---|---|---|---|---|---|
| Ln crop productivity | 0.071*** | 0.021*** | 0.061*** | -0.052*** | -0.049*** | -0.018*** | -0.009*** |
| | (0.008) | (0.004) | (0.008) | (0.006) | (0.006) | (0.002) | (0.001) |
| Ln maize yield | 0.043*** | 0.029*** | 0.044*** | -0.033*** | -0.032*** | -0.009** | -0.005** |
| | (0.011) | (0.006) | (0.011) | (0.009) | (0.010) | (0.004) | (0.002) |
| Ln paddy yield | 0.015 | 0.006 | 0.020 | 0.001 | -0.018 | -0.005 | -0.004 |
| | (0.019) | (0.008) | (0.016) | (0.016) | (0.019) | (0.006) | (0.004) |
| Ln labor productivity | 0.043*** | 0.009*** | 0.033*** | -0.027*** | -0.024*** | -0.010*** | -0.005*** |
| | (0.009) | (0.004) | (0.008) | (0.006) | (0.007) | (0.003) | (0.001) |

Models 1-3 were estimated using OLS with logarithmic transformation of dependent variables. Models 4&5 were estimated using linear probability model estimator, while models 6&7 uses the two-part estimator (first part used Logit and second part used GLM).

**Table A2**. Effects of crop productivity on welfare - FE

| Variable | Consumption expenditure | Dietary diversity | Caloric intake | Headcount | Food insecure | Poverty gap | Poverty severity |
|---|---|---|---|---|---|---|---|
| Ln crop productivity | 0.059*** | 0.025*** | 0.051*** | -0.034*** | -0.036*** | -0.017*** | -0.008*** |
| | (0.013) | (0.006) | (0.013) | (0.012) | (0.012) | (0.003) | (0.001) |
| Household size | -0.065*** | -0.000 | -0.051*** | 0.044*** | 0.038*** | 0.016*** | 0.007*** |
| | (0.006) | (0.003) | (0.006) | (0.006) | (0.006) | (0.002) | (0.001) |
| Dependency ratio | -0.026** | 0.005 | -0.031** | 0.003 | 0.030** | -0.001 | -0.001 |
| | (0.012) | (0.006) | (0.014) | (0.011) | (0.012) | (0.004) | (0.002) |
| Gender | 0.040 | -0.011 | -0.030 | -0.017 | -0.016 | -0.022 | -0.016* |
| | (0.052) | (0.024) | (0.052) | (0.044) | (0.046) | (0.017) | (0.009) |
| Age | -0.001 | -0.001* | -0.002 | 0.001 | 0.001 | 0.001* | 0.000 |
| | (0.002) | (0.001) | (0.001) | (0.001) | (0.001) | (0.000) | (0.000) |
| Education | 0.046 | -0.030 | -0.082 | -0.033 | 0.154** | -0.045* | -0.017 |
| | (0.079) | (0.050) | (0.092) | (0.075) | (0.076) | (0.023) | (0.014) |
| Wage work | -0.016 | -0.026 | -0.011 | -0.003 | 0.033 | 0.018 | 0.010 |
| | (0.039) | (0.018) | (0.043) | (0.036) | (0.039) | (0.014) | (0.008) |
| Non-farm work | 0.134*** | 0.016 | 0.019 | -0.062* | -0.038 | -0.024 | -0.014* |
| | (0.039) | (0.020) | (0.038) | (0.037) | (0.036) | (0.016) | (0.009) |
| Credit | 0.055 | 0.037* | 0.088** | 0.006 | -0.084** | -0.012 | -0.001 |
| | (0.038) | (0.020) | (0.038) | (0.037) | (0.039) | (0.015) | (0.008) |
| Remittance | 0.044 | 0.026 | 0.055 | -0.041 | -0.075** | -0.015 | -0.008 |
| | (0.031) | (0.016) | (0.035) | (0.028) | (0.031) | (0.011) | (0.006) |
| TLU | 0.019*** | 0.004*** | 0.020*** | -0.009*** | -0.013*** | -0.003*** | -0.001** |
| | (0.003) | (0.001) | (0.004) | (0.003) | (0.003) | (0.001) | (0.001) |
| Asset index | 0.125*** | 0.048*** | 0.068*** | -0.080*** | -0.044*** | -0.038*** | -0.019*** |
| | (0.017) | (0.007) | (0.017) | (0.014) | (0.016) | (0.007) | (0.004) |
| Agric capital index | -0.005 | 0.013** | -0.014 | -0.014 | -0.003 | -0.001 | 0.001 |
| | (0.013) | (0.005) | (0.010) | (0.015) | (0.013) | (0.007) | (0.004) |
| Erosion control | -0.039 | -0.014 | -0.071** | 0.022 | 0.068* | 0.001 | -0.000 |
| | (0.041) | (0.019) | (0.035) | (0.033) | (0.035) | (0.013) | (0.009) |
| Land area | 0.002 | 0.000 | 0.002** | -0.002 | -0.002*** | -0.001 | -0.000 |
| | (0.001) | (0.000) | (0.001) | (0.001) | (0.001) | (0.000) | (0.000) |
| Extension | 0.075* | 0.048** | -0.043 | -0.018 | 0.027 | -0.006 | -0.005 |
| | (0.044) | (0.020) | (0.037) | (0.034) | (0.040) | (0.014) | (0.007) |
| Fisher price | 0.599 | 0.054 | -0.086 | -0.793 | 0.330 | 0.064 | 0.056 |
| | (0.840) | (0.488) | (0.895) | (0.720) | (0.823) | (0.265) | (0.151) |
| Agric wage EA | 0.020 | 0.003 | -0.005 | -0.018 | -0.017 | -0.011 | -0.006 |
| | (0.026) | (0.010) | (0.023) | (0.018) | (0.021) | (0.008) | (0.004) |
| Fertilizer price EA | 0.069 | -0.000 | 0.036 | -0.046 | -0.011 | 0.005 | 0.003 |
| | (0.050) | (0.018) | (0.040) | (0.034) | (0.042) | (0.013) | (0.008) |
| Distance to market | 0.003 | -0.000 | 0.001 | -0.002 | -0.004** | -0.001 | -0.001 |
| | (0.002) | (0.001) | (0.002) | (0.002) | (0.002) | (0.001) | (0.000) |
| Distance to road | -0.002 | 0.001 | -0.005 | 0.004 | 0.011** | 0.002 | 0.001 |
| | (0.005) | (0.004) | (0.005) | (0.004) | (0.005) | (0.001) | (0.001) |
| Tropical warm | 0.071 | -0.094** | 0.057 | -0.117 | 0.008 | -0.014 | -0.014 |
| | (0.112) | (0.044) | (0.087) | (0.105) | (0.096) | (0.034) | (0.018) |
| Round | -0.143*** | 0.016 | 0.024 | 0.132*** | 0.029 | 0.037*** | 0.018*** |
| | (0.048) | (0.022) | (0.042) | (0.037) | (0.041) | (0.011) | (0.006) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Constant | 9.558*** | 1.744*** | 7.563*** | 1.670** | 0.465 | | |
| | (0.901) | (0.481) | (0.955) | (0.750) | (0.881) | | |
| N | 2,800 | 2,791 | 2,778 | 2,800 | 2,800 | 2,800 | 2,800 |
| $R^2$ | 0.186 | 0.082 | 0.101 | 0.111 | 0.077 | | |
| ll | -610.4 | 1388 | -561.4 | -326.7 | -488.5 | . | . |
| F | 12.31 | 6.719 | 6.686 | 7.874 | 5.365 | . | . |

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. Columns 1-3 were estimated using FE OLS with logarithmic transformation of dependent variables. Columns 4&5 were estimated using FE linear probability model, while columns 6&7 employed the two-part model estimator (first part uses Logit and second part uses GLM).

