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Timor-Leste Poverty

Making Agriculture Work for the Poor in Timor-Leste

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Abstract

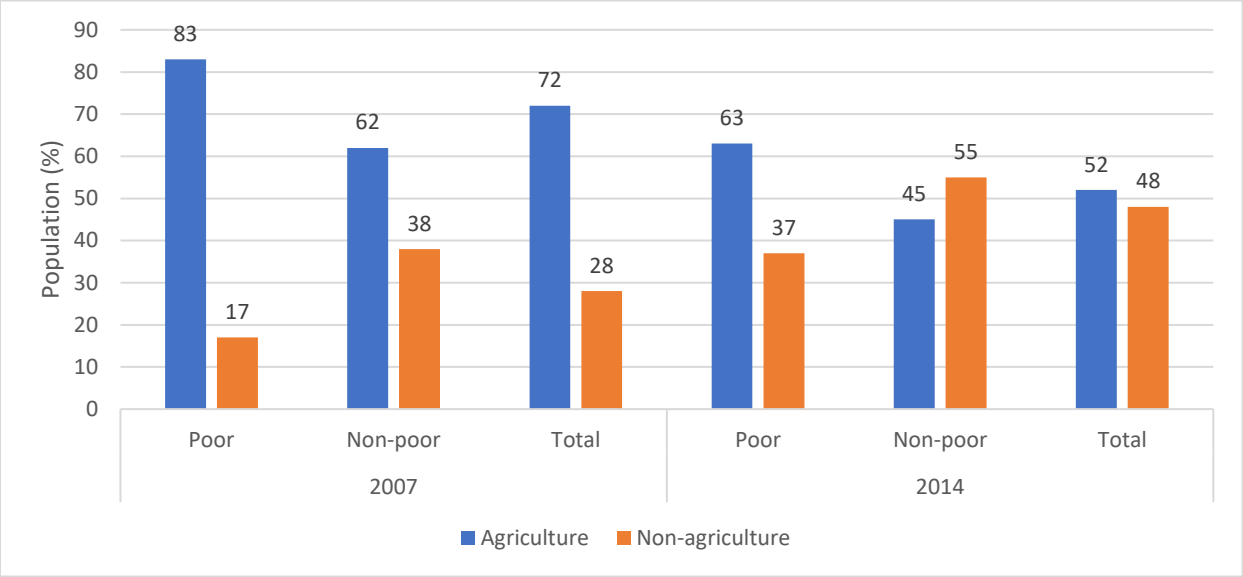
About 80 percent of the poor households in Timor-Leste live in rural areas and are dependent on agriculture for their livelihood. It is therefore widely acknowledged that growth in the agriculture sector is an important channel through which poverty can be reduced in the country. That notwithstanding, the country's agricultural production system is one of the least developed in the world and all subsectors are dominated by subsistence systems and by farmers who are very risk averse. Agricultural productivity in the country is also well below that of other small island developing states and has fallen below the average for other low-income, food-deficit countries in recent years making the sector underperform in terms of its contribution to food security, sufficient livelihood, and overall economic growth.

Using data from the 2007 and 2014 of the Timor-Leste Survey of Living Standards, the note provides insight into the extent to which increases in agricultural productivity can contribute to poverty reduction, including assessing the drivers of, and identifying the constraints to, increasing agricultural productivity in the country. The note finds that improvements in agricultural productivity reduce the probability of being poor among agricultural households. Yet, improving productivity goes beyond the confines of raising yield or decreasing cost to include enhancing food quality and promoting higher value products. To do so, the following factors ought to be considered: facilitation of mechanization, improvement in the use of chemical (fertilizer, pesticides, and herbicides) inputs, enhancement in access to credit and extension, encouragement to farmers to join farmer groups, expansion of the commercialization of farm produce, and reduction in the gender gap in agricultural productivity. Investment in the sector can be improved by allocating the limited public funds more strategically and better correspond with local poverty. The findings from this study contribute to existing evidence pertinent to guide how agricultural policy can effectively help reducing poverty in the country.

1. Introduction

Agriculture remains the main economic activity in Timor-Leste. The sector provides subsistence to a majority (72 percent in 2007, 52 percent in 2014, Figure 1) of the population, and accounts for over 90 percent of total exports (mainly coffee).[1] Yet it represents only 11.4 percent of the GDP. Given the number of people employed in the sector, this suggests that most farmers in the country remain locked in low-productivity, subsistence agriculture.

Figure 1: Distribution of the population by poverty status and sector, 2007–2014



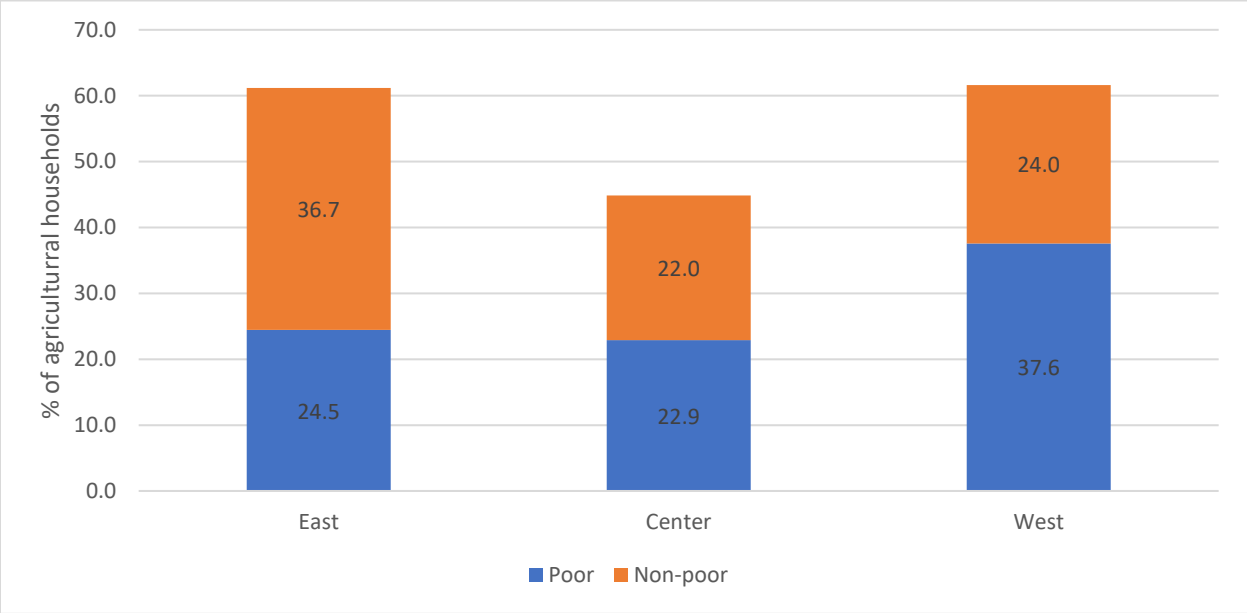
Source: 2007 and 2014 Timor-Leste Survey of Living Standards

A majority (83 percent in 2007, 63 percent in 2014) of the poor depend on agriculture for their livelihood (Figure 1). Across the three regions of the country, agricultural households tend to be concentrated in the west and east (61 percent in 2014), and among agricultural households, poverty tends to be more prevalent in the west than in the east or the center (Figure 2). Because most of the poor depends on agriculture, the sector is widely regarded as a major channel through which poverty can be reduced in Timor-Leste. This notion is supported by historical evidence that agriculture has played an integral role in successful poverty reduction elsewhere in Asia, and that growth in agriculture tends to be more beneficial to the poor than growth in other sectors of agrarian, developing economies (DFID 2004). In Myanmar, growth of the agriculture sector accounted for at least 46 percent of the poverty reduction seen between 2005 and 2015, much of which was achieved by enhanced productivity and crop diversification (World Bank, 2019). The Cambodia experience also shows that a 10 percent increase in agricultural land productivity reduces the head count poverty rate by one percentage point (World Bank, 2019). Experiences from Thailand show that agricultural competitiveness is key to support the development of the

[1] Fanzo and Bonis-Profumo (2017) provide a detailed overview of the kinds of crops produced and the nature of employment in Timor-Leste.

sector, which requires sound and consistent macroeconomic policies, including an open agricultural trade policy that encourages private investment, and investments in public goods that encourage productivity growth (World Bank, 2019).