**Table A3**. Effects of maize productivity on welfare – FE

| VARIABLES | Consumption expenditure | Dietary diversity | Caloric intake | Headcount | Food insecure | Poverty gap | Poverty severity |
|---|---|---|---|---|---|---|---|
| Ln maize yield | 0.073*** | 0.024*** | 0.061*** | -0.046*** | -0.045*** | -0.009** | -0.004** |
| | (0.017) | (0.009) | (0.017) | (0.014) | (0.016) | (0.004) | (0.002) |
| Household size | -0.056*** | -0.001 | -0.047*** | 0.042*** | 0.035*** | 0.016*** | 0.007*** |
| | (0.006) | (0.003) | (0.006) | (0.006) | (0.006) | (0.002) | (0.001) |
| Dependency ratio | -0.020 | 0.009 | -0.026 | -0.000 | 0.029** | -0.003 | -0.002 |
| | (0.014) | (0.006) | (0.016) | (0.012) | (0.014) | (0.005) | (0.003) |
| Gender | 0.045 | -0.021 | -0.070 | -0.015 | 0.002 | -0.013 | -0.012 |
| | (0.060) | (0.028) | (0.055) | (0.051) | (0.053) | (0.018) | (0.010) |
| Age | 0.000 | -0.000 | -0.000 | 0.000 | -0.000 | 0.000 | 0.000 |
| | (0.002) | (0.001) | (0.001) | (0.001) | (0.001) | (0.000) | (0.000) |
| Education | 0.061 | -0.027 | -0.060 | -0.005 | 0.114 | -0.051** | -0.025 |
| | (0.092) | (0.059) | (0.104) | (0.085) | (0.090) | (0.025) | (0.016) |
| Wage work | 0.023 | -0.025 | 0.022 | -0.045 | 0.006 | 0.007 | 0.005 |
| | (0.043) | (0.021) | (0.043) | (0.039) | (0.040) | (0.015) | (0.008) |
| Non-farm work | 0.138*** | 0.013 | 0.041 | -0.048 | -0.053 | -0.019 | -0.013 |
| | (0.044) | (0.024) | (0.040) | (0.043) | (0.040) | (0.017) | (0.009) |
| Credit | 0.066 | 0.039 | 0.081* | -0.021 | -0.078* | -0.015 | -0.001 |
| | (0.043) | (0.024) | (0.044) | (0.039) | (0.043) | (0.016) | (0.009) |
| Remittance | 0.054 | 0.033* | 0.086** | -0.052 | -0.091*** | -0.023** | -0.013** |
| | (0.033) | (0.018) | (0.036) | (0.032) | (0.034) | (0.011) | (0.006) |
| TLU | 0.019*** | 0.003** | 0.021*** | -0.010*** | -0.012*** | -0.003*** | -0.001** |
| | (0.004) | (0.001) | (0.004) | (0.004) | (0.003) | (0.001) | (0.001) |
| Asset index | 0.118*** | 0.052*** | 0.061*** | -0.082*** | -0.038** | -0.042*** | -0.020*** |
| | (0.019) | (0.008) | (0.019) | (0.016) | (0.018) | (0.008) | (0.005) |
| Agric capital index | -0.001 | 0.013** | -0.015 | -0.014 | -0.002 | -0.003 | -0.000 |
| | (0.015) | (0.006) | (0.010) | (0.017) | (0.012) | (0.009) | (0.006) |
| Erosion control | -0.065 | -0.016 | -0.090** | 0.053 | 0.085** | 0.010 | 0.005 |
| | (0.043) | (0.021) | (0.041) | (0.038) | (0.039) | (0.012) | (0.008) |
| Land area | 0.060 | 0.064*** | -0.046 | -0.024 | 0.024 | -0.009 | -0.006 |
| | (0.053) | (0.022) | (0.041) | (0.041) | (0.041) | (0.014) | (0.007) |
| Extension | 0.002* | 0.001 | 0.002** | -0.002* | -0.002*** | -0.001* | -0.001* |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.000) |
| Fisher price | 0.562 | -0.195 | -0.667 | -0.806 | 0.496 | 0.121 | 0.102 |
| | (0.895) | (0.574) | (0.974) | (0.816) | (0.931) | (0.273) | (0.158) |
| Agric wage EA | 0.006 | 0.011 | -0.007 | -0.018 | -0.016 | -0.009 | -0.005 |
| | (0.022) | (0.011) | (0.025) | (0.018) | (0.022) | (0.008) | (0.004) |
| Fertilizer price EA | 0.083 | 0.010 | 0.062 | -0.032 | -0.034 | 0.011 | 0.003 |
| | (0.052) | (0.019) | (0.039) | (0.043) | (0.044) | (0.015) | (0.009) |
| Distance to market | -0.002 | -0.001 | -0.001 | 0.002 | -0.001 | -0.000 | -0.000 |
| | (0.003) | (0.001) | (0.003) | (0.002) | (0.002) | (0.001) | (0.000) |
| Distance to road | -0.002 | 0.003 | -0.004 | 0.007 | 0.008 | 0.002 | 0.001 |
| | (0.005) | (0.005) | (0.006) | (0.005) | (0.006) | (0.002) | (0.001) |
| Tropical warm | 0.069 | -0.084 | 0.042 | -0.104 | -0.030 | -0.004 | -0.005 |
| | (0.108) | (0.052) | (0.094) | (0.108) | (0.094) | (0.038) | (0.021) |
| Round | -0.160*** | -0.007 | 0.012 | 0.160*** | 0.045 | 0.038*** | 0.016*** |
| | (0.045) | (0.026) | (0.047) | (0.041) | (0.045) | (0.011) | (0.006) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Constant | 10.105*** | 1.962*** | 8.262*** | 1.142 | 0.231 | | |
| | (1.045) | (0.577) | (1.104) | (0.924) | (0.991) | | |
| N | 2,419 | 2,413 | 2,401 | 2,419 | 2,419 | 2,419 | 2,419 |
| $R^2$ | 0.187 | 0.086 | 0.109 | 0.122 | 0.076 | | |
| ll | -381.4 | 1250 | -390.9 | -222.4 | -328.0 | . | . |
| F | 11.29 | 5.870 | 5.867 | 8.366 | 5.322 | . | . |

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. Columns 1-3 were estimated using FE OLS with logarithmic transformation of dependent variables. Columns 4&5 were estimated using FE linear probability model, while columns 6&7 employed the two-part model estimator (first part uses Logit and second part uses GLM).

**Table A4**. Effects of paddy rice productivity on welfare – FE

| Variable | Consumption expenditure | Dietary diversity | Caloric intake | Headcount | Food insecure | Poverty gap | Poverty severity |
|---|---|---|---|---|---|---|---|
| Ln paddy yield | 0.082** | 0.031** | 0.099** | -0.039 | -0.093** | -0.013** | -0.008*** |
| | (0.038) | (0.016) | (0.038) | (0.046) | (0.046) | (0.005) | (0.003) |
| Household size | -0.043*** | -0.001 | -0.035*** | 0.043*** | 0.024* | 0.013*** | 0.004*** |
| | (0.011) | (0.006) | (0.011) | (0.011) | (0.013) | (0.003) | (0.001) |
| Dependency ratio | -0.016 | -0.005 | 0.017 | 0.017 | 0.012 | -0.004 | -0.001 |
| | (0.022) | (0.010) | (0.028) | (0.025) | (0.024) | (0.009) | (0.004) |
| Gender | -0.073 | 0.056 | 0.027 | -0.129 | 0.050 | -0.024 | -0.015 |
| | (0.158) | (0.054) | (0.152) | (0.180) | (0.157) | (0.042) | (0.017) |
| Age | 0.002 | -0.001 | 0.003 | 0.003 | -0.003 | 0.001 | -0.000 |
| | (0.004) | (0.002) | (0.003) | (0.004) | (0.004) | (0.001) | (0.001) |
| Education | -0.023 | 0.022 | -0.333 | 0.074 | 0.424** | -0.065 | -0.066** |
| | (0.209) | (0.088) | (0.205) | (0.187) | (0.165) | (0.051) | (0.033) |
| Wage work | -0.025 | -0.049 | 0.129 | -0.010 | -0.141 | 0.026 | 0.017 |
| | (0.094) | (0.056) | (0.106) | (0.102) | (0.087) | (0.026) | (0.012) |
| Non-farm work | 0.115 | -0.059 | -0.013 | -0.005 | -0.044 | -0.022 | -0.010 |
| | (0.102) | (0.047) | (0.078) | (0.103) | (0.108) | (0.024) | (0.011) |
| Credit | -0.182* | 0.026 | -0.063 | 0.208* | -0.018 | 0.042 | 0.013 |
| | (0.097) | (0.028) | (0.108) | (0.122) | (0.148) | (0.027) | (0.012) |
| Remittance | -0.132 | -0.013 | -0.036 | 0.140 | 0.010 | 0.022 | 0.016* |
| | (0.102) | (0.059) | (0.111) | (0.110) | (0.086) | (0.022) | (0.009) |
| TLU | 0.013** | 0.003 | 0.010** | -0.011** | -0.005 | -0.006** | -0.002* |
| | (0.006) | (0.002) | (0.004) | (0.006) | (0.006) | (0.003) | (0.001) |
| Asset index | 0.112** | 0.048*** | 0.081* | -0.095** | -0.096** | -0.020 | -0.008 |
| | (0.045) | (0.017) | (0.045) | (0.040) | (0.039) | (0.014) | (0.006) |
| Agric capital index | 0.027 | 0.027 | -0.022 | -0.086 | 0.026 | -0.014 | -0.002 |
| | (0.053) | (0.023) | (0.049) | (0.059) | (0.058) | (0.013) | (0.006) |
| Erosion control | 0.030 | 0.022 | 0.071 | -0.102 | -0.013 | -0.032 | -0.012 |
| | (0.095) | (0.045) | (0.075) | (0.094) | (0.081) | (0.023) | (0.011) |
| Land area | -0.000 | -0.000 | 0.002 | -0.000 | -0.002 | 0.000 | 0.000 |
| | (0.002) | (0.000) | (0.001) | (0.002) | (0.001) | (0.000) | (0.000) |
| Extension | 0.180 | 0.029 | -0.136 | -0.130* | 0.045 | -0.016 | -0.010 |
| | (0.114) | (0.039) | (0.106) | (0.067) | (0.096) | (0.035) | (0.018) |
| Fisher price | 0.747 | 1.154 | 0.559 | -1.204 | 1.068 | -0.854 | -0.364 |
| | (2.746) | (1.591) | (3.345) | (2.365) | (3.285) | (0.736) | (0.330) |
| Agric wage EA | -0.039 | -0.037 | 0.067 | 0.130** | -0.072 | -0.008 | -0.009 |
| | (0.066) | (0.036) | (0.081) | (0.060) | (0.069) | (0.017) | (0.008) |
| Fertilizer price EA | 0.022 | 0.122 | 0.304* | -0.220* | -0.353* | -0.059* | -0.024 |
| | (0.198) | (0.110) | (0.178) | (0.131) | (0.182) | (0.034) | (0.016) |
| Distance to market | 0.003 | 0.001* | 0.001 | 0.002 | -0.004 | -0.001 | -0.001*** |
| | (0.003) | (0.001) | (0.003) | (0.003) | (0.005) | (0.001) | (0.000) |
| Distance to road | 0.018* | -0.003 | 0.022** | -0.011 | -0.003 | -0.001 | -0.000 |
| | (0.010) | (0.003) | (0.011) | (0.008) | (0.012) | (0.002) | (0.001) |
| Tropical warm | 0.054 | -0.180*** | 0.275 | -0.278 | -0.174 | 0.020 | 0.012 |
| | (0.216) | (0.059) | (0.233) | (0.190) | (0.353) | (0.045) | (0.018) |
| Round | -0.206 | -0.015 | -0.181 | 0.038 | 0.138 | 0.076*** | 0.043** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | (0.147) | (0.060) | (0.144) | (0.139) | (0.162) | (0.026) | (0.016) |
| Constant | 9.837*** | 0.303 | 3.474 | 1.852 | 3.436 | | |
| | (3.241) | (1.538) | (3.473) | (2.635) | (3.348) | | |
| N | 486 | 484 | 484 | 486 | 486 | 486 | 486 |
| $R^2$ | 0.292 | 0.128 | 0.204 | 0.243 | 0.142 | | |
| ll | 55.56 | 423.6 | 62.05 | 64.89 | 28.75 | . | . |
| F | 5.789 | 3.349 | 5.785 | 4.377 | 1.760 | . | . |

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. Columns 1-3 were estimated using FE OLS with logarithmic transformation of dependent variables. Columns 4&5 were estimated using FE linear probability model, while columns 6&7 employed the two-part model estimator (first part uses Logit and second part uses GLM).

**Table A5**. Effects of labor productivity on welfare – FE

| Variable | Consumption expenditure | Dietary diversity | Caloric intake | Headcount | Food insecure | Poverty gap | Poverty severity |
|---|---|---|---|---|---|---|---|
| Ln labor productivity | 0.030** | 0.012** | 0.030*** | -0.018* | -0.016 | -0.010*** | -0.005*** |
| | (0.012) | (0.006) | (0.011) | (0.010) | (0.011) | (0.003) | (0.001) |
| Household size | -0.061*** | 0.002 | -0.047*** | 0.042*** | 0.036*** | 0.015*** | 0.007*** |
| | (0.006) | (0.003) | (0.006) | (0.006) | (0.006) | (0.002) | (0.001) |
| Dependency ratio | -0.023* | 0.007 | -0.027* | 0.001 | 0.028** | -0.003 | -0.002 |
| | (0.012) | (0.006) | (0.015) | (0.011) | (0.012) | (0.004) | (0.002) |
| Gender | 0.035 | -0.013 | -0.035 | -0.014 | -0.014 | -0.020 | -0.015* |
| | (0.053) | (0.024) | (0.053) | (0.044) | (0.046) | (0.017) | (0.009) |
| Age | -0.000 | -0.001 | -0.001 | 0.000 | 0.001 | 0.001 | 0.000 |
| | (0.002) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.000) |
| Education | 0.051 | -0.027 | -0.076 | -0.036 | 0.151** | -0.048** | -0.018 |
| | (0.080) | (0.051) | (0.093) | (0.075) | (0.076) | (0.021) | (0.013) |
| Wage work | -0.026 | -0.030 | -0.018 | 0.002 | 0.039 | 0.018 | 0.010 |
| | (0.039) | (0.018) | (0.043) | (0.036) | (0.039) | (0.014) | (0.008) |
| Non-farm work | 0.133*** | 0.015 | 0.018 | -0.061* | -0.037 | -0.022 | -0.013 |
| | (0.040) | (0.020) | (0.038) | (0.037) | (0.036) | (0.015) | (0.008) |
| Credit | 0.059 | 0.039** | 0.091** | 0.004 | -0.087** | -0.013 | -0.001 |
| | (0.038) | (0.020) | (0.038) | (0.037) | (0.039) | (0.015) | (0.009) |
| Remittance | 0.046 | 0.027 | 0.058 | -0.043 | -0.077** | -0.015 | -0.008 |
| | (0.032) | (0.017) | (0.035) | (0.028) | (0.031) | (0.011) | (0.006) |
| TLU | 0.020*** | 0.004*** | 0.020*** | -0.010*** | -0.013*** | -0.003*** | -0.001** |
| | (0.003) | (0.001) | (0.004) | (0.003) | (0.003) | (0.001) | (0.001) |
| Asset index | 0.130*** | 0.050*** | 0.072*** | -0.083*** | -0.046*** | -0.040*** | -0.020*** |
| | (0.017) | (0.007) | (0.017) | (0.014) | (0.016) | (0.007) | (0.004) |
| Agric capital index | 0.001 | 0.015*** | -0.010 | -0.017 | -0.006 | -0.003 | 0.000 |
| | (0.014) | (0.005) | (0.011) | (0.016) | (0.013) | (0.007) | (0.004) |
| Erosion control | -0.037 | -0.014 | -0.071** | 0.021 | 0.067* | 0.002 | 0.000 |
| | (0.041) | (0.019) | (0.035) | (0.033) | (0.035) | (0.013) | (0.009) |
| Land area | 0.002* | 0.000 | 0.002** | -0.002* | -0.002*** | -0.001* | -0.000* |
| | (0.001) | (0.000) | (0.001) | (0.001) | (0.001) | (0.000) | (0.000) |
| Extension | 0.085* | 0.053*** | -0.035 | -0.023 | 0.021 | -0.008 | -0.006 |
| | (0.044) | (0.020) | (0.037) | (0.034) | (0.040) | (0.014) | (0.007) |
| Fisher price | 0.679 | 0.087 | -0.017 | -0.841 | 0.284 | 0.045 | 0.045 |
| | (0.850) | (0.494) | (0.908) | (0.727) | (0.828) | (0.266) | (0.150) |
| Agric wage EA | 0.021 | 0.004 | -0.003 | -0.019 | -0.018 | -0.012 | -0.007 |
| | (0.026) | (0.010) | (0.023) | (0.019) | (0.022) | (0.008) | (0.004) |
| Fertilizer price EA | 0.069 | -0.000 | 0.036 | -0.046 | -0.011 | 0.005 | 0.002 |
| | (0.049) | (0.018) | (0.040) | (0.033) | (0.042) | (0.013) | (0.008) |
| Distance to market | 0.002 | -0.000 | 0.001 | -0.001 | -0.004** | -0.001 | -0.001 |
| | (0.002) | (0.001) | (0.002) | (0.002) | (0.002) | (0.001) | (0.000) |
| Distance to road | -0.001 | 0.002 | -0.004 | 0.004 | 0.010** | 0.001 | 0.000 |
| | (0.005) | (0.004) | (0.005) | (0.004) | (0.005) | (0.001) | (0.001) |
| Tropical warm | 0.068 | -0.094** | 0.056 | -0.116 | 0.009 | -0.011 | -0.012 |
| | (0.113) | (0.044) | (0.089) | (0.106) | (0.099) | (0.035) | (0.018) |
| Round | -0.174*** | 0.003 | -0.003 | 0.149*** | 0.047 | 0.046*** | 0.022*** |
| | (0.047) | (0.022) | (0.041) | (0.037) | (0.040) | (0.011) | (0.006) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Constant | 10.171*** | 2.005*** | 8.083*** | 1.325* | 0.095 | | |
| | (0.912) | (0.489) | (0.957) | (0.756) | (0.871) | | |
| N | 2,799 | 2,790 | 2,777 | 2,799 | 2,799 | 2,799 | 2,799 |
| $R^2$ | 0.175 | 0.073 | 0.093 | 0.107 | 0.072 | | |
| ll | -629.0 | 1373 | -573.0 | -333.9 | -496.4 | . | . |
| F | 12.25 | 5.962 | 6.114 | 7.580 | 5.068 | . | . |