Figure 2: Poverty among agricultural households in 2014



Source: 2014 Timor-Leste Survey of Living Standards

Timor-Leste has one of the least developed agricultural production systems in the world. All subsectors are dominated by subsistence systems and by farmers who are very risk averse (Denning 2013; World Bank 2017). Only 30 percent of the country's arable land is currently under crop production and grazing, and the sector's productivity has been very low. Agricultural productivity as measured by the value of crop output per hectare in Timor-Leste is well below that of other small island developing states and has fallen below the average for other low-income, food-deficit countries in recent years (Figure 3a). Also, agriculture value added per worker has been falling since 2012 (Figure 3b). The estimated 64,000 metric tons of maize and 65,000 metric tons of rice produced in 2015 are 30 percent below the five-year average and well below the country's estimated requirements (245,000 metric tons) of these staples (FAO statistics). The country's cereal yield is also among the lowest in the East Asia and Pacific region (UN Women and World Bank 2018). The agriculture sector is underperforming in terms of its contribution to food security, sufficient livelihood, and overall economic growth. Therefore, the development of the agriculture sector is an important part of the structural transformation of the economy.

Figure 3a: Value of Crop Output per ha

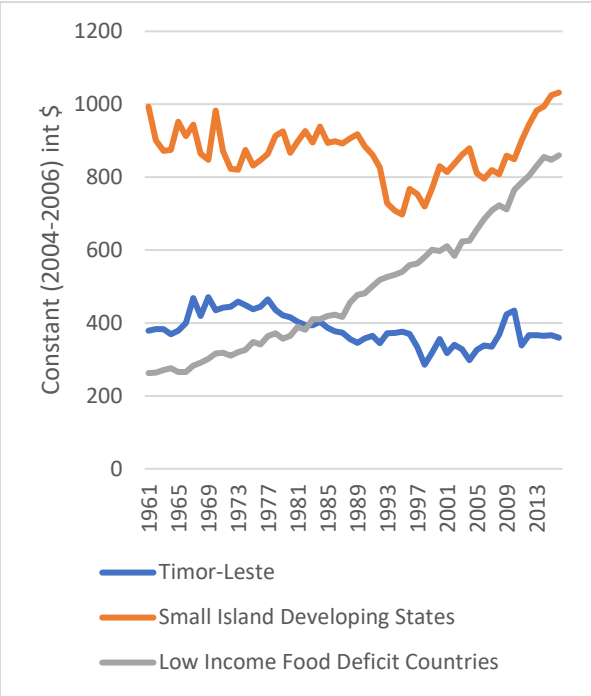
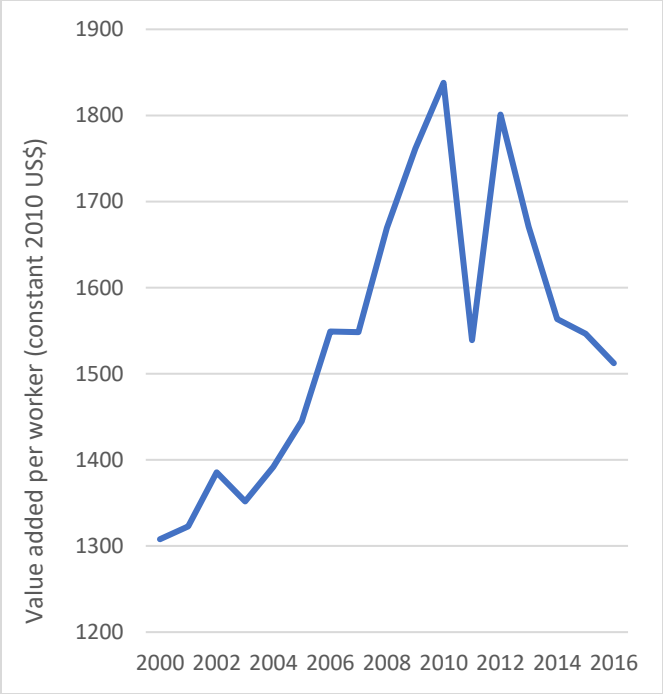


Figure 3b: Agriculture value added per worker



Source: FAOSTAT

This note uses data from the 2007 and 2014 waves of the Timor-Leste Survey of Living Standards to address the following questions: To what extent does agricultural productivity affect poverty? What are the drivers of agricultural productivity? What are the constraints involved in increasing agricultural productivity? What can be done to increase agricultural productivity? These questions are in line with the country's Strategic Development Plan 2011–2030 (SDP), which highlights the relevance of agriculture for poverty alleviation, economic diversification, employment, and economic growth. In committing to deliver this SDP, the Ministry of Agriculture and Fisheries developed the Strategic Plan 2014–2020, that seeks to support the transition from subsistence to commercial agriculture, improve rural incomes and livelihoods, and reduce poverty. Thus, answers to these aforementioned questions will provide guidance on how agricultural policy can help reduce poverty in the country.

Agricultural productivity affects poverty levels both directly through the *"food and income" pathway*[2] and indirectly through the *"wage" pathway*.[3] Since hired farm labor is usually supplied by poor households, an increase in wages is likely to increase the incomes of poor households and,

[2] De Janvry and Sadoulet (1996), Acharya and Sophal (2002), and Hazell et al. (1991) provide evidence of the "food and income" pathway to increase the availability of food and household incomes. De Janvry and Sadoulet (1996) observe that a 1 percent increase in total factor productivity (a measure of agricultural productivity) produces a 0.5 percent increase in the income levels of smallholder farmers in Asia.

[3] Agricultural expansion usually increases the amount of land under cultivation, the intensity of cultivation, and/or the frequency of cropping, which in turn increases the demand for hired farm labor (Hayami and Ruttan 1985; Lipton and Longhurst 1989; Irz et al. 2001) that helps drive up wages.

thus, their welfare.[4] Agriculture can help reduce poverty through two additional indirect channels. The first channel is the *"food price" pathway*.[5] Increases in agricultural output supply can drive down food prices. Since many poor households are net food buyers and spend a substantial part of their income on food, reduced food prices improve their poverty and food security status (Darko et al., 2018). Second, improvements in agricultural output may indirectly affect households' welfare through the *"non-farm sector" pathway*. Growth in agricultural productivity provides a significant proportion of the raw materials used in Timor-Leste's non-farm sector. The increase in incomes resulting from a growth in agricultural productivity could raise the demand for goods and services produced in the non-farm sector. This escalating demand could in turn stimulate employment in the non-farm sector through forward and backward linkages, and eventually increase off-farm household incomes (Hanmer and Naschold 2000; Mellor 1999).

2. Data and Methodology

The study uses nationally representative data from the 2007 and 2014 waves of the Timor-Leste Survey of Living Standards. The surveys, which each spanned over a 12-month period of data collection, are very comprehensive and covering the following subjects: demographics, housing, access to facilities, durable goods, education, health, employment, social capital, and subjective well-being. In all, 4,477 and 5,916 households were covered in 2007 and 2014 respectively, out of which 72 percent in 2007 and 52 percent in 2014 were agricultural households. The analyses in this policy note focused on the agricultural households. Since only sub-group of population are included in the analyses, the two cross-sectional surveys are therefore pooled to increase the sample size in hopes of improving precision of the estimates.

To answer the question on the extent to which agricultural productivity affect poverty, the analyses are conducted using five measures of poverty: whether or not a household is poor (i.e. poor/non-poor based on the national poverty line), per capita annual consumption expenditure, poverty gap, poverty severity, and relative deprivation in terms of per capita consumption expenditure. Agricultural productivity is measured here as the monetary value of all crops produced by the household per hectare of land cultivated ($/ha).[6] This measure allows productivity to be estimated in terms of all crops produced by the household. For a given household, this measure is computed as follows: (1) multiply the output harvested of each cultivated crop by the price of the crop, (2) sum the values of all crops cultivated, and (3) divide by the total hectares of land cultivated. This

[4] Datt and Ravallion (1998), for instance, find that higher real wages resulting from increases in agricultural productivity helped reduce absolute poverty levels in India. Also in India, Saxena and Farrington (2003) report that agricultural labor wages rose by 3 percent per annum following an increase in agricultural productivity during the 1970s and 1980s.

[5] Otsuka (2000) and Biswanger and Quinzon (1986) observe that much of the positive impact of Asia's green revolution in technology on inequality and poverty resulted from lower food prices accruing from output expansion. Schuh (2000) also suggests that world agriculture's greatest achievement in the fight against poverty came via the supply of affordable food to the masses.

[6] Several other studies have measured agricultural productivity in this way, including UN Women and World Bank (2018), Darko et al. (2018), Dzanku et al. (2015) and Oseni et al. (2014). Like other measures, this measure of productivity, is not without shortcomings: apart from land, it does not account for any other inputs used in crop production.

approach was used because the data available for this study does not permit the measurement of productivity in terms of yield, labor, or total factor productivity.

The crop prices used in estimating agricultural productivity are mean "cluster" level prices. "Cluster" is the survey unit used in administering the questionnaires, with each "cluster" containing 12-15 households. The "cluster" level mean prices are used because we assume that households within the same "cluster" faced the same price for each crop. This assumption is plausible because the data was collected from households within a "cluster" at the same time. A similar assumption has been made in the literature (Deaton 1988; Hoang, 2018, Darko et al., 2018).