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. Columns 1-3 were estimated using FE OLS with logarithmic transformation of dependent variables. Columns 4&5 were estimated using FE linear probability model, while columns 6&7 employed the two-part model estimator (first part uses Logit and second part uses GLM).

**Table A6**. Effects of crop productivity on welfare – 2SLS

| Variable | Consumption expenditure | Dietary diversity | Caloric intake | Headcount | Food insecure |
|---|---|---|---|---|---|
| Ln crop productivity | 0.237*** | 0.055* | 0.099 | -0.205*** | -0.091* |
| | (0.075) | (0.028) | (0.062) | (0.060) | (0.053) |
| Household size | -0.093*** | -0.001 | -0.053*** | 0.060*** | 0.039*** |
| | (0.006) | (0.002) | (0.005) | (0.005) | (0.004) |
| Dependency ratio | -0.048*** | 0.002 | -0.050*** | 0.017* | 0.040*** |
| | (0.011) | (0.005) | (0.012) | (0.009) | (0.009) |
| Gender | 0.064* | 0.027* | 0.038 | -0.042 | -0.033 |
| | (0.035) | (0.015) | (0.031) | (0.030) | (0.027) |
| Age | 0.002*** | -0.001** | 0.001 | -0.001** | -0.000 |
| | (0.001) | (0.000) | (0.001) | (0.001) | (0.001) |
| Education | 0.131*** | 0.039 | 0.047 | -0.087** | -0.028 |
| | (0.046) | (0.024) | (0.045) | (0.038) | (0.040) |
| Wage work | 0.072* | -0.006 | 0.013 | -0.054* | -0.003 |
| | (0.037) | (0.016) | (0.032) | (0.031) | (0.029) |
| Non-farm work | 0.169*** | 0.032*** | 0.061** | -0.103*** | -0.047* |
| | (0.028) | (0.012) | (0.027) | (0.023) | (0.024) |
| Credit | 0.066** | -0.002 | 0.021 | -0.036 | -0.035 |
| | (0.031) | (0.013) | (0.027) | (0.027) | (0.028) |
| Remittance | 0.068** | 0.028** | 0.007 | -0.062*** | -0.017 |
| | (0.026) | (0.012) | (0.023) | (0.022) | (0.022) |
| TLU | 0.011*** | 0.001 | 0.014*** | -0.005* | -0.009*** |
| | (0.004) | (0.001) | (0.003) | (0.003) | (0.003) |
| Asset index | 0.141*** | 0.054*** | 0.028*** | -0.060*** | -0.023*** |
| | (0.011) | (0.004) | (0.009) | (0.008) | (0.008) |
| Agric capital index | 0.000 | -0.007 | -0.012 | 0.007 | 0.001 |
| | (0.017) | (0.005) | (0.010) | (0.009) | (0.010) |
| Erosion control | -0.039 | 0.012 | -0.018 | 0.017 | 0.015 |
| | (0.030) | (0.013) | (0.026) | (0.026) | (0.026) |
| Land area | -0.001 | -0.001 | 0.001 | 0.001 | -0.001 |
| | (0.002) | (0.001) | (0.001) | (0.001) | (0.001) |
| Extension | 0.011 | 0.020 | -0.016 | 0.012 | 0.055* |
| | (0.038) | (0.017) | (0.034) | (0.030) | (0.030) |
| Fisher price | -0.696 | 0.098 | 0.181 | 0.079 | 0.520 |
| | (0.436) | (0.194) | (0.384) | (0.377) | (0.369) |
| Agric wage EA | 0.006 | 0.013** | 0.016 | -0.000 | -0.013 |
| | (0.014) | (0.006) | (0.013) | (0.011) | (0.011) |
| Fertilizer price EA | 0.024 | 0.009 | 0.031 | -0.031 | -0.000 |
| | (0.023) | (0.011) | (0.020) | (0.019) | (0.019) |
| Distance to market | -0.001** | -0.000*** | -0.000 | 0.000* | 0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Distance to road | 0.001 | 0.000 | -0.001 | -0.001* | 0.000 |
| | (0.001) | (0.000) | (0.000) | (0.000) | (0.000) |
| Tropical warm | 0.011 | -0.009 | -0.013 | -0.011 | 0.034* |
| | (0.022) | (0.010) | (0.019) | (0.018) | (0.018) |
| Constant | 9.250*** | 1.167** | 6.472*** | 2.676*** | 0.811 |
| | (1.210) | (0.471) | (1.003) | (0.987) | (0.883) |
| N | 2,799 | 2,790 | 2,777 | 2,799 | 2,799 |
| ll | -2189 | 51.25 | -1935 | -1783 | -1730 |

| | | | | | |
|---|---|---|---|---|---|
| Second stage F Stats. | 54.36 | 26.39 | 13.62 | 27.39 | 10.00 |
| P value for F Stat. | 0 | 0 | 0 | 0 | 0 |
| *Test for overidentification* | | | | | |
| Hansen's J Stat. | 3.123 | 0.715 | 1.039 | 4.015 | 0.641 |
| P value | 0.0772 | 0.398 | 0.308 | 0.0451 | 0.423 |
| *Test for underidentification* | | | | | |
| Kleibergen-Paak LM Stat | 43.05 | 41.87 | 41.82 | 43.05 | 43.05 |
| P value | 4.48e-10 | 8.09e-10 | 8.32e-10 | 4.48e-10 | 4.48e-10 |
| *Test for weak identification* | | | | | |
| Kleibergen-Paark F Stat | 23.74 | 23.07 | 23.04 | 23.74 | 23.74 |
| *Endogeneity test* | | | | | |
| Endogeneity Stat. | 7.542 | 1.463 | 0.342 | 8.680 | 0.731 |
| P value | 0.00603 | 0.226 | 0.559 | 0.00322 | 0.393 |

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. Standard errors in parentheses. Columns 1-3 were estimated using 2SLS OLS with logarithmic transformation of dependent variables. Columns 4&5 were estimated using 2SLS linear probability model.

**Table A7**. Effects of maize productivity on welfare – 2SLS

| Variable | Consumption expenditure | Dietary diversity | Caloric intake | Headcount | Food insecure |
|---|---|---|---|---|---|
| Ln maize yield | 0.221 | 0.128 | 0.195 | -0.187 | -0.168 |
| | (0.228) | (0.102) | (0.184) | (0.165) | (0.175) |
| Household size | -0.078*** | 0.001 | -0.046*** | 0.050*** | 0.033*** |
| | (0.004) | (0.002) | (0.004) | (0.003) | (0.004) |
| Dependency ratio | -0.037*** | 0.007 | -0.045*** | 0.005 | 0.035*** |
| | (0.012) | (0.006) | (0.015) | (0.009) | (0.011) |
| Gender | -0.004 | 0.008 | 0.001 | 0.016 | 0.004 |
| | (0.026) | (0.012) | (0.025) | (0.022) | (0.023) |
| Age | 0.003** | -0.000 | 0.002 | -0.002* | -0.001 |
| | (0.002) | (0.001) | (0.001) | (0.001) | (0.001) |
| Education | 0.105** | 0.026 | 0.041 | -0.079* | -0.017 |
| | (0.050) | (0.030) | (0.051) | (0.041) | (0.048) |
| Wage work | 0.004 | -0.025* | -0.011 | 0.009 | 0.026 |
| | (0.029) | (0.014) | (0.029) | (0.025) | (0.026) |
| Non-farm work | 0.183*** | 0.043*** | 0.072** | -0.110*** | -0.052* |
| | (0.030) | (0.015) | (0.031) | (0.025) | (0.027) |
| Credit | 0.074** | 0.009 | 0.039 | -0.057** | -0.056* |
| | (0.032) | (0.016) | (0.031) | (0.027) | (0.030) |
| Remittance | 0.046* | 0.025** | -0.012 | -0.037* | -0.010 |
| | (0.025) | (0.013) | (0.025) | (0.022) | (0.023) |
| TLU | 0.016*** | 0.001 | 0.016*** | -0.010*** | -0.009*** |
| | (0.004) | (0.002) | (0.003) | (0.003) | (0.003) |
| Asset index | 0.137*** | 0.043*** | 0.014 | -0.057*** | -0.012 |
| | (0.029) | (0.013) | (0.023) | (0.021) | (0.022) |
| Agric capital index | 0.028 | -0.001 | -0.002 | -0.015** | -0.008 |
| | (0.017) | (0.004) | (0.009) | (0.007) | (0.009) |
| Erosion control | -0.067 | -0.009 | -0.040 | 0.038 | 0.040 |
| | (0.053) | (0.025) | (0.047) | (0.043) | (0.045) |
| Land area | 0.006** | 0.002 | 0.005** | -0.005** | -0.004* |
| | (0.003) | (0.001) | (0.003) | (0.002) | (0.002) |
| Extension | 0.018 | 0.003 | -0.054 | 0.008 | 0.084* |
| | (0.060) | (0.029) | (0.051) | (0.045) | (0.048) |
| Fisher price | -1.731** | -0.446 | -0.235 | 1.216** | 1.084** |
| | (0.685) | (0.310) | (0.602) | (0.523) | (0.543) |
| Agric wage EA | -0.013 | 0.006 | -0.002 | 0.016 | 0.001 |
| | (0.017) | (0.008) | (0.015) | (0.014) | (0.014) |
| Fertilizer price EA | -0.006 | 0.011 | 0.022 | -0.002 | -0.005 |
| | (0.021) | (0.016) | (0.021) | (0.018) | (0.023) |
| Distance to market | -0.000 | -0.000** | 0.000 | 0.000 | -0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Distance to road | 0.001 | 0.000 | -0.001 | -0.001 | -0.000 |
| | (0.001) | (0.000) | (0.001) | (0.001) | (0.001) |
| Tropical warm | 0.057 | 0.013 | 0.030 | -0.052 | -0.006 |
| | (0.043) | (0.020) | (0.036) | (0.033) | (0.034) |
| Constant | 11.862*** | 1.468*** | 6.867*** | 0.141 | 0.310 |
| | (1.191) | (0.568) | (0.989) | (0.891) | (0.949) |
| N | 2,418 | 2,412 | 2,400 | 2,418 | 2,418 |
| ll | -1855 | -127.9 | -1807 | -1495 | -1604 |

| | | | | | |
|---|---|---|---|---|---|
| Second stage F Stats. | 48.66 | 18.33 | 9.536 | 25.65 | 6.952 |
| P value for F Stat. | 0 | 0 | 0 | 0 | 0 |
| *Test for overidentification* | | | | | |
| Hansen's J Stat. | 0 | 0 | 0 | 0 | 0 |
| P value | . | . | . | . | . |
| *Test for underidentification* | 6.202 | 6.215 | 6.339 | 6.202 | 6.202 |
| Kleibergen-Paak LM Stat | | | | | |
| P value | 0.0128 | 0.0127 | 0.0118 | 0.0128 | 0.0128 |
| *Test for weak identification* | | | | | |
| Kleibergen-Paark F Stat | 6.093 | 6.108 | 6.226 | 6.093 | 6.093 |
| *Endogeneity test* | | | | | |
| Endogeneity Stat. | 0.686 | 1.190 | 0.694 | 0.921 | 0.615 |
| P value | 0.408 | 0.275 | 0.405 | 0.337 | 0.433 |

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. Standard errors in parentheses. Standard errors in parentheses. Columns 1-3 were estimated using 2SLS OLS with logarithmic transformation of dependent variables. Columns 4&5 were estimated using 2SLS linear probability model.