Depending on the poverty indicator used, the effect of agricultural expenditure on poverty and welfare is estimated using a logit estimator, ordinary least squares (OLS) estimator, a two-part estimator, or ordered-probit estimator. The household logit estimator is used when poverty is measured with a binary indicator (1 = poor; 0 otherwise); OLS is used when poverty is measured by per capita annual consumption expenditure and relative deprivation in terms of consumption expenditure; and the two-part estimator is used when it is measured using either poverty gap or poverty severity. The first part of the two-part estimator estimates the probability of being poor using a logit estimator, while the second part estimates the extent of poverty conditional on being poor using the fractional logit estimator (Belotti and Manning, 2015).

To understand the drivers of agricultural productivity, exploratory analyses are used to identify the constraints to increasing agricultural productivity. A simple household-level OLS specification is used to assess the determinants of agricultural productivity. The detailed methodology used in the analyses is described in Appendix B.

3. Results

Impact of Agricultural Productivity on Poverty

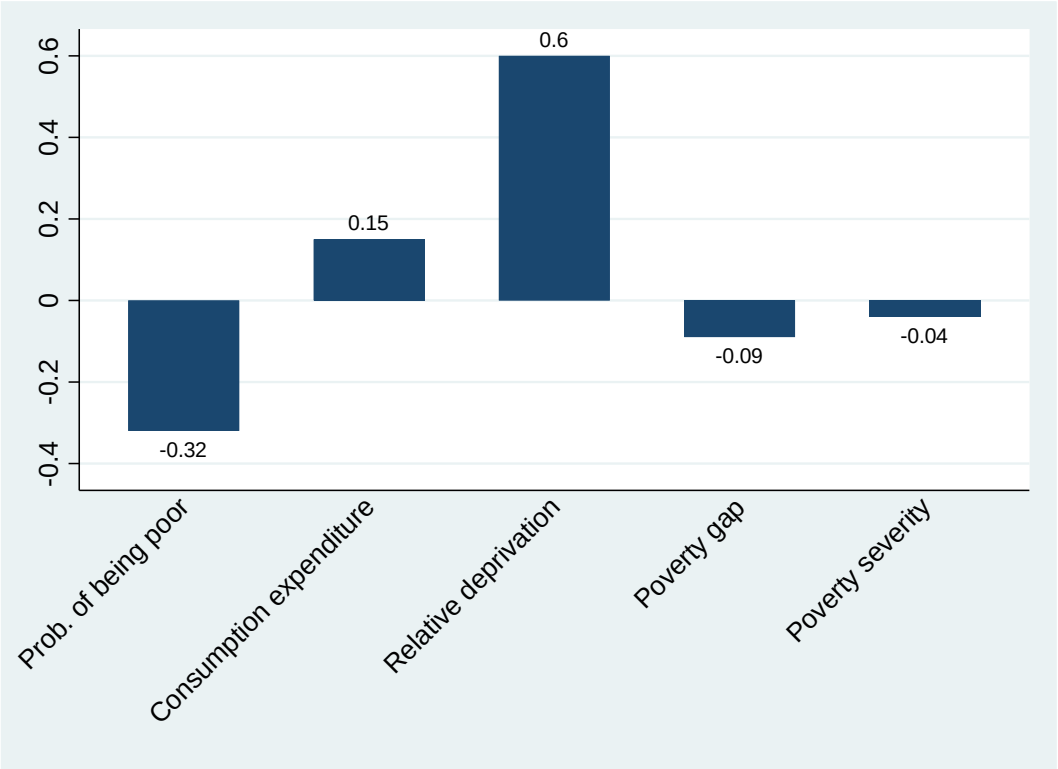
Descriptive statistics of the key variables are presented in Table 1 in Appendix A. Figure 4 presents the summary results of the analyses of the effect of agricultural productivity on poverty (see Table 2 in Appendix A for detailed results). The results indicate that agricultural productivity has the expected, significant inverse relationship with all the measures of poverty. All else being equal, a 10 percent increase in agricultural productivity reduces the probability of being poor by 0.32 percent, increases per capita consumption expenditure by 0.15 percent, reduces the poverty gap by 0.09 percentage points, reduces the severity of poverty by 0.04 percentage points, and increases relative deprivation by 0.6 percent.