**Table A8**. Effects of paddy productivity on welfare – 2SLS

| Variable | Consumption expenditure | Dietary diversity | Caloric intake | Headcount | Food insecure |
|---|---|---|---|---|---|
| Ln paddy yield | -0.488 | -0.012 | -0.468 | 0.251 | 0.283 |
| | (0.297) | (0.070) | (0.296) | (0.154) | (0.189) |
| Household size | -0.063*** | -0.005 | -0.039*** | 0.048*** | 0.030*** |
| | (0.009) | (0.003) | (0.009) | (0.007) | (0.008) |
| Dependency ratio | -0.003 | 0.001 | -0.010 | -0.006 | 0.033 |
| | (0.024) | (0.007) | (0.031) | (0.018) | (0.021) |
| Gender | 0.031 | 0.012 | 0.020 | -0.023 | -0.042 |
| | (0.076) | (0.024) | (0.078) | (0.059) | (0.061) |
| Age | -0.004 | -0.001 | -0.006 | 0.003 | 0.001 |
| | (0.005) | (0.001) | (0.005) | (0.003) | (0.003) |
| Education | 0.183 | 0.080** | 0.147 | -0.077 | -0.079 |
| | (0.142) | (0.036) | (0.140) | (0.088) | (0.102) |
| Wage work | 0.093 | -0.007 | 0.091 | -0.065 | -0.135* |
| | (0.092) | (0.033) | (0.095) | (0.065) | (0.069) |
| Non-farm work | 0.070 | 0.016 | -0.066 | -0.046 | -0.031 |
| | (0.115) | (0.030) | (0.113) | (0.074) | (0.085) |
| Credit | -0.085 | 0.001 | -0.115 | 0.070 | 0.056 |
| | (0.104) | (0.031) | (0.115) | (0.078) | (0.095) |
| Remittance | -0.126 | -0.003 | -0.209** | 0.075 | 0.122* |
| | (0.099) | (0.031) | (0.096) | (0.069) | (0.072) |
| TLU | 0.020*** | 0.004*** | 0.018*** | -0.012*** | -0.013*** |
| | (0.005) | (0.001) | (0.005) | (0.003) | (0.004) |
| Asset index | 0.168*** | 0.059*** | 0.097** | -0.110*** | -0.068** |
| | (0.039) | (0.009) | (0.042) | (0.024) | (0.028) |
| Agric capital index | 0.089** | 0.002 | 0.100** | -0.087*** | -0.074* |
| | (0.043) | (0.012) | (0.045) | (0.031) | (0.041) |
| Erosion control | 0.031 | 0.002 | 0.049 | -0.050 | -0.012 |
| | (0.079) | (0.025) | (0.084) | (0.056) | (0.064) |
| Land area | -0.001 | 0.000 | -0.001 | -0.001 | -0.000 |
| | (0.003) | (0.001) | (0.003) | (0.002) | (0.002) |
| Extension | 0.221* | 0.036 | 0.154 | -0.115 | -0.057 |
| | (0.118) | (0.030) | (0.127) | (0.075) | (0.091) |
| Fisher price | 1.186 | 1.055** | 2.080 | -1.708 | -1.881 |
| | (1.980) | (0.532) | (2.001) | (1.182) | (1.441) |
| Agric wage EA | 0.057 | -0.010 | 0.090 | 0.010 | -0.053 |
| | (0.061) | (0.018) | (0.062) | (0.038) | (0.043) |
| Fertilizer price EA | -0.065 | 0.015 | -0.017 | 0.013 | 0.048 |
| | (0.074) | (0.012) | (0.080) | (0.046) | (0.053) |
| Distance to market | -0.001 | -0.000 | -0.001 | 0.001 | 0.001 |
| | (0.001) | (0.000) | (0.001) | (0.001) | (0.001) |
| Distance to road | -0.002 | 0.000 | -0.002 | 0.002* | 0.000 |
| | (0.002) | (0.000) | (0.002) | (0.001) | (0.001) |
| Tropical warm | 0.109 | 0.023 | 0.009 | -0.078 | 0.027 |
| | (0.070) | (0.023) | (0.068) | (0.051) | (0.057) |
| Constant | 14.257*** | 1.212*** | 9.364*** | -0.579 | -0.186 |
| | (1.547) | (0.397) | (1.605) | (1.037) | (1.170) |
| N | 486 | 484 | 484 | 486 | 486 |
| ll | -492.7 | 91.26 | -485.5 | -336.4 | -382.0 |

| | | | | | |
|---|---|---|---|---|---|
| Second stage F Stats. | 4.715 | 5.086 | 1.825 | 5.795 | 1.986 |
| P value for F Stat. | 0 | 0 | 0.0130 | 0 | 0.00522 |
| *Test for overidentification* | | | | | |
| Hansen's J Stat. | 2.974 | 1.141 | 3.168 | 0.332 | 1.581 |
| P value | 0.0846 | 0.285 | 0.0751 | 0.564 | 0.209 |
| *Test for underidentification* | | | | | |
| Kleibergen-Paak LM Stat | 11.07 | 10.71 | 10.71 | 11.07 | 11.07 |
| P value | 0.00394 | 0.00471 | 0.00471 | 0.00394 | 0.00394 |
| *Test for weak identification* | | | | | |
| Kleibergen-Paark F Stat | 4.779 | 4.630 | 4.630 | 4.779 | 4.779 |
| *Endogeneity test* | | | | | |
| Endogeneity Stat. | 6.495 | 0.0584 | 5.768 | 3.715 | 3.579 |
| P value | 0.0108 | 0.809 | 0.0163 | 0.0539 | 0.0585 |

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. Standard errors in parentheses. Standard errors in parentheses. Columns 1-3 were estimated using 2SLS OLS with logarithmic transformation of dependent variables. Columns 4&5 were estimated using 2SLS linear probability model.

**Table A9**. Effects of labor productivity on welfare – 2SLS

| Variable | Consumption expenditure | Dietary diversity | Caloric intake | Headcount | Food insecure |
|---|---|---|---|---|---|
| Ln labor productivity | -0.748 | 0.055* | 0.020 | -0.039 | -0.027 |
| | (3.527) | (0.030) | (0.059) | (0.051) | (0.055) |
| Household size | -0.123 | 0.005* | -0.046*** | 0.047*** | 0.032*** |
| | (0.202) | (0.002) | (0.005) | (0.004) | (0.004) |
| Dependency ratio | -0.065 | 0.007 | -0.044*** | 0.006 | 0.034*** |
| | (0.135) | (0.005) | (0.012) | (0.008) | (0.009) |
| Gender | -0.065 | 0.012 | 0.003 | 0.027 | -0.003 |
| | (0.222) | (0.011) | (0.022) | (0.020) | (0.021) |
| Age | -0.004 | -0.000 | 0.001 | -0.002** | -0.001 |
| | (0.027) | (0.000) | (0.001) | (0.001) | (0.001) |
| Education | 0.173 | 0.033 | 0.042 | -0.075** | -0.023 |
| | (0.287) | (0.024) | (0.046) | (0.032) | (0.039) |
| Wage work | -0.088 | -0.017 | -0.017 | 0.006 | 0.023 |
| | (0.409) | (0.014) | (0.027) | (0.023) | (0.024) |
| Non-farm work | 0.191* | 0.033*** | 0.063** | -0.108*** | -0.049** |
| | (0.102) | (0.013) | (0.027) | (0.021) | (0.024) |
| Credit | 0.102 | -0.002 | 0.024 | -0.044* | -0.038 |
| | (0.123) | (0.014) | (0.028) | (0.024) | (0.027) |
| Remittance | -0.035 | 0.028** | -0.004 | -0.041** | -0.009 |
| | (0.387) | (0.012) | (0.023) | (0.020) | (0.021) |
| TLU | 0.043 | 0.001 | 0.017*** | -0.012*** | -0.011*** |
| | (0.109) | (0.001) | (0.003) | (0.002) | (0.003) |
| Asset index | 0.233 | 0.054*** | 0.035*** | -0.075*** | -0.028*** |
| | (0.332) | (0.004) | (0.010) | (0.007) | (0.008) |
| Agric capital index | 0.121 | -0.008 | -0.003 | -0.012 | -0.006 |
| | (0.440) | (0.005) | (0.011) | (0.009) | (0.011) |
| Erosion control | 0.011 | 0.020 | -0.003 | -0.014 | 0.001 |
| | (0.070) | (0.013) | (0.025) | (0.022) | (0.024) |
| Land area | 0.012 | -0.001 | 0.003*** | -0.002** | -0.002** |
| | (0.043) | (0.000) | (0.001) | (0.001) | (0.001) |
| Extension | 0.195 | 0.025 | 0.005 | -0.032 | 0.037 |
| | (0.571) | (0.016) | (0.031) | (0.025) | (0.028) |
| Fisher price | 0.000 | -0.121 | -0.102 | 0.665** | 0.795** |
| | (0.000) | (0.194) | (0.384) | (0.328) | (0.350) |
| Agric wage EA | 0.101 | 0.005 | 0.011 | 0.009 | -0.007 |
| | (0.527) | (0.008) | (0.015) | (0.013) | (0.013) |
| Fertilizer price EA | -0.181 | 0.014 | 0.022 | -0.011 | 0.006 |
| | (0.797) | (0.012) | (0.024) | (0.019) | (0.021) |
| Distance to market | -0.000 | -0.000*** | -0.000 | 0.000 | -0.000 |
| | (0.001) | (0.000) | (0.000) | (0.000) | (0.000) |
| Distance to road | -0.001 | 0.000 | -0.001 | -0.001** | 0.000 |
| | (0.006) | (0.000) | (0.001) | (0.000) | (0.000) |
| Tropical warm | -0.054 | -0.002 | -0.006 | -0.023 | 0.028 |
| | (0.371) | (0.010) | (0.020) | (0.018) | (0.019) |
| Constant | 12.787*** | 2.032*** | 8.027*** | -0.535* | -0.620* |
| | (4.375) | (0.178) | (0.347) | (0.300) | (0.322) |
| N | 2,798 | 2,789 | 2,776 | 2,798 | 2,798 |
| ll | -4320 | -2.906 | -1942 | -1541 | -1728 |

| | | | | | |
|---|---|---|---|---|---|
| Second stage F Stats. | 12.09 | 25.70 | 13.29 | 35.86 | 9.648 |
| P value for F Stat. | 0 | 0 | 0 | 0 | 0 |
| *Test for overidentification* | | | | | |
| Hansen's J Stat. | 0 | 0 | 0 | 0 | 0 |
| P value | . | . | . | . | . |
| *Test for underidentification* | | | | | |
| Kleibergen-Paak LM Stat | 42.36 | 41.30 | 41.20 | 42.36 | 42.36 |
| P value | 7.60e-11 | 1.30e-10 | 1.38e-10 | 7.60e-11 | 7.60e-11 |
| *Test for weak identification* | | | | | |
| Kleibergen-Paark F Stat | 41.38 | 40.43 | 40.29 | 41.38 | 41.38 |
| *Endogeneity test* | | | | | |
| Endogeneity Stat. | 0.0245 | 2.530 | 0.0540 | 0.0571 | 0.00240 |
| P value | 0.876 | 0.112 | 0.816 | 0.811 | 0.961 |

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. Standard errors in parentheses. Standard errors in parentheses. Columns 1-3 were estimated using 2SLS OLS with logarithmic transformation of dependent variables. Columns 4&5 were estimated using 2SLS linear probability model.

**Table A10**. Effects of crop and labor productivity on composite welfare

| | Crop productivity | | | | Labor productivity | | | |
|---|---|---|---|---|---|---|---|---|
| Variable | Estimate | Category 0 | Category 1 | Category 2 | Estimate | Category 0 | Category 1 | Category 2 |
| Ln crop productivity | 0.161*** | -0.037*** | -0.018*** | 0.054*** | | | | |
| | (0.022) | (0.005) | (0.003) | (0.007) | | | | |
| Ln labor productivity | | | | | 0.070*** | -0.016*** | -0.008*** | 0.024*** |
| | | | | | (0.023) | (0.005) | (0.003) | (0.008) |
| Household size | -0.153*** | 0.035*** | 0.017*** | -0.052*** | -0.141*** | 0.033*** | 0.016*** | -0.049*** |
| | (0.019) | (0.004) | (0.002) | (0.006) | (0.018) | (0.004) | (0.002) | (0.006) |
| Dependency ratio | -0.039 | 0.009 | 0.004 | -0.013 | -0.031 | 0.007 | 0.004 | -0.011 |
| | (0.038) | (0.009) | (0.004) | (0.013) | (0.038) | (0.009) | (0.004) | (0.013) |
| Gender | 0.051 | -0.012 | -0.006 | 0.017 | 0.030 | -0.007 | -0.003 | 0.010 |
| | (0.139) | (0.032) | (0.015) | (0.047) | (0.137) | (0.032) | (0.015) | (0.047) |
| Age | -0.008* | 0.002* | 0.001* | -0.003* | -0.006 | 0.001 | 0.001 | -0.002 |
| | (0.004) | (0.001) | (0.000) | (0.002) | (0.004) | (0.001) | (0.001) | (0.002) |
| Education | -0.132 | 0.030 | 0.015 | -0.045 | -0.134 | 0.031 | 0.015 | -0.046 |
| | (0.260) | (0.059) | (0.029) | (0.088) | (0.251) | (0.058) | (0.028) | (0.086) |
| Wage work | -0.172 | 0.039 | 0.019 | -0.058 | -0.179 | 0.042 | 0.020 | -0.062 |
| | (0.117) | (0.027) | (0.013) | (0.040) | (0.116) | (0.027) | (0.013) | (0.040) |
| Non-farm work | 0.148 | -0.034 | -0.016 | 0.050 | 0.138 | -0.032 | -0.015 | 0.048 |
| | (0.128) | (0.029) | (0.014) | (0.043) | (0.124) | (0.029) | (0.014) | (0.043) |
| Credit | 0.193 | -0.044 | -0.021* | 0.065 | 0.208* | -0.048* | -0.023* | 0.071* |
| | (0.117) | (0.027) | (0.013) | (0.040) | (0.114) | (0.027) | (0.013) | (0.039) |
| Remittance | 0.216** | -0.049** | -0.024** | 0.073** | 0.228** | -0.053** | -0.025** | 0.078** |
| | (0.093) | (0.022) | (0.010) | (0.032) | (0.092) | (0.022) | (0.010) | (0.032) |
| TLU | 0.041*** | -0.009*** | -0.005*** | 0.014*** | 0.042*** | -0.010*** | -0.005*** | 0.014*** |
| | (0.010) | (0.002) | (0.001) | (0.004) | (0.011) | (0.003) | (0.001) | (0.004) |
| Asset index | 0.238*** | -0.054*** | -0.026*** | 0.081*** | 0.244*** | -0.057*** | -0.027*** | 0.084*** |
| | (0.051) | (0.012) | (0.006) | (0.017) | (0.050) | (0.012) | (0.006) | (0.017) |
| Agric capital index | 0.007 | -0.002 | -0.001 | 0.002 | 0.023 | -0.005 | -0.003 | 0.008 |
| | (0.046) | (0.010) | (0.005) | (0.016) | (0.046) | (0.011) | (0.005) | (0.016) |
| Erosion control | -0.071 | 0.016 | 0.008 | -0.024 | -0.068 | 0.016 | 0.008 | -0.023 |
| | (0.120) | (0.027) | (0.013) | (0.041) | (0.117) | (0.027) | (0.013) | (0.040) |
| Land area | 0.008** | -0.002** | -0.001** | 0.003** | 0.010** | -0.002** | -0.001** | 0.004** |
| | (0.004) | (0.001) | (0.000) | (0.001) | (0.004) | (0.001) | (0.000) | (0.001) |
| Extension | 0.003 | -0.001 | -0.000 | 0.001 | 0.032 | -0.007 | -0.004 | 0.011 |
| | (0.138) | (0.031) | (0.015) | (0.047) | (0.134) | (0.031) | (0.015) | (0.046) |
| Fisher price | -3.095* | 0.706* | 0.343* | -1.048* | -3.912** | 0.907** | 0.437** | -1.345** |
| | (1.782) | (0.409) | (0.196) | (0.604) | (1.764) | (0.412) | (0.196) | (0.606) |
| Agric wage EA | 0.041 | -0.009 | -0.005 | 0.014 | 0.021 | -0.005 | -0.002 | 0.007 |
| | (0.059) | (0.014) | (0.007) | (0.020) | (0.059) | (0.014) | (0.007) | (0.020) |
| Fertilizer price EA | -0.054 | 0.012 | 0.006 | -0.018 | -0.064 | 0.015 | 0.007 | -0.022 |
| | (0.126) | (0.029) | (0.014) | (0.043) | (0.123) | (0.028) | (0.014) | (0.042) |
| Distance to market | 0.008 | -0.002 | -0.001 | 0.003 | 0.007 | -0.002 | -0.001 | 0.002 |
| | (0.006) | (0.001) | (0.001) | (0.002) | (0.006) | (0.001) | (0.001) | (0.002) |
| Distance to road | -0.033*** | 0.007*** | 0.004*** | -0.011*** | -0.030*** | 0.007*** | 0.003*** | -0.010*** |
| | (0.011) | (0.002) | (0.001) | (0.004) | (0.011) | (0.002) | (0.001) | (0.004) |
| Tropical warm | 0.082 | -0.019 | -0.009 | 0.028 | 0.056 | -0.013 | -0.006 | 0.019 |
| | (0.303) | (0.069) | (0.034) | (0.103) | (0.308) | (0.071) | (0.034) | (0.106) |
| /cut1 | 0.553 | | | | -1.400 | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (1.707) | | | | (1.702) | | | |
| /cut2 | 1.393 | | | | -0.573 | | | |
| | (1.708) | | | | (1.702) | | | |
| | | | | | | | | |
| N | 2,800 | 2,800 | 2,800 | 2,800 | 2,799 | 2,799 | 2,799 | 2,799 |

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. Category 0 = Poor and food insecure; category 1 = non-poor and food insecure or poor and food secured; category 2 = non-poor and food secure. Estimated using Mundlak (1978) approach. The results represent the marginal effects of the probability of being in a given category.

**Table A11**. Effects of maize and paddy productivity on composite welfare

| | Maize yield | | | | Paddy yield | | | |
|---|---|---|---|---|---|---|---|---|
| Variable | Estimate | Category 0 | Category 1 | Category 2 | Estimate | Category 0 | Category 1 | Category 2 |
| Ln maize yield | 0.088** | -0.020** | -0.010** | 0.030** | | | | |
| | (0.035) | (0.008) | (0.004) | (0.012) | | | | |
| Ln paddy yield | | | | | 0.083 | -0.018 | -0.008 | 0.026 |
| | | | | | (0.062) | (0.014) | (0.005) | (0.019) |
| Household size | -0.134*** | 0.031*** | 0.015*** | -0.046*** | -0.152*** | 0.033*** | 0.014*** | -0.047*** |
| | (0.018) | (0.004) | (0.002) | (0.006) | (0.038) | (0.008) | (0.004) | (0.011) |
| Dependency ratio | -0.016 | 0.004 | 0.002 | -0.005 | -0.069 | 0.015 | 0.006 | -0.021 |
| | (0.040) | (0.009) | (0.004) | (0.014) | (0.092) | (0.020) | (0.008) | (0.028) |
| Gender | 0.033 | -0.008 | -0.004 | 0.011 | -0.038 | 0.008 | 0.004 | -0.012 |
| | (0.147) | (0.034) | (0.016) | (0.050) | (0.385) | (0.083) | (0.036) | (0.119) |
| Age | -0.005 | 0.001 | 0.001 | -0.002 | -0.023 | 0.005 | 0.002* | -0.007 |
| | (0.004) | (0.001) | (0.000) | (0.001) | (0.014) | (0.003) | (0.001) | (0.004) |
| Education | -0.213 | 0.050 | 0.023 | -0.073 | -1.401*** | 0.303*** | 0.131*** | -0.433*** |
| | (0.284) | (0.066) | (0.031) | (0.097) | (0.482) | (0.105) | (0.041) | (0.140) |
| Wage work | -0.118 | 0.027 | 0.013 | -0.040 | -0.001 | 0.000 | 0.000 | -0.000 |
| | (0.123) | (0.028) | (0.013) | (0.042) | (0.271) | (0.058) | (0.025) | (0.084) |
| Non-farm work | 0.124 | -0.029 | -0.014 | 0.043 | 0.110 | -0.024 | -0.010 | 0.034 |
| | (0.137) | (0.032) | (0.015) | (0.047) | (0.244) | (0.053) | (0.023) | (0.076) |
| Credit | 0.272** | -0.063** | -0.030** | 0.093** | -0.387 | 0.084 | 0.036 | -0.120 |
| | (0.128) | (0.030) | (0.014) | (0.043) | (0.299) | (0.066) | (0.025) | (0.091) |
| Remittance | 0.262*** | -0.061** | -0.029*** | 0.090*** | 0.062 | -0.013 | -0.006 | 0.019 |
| | (0.100) | (0.023) | (0.011) | (0.034) | (0.217) | (0.047) | (0.020) | (0.067) |
| TLU | 0.040*** | -0.009*** | -0.004*** | 0.014*** | 0.047* | -0.010* | -0.004* | 0.014* |
| | (0.011) | (0.003) | (0.001) | (0.004) | (0.026) | (0.005) | (0.003) | (0.008) |
| Asset index | 0.250*** | -0.058*** | -0.027*** | 0.085*** | 0.335** | -0.072** | -0.031** | 0.104** |
| | (0.056) | (0.013) | (0.006) | (0.019) | (0.132) | (0.029) | (0.012) | (0.040) |
| Agric capital index | 0.022 | -0.005 | -0.002 | 0.008 | 0.285*** | -0.062** | -0.027*** | 0.088*** |
| | (0.047) | (0.011) | (0.005) | (0.016) | (0.105) | (0.024) | (0.009) | (0.032) |
| Erosion control | -0.152 | 0.035 | 0.017 | -0.052 | 0.323 | -0.070 | -0.030 | 0.100 |
| | (0.119) | (0.028) | (0.013) | (0.041) | (0.208) | (0.045) | (0.019) | (0.064) |
| Land area | 0.011** | -0.003** | -0.001** | 0.004** | 0.008 | -0.002 | -0.001 | 0.002 |
| | (0.004) | (0.001) | (0.000) | (0.001) | (0.007) | (0.001) | (0.001) | (0.002) |
| Extension | 0.007 | -0.002 | -0.001 | 0.002 | 0.040 | -0.009 | -0.004 | 0.012 |
| | (0.144) | (0.033) | (0.016) | (0.049) | (0.302) | (0.065) | (0.028) | (0.093) |
| Fisher price | -4.149** | 0.963** | 0.455** | -1.418** | -2.728 | 0.589 | 0.255 | -0.844 |
| | (1.814) | (0.425) | (0.196) | (0.618) | (6.518) | (1.401) | (0.620) | (2.019) |
| Agric wage EA | 0.017 | -0.004 | -0.002 | 0.006 | -0.060 | 0.013 | 0.006 | -0.018 |
| | (0.061) | (0.014) | (0.007) | (0.021) | (0.141) | (0.031) | (0.013) | (0.044) |
| Fertilizer price EA | -0.052 | 0.012 | 0.006 | -0.018 | 0.405* | -0.087** | -0.038* | 0.125** |
| | (0.132) | (0.030) | (0.014) | (0.045) | (0.207) | (0.043) | (0.020) | (0.063) |
| Distance to market | 0.001 | -0.000 | -0.000 | 0.001 | 0.002 | -0.000 | -0.000 | 0.001 |
| | (0.005) | (0.001) | (0.001) | (0.002) | (0.011) | (0.002) | (0.001) | (0.003) |
| Distance to road | -0.031*** | 0.007*** | 0.003*** | -0.011*** | 0.002 | -0.000 | -0.000 | 0.001 |
| | (0.011) | (0.003) | (0.001) | (0.004) | (0.026) | (0.006) | (0.002) | (0.008) |
| Tropical warm | 0.001 | -0.000 | -0.000 | 0.000 | 0.344 | -0.074 | -0.032 | 0.107 |
| | (0.309) | (0.072) | (0.034) | (0.106) | (0.427) | (0.092) | (0.040) | (0.131) |
| /cut1 | -1.767 | | | | 7.190** | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (1.859) | | | | (2.855) | | | |
| /cut2 | -0.959 | | | | 8.075*** | | | |
| | (1.860) | | | | (2.864) | | | |
| N | 2,418 | 2,418 | 2,418 | 2,418 | 486 | 486 | 486 | 486 |

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. Category 0 = Poor and food insecure; category 1 = non-poor and food insecure or poor and food secured; category 2 = non-poor and food secure. Estimated using Mundlak (1978) approach. The results represent the marginal effects of the probability of being in a given category.