Several other factors—including education, livestock ownership, the amount of cultivated land, household size, area of residence, and gender—affect the likelihood that agricultural households will be poor. Household heads with pre-secondary or secondary education are 0.11 percent and 0.21 percent less likely to be poor, respectively, than those with no education. Livestock-owning households are 0.2 percent less likely to be poor than those with no livestock. A 10 percent increase in the area of land cultivated reduces the probability of being poor by 0.31 percent. An increase in the household size by one person increases the probability of being poor by 0.13 percent. In addition, residing in the west and central parts of the country increases the probability of being

poor by 0.34 and 0.14 percent, respectively, compared to residing in the east, and residents of urban areas are 0.11 percent less likely to be poor than rural residents. Female-headed households (FHHs) are 0.1 percent less likely to be poor than male-headed households (MHHs).

The direction of the effect of agricultural productivity on the poverty measures supports the widely held notion that improving agricultural productivity could be an effective channel for poverty reduction. A similar significant, inverse relationship between agricultural productivity and poverty has been found in other developing agrarian countries like Malawi, Nigeria, Ghana, and Tanzania (Darko et al. 2018; Oseni et al. 2014; Dzanku 2015; Sarris et al. 2006).

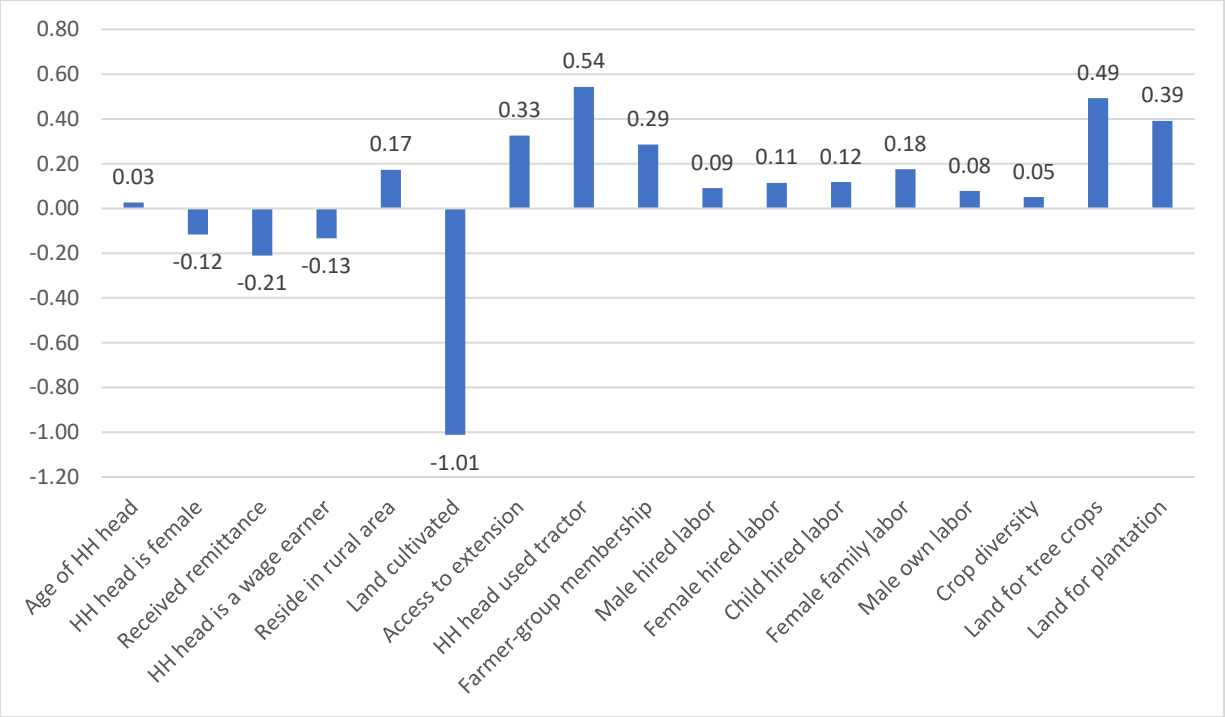
Figure 4: Effect of Agricultural Productivity on Poverty and Welfare



Determinants of (and Constraints to Increasing) Agricultural Productivity

Agricultural productivity has been low in Timor-Leste—only $6,649/ha in 2014. This section examines the determinants of agricultural productivity and identifies factors that limit it in order to identify channels through which it can be increased. The empirical estimates indicate that agricultural productivity is influenced by the amount of land under cultivation, the share of cultivated land allocated to tree crops and plantation, access to agricultural extension service, age of household head, mechanization, crop diversification, having other sources of income, and amount of hired and family labor (Figure 5 and Table 3 of Appendix A).

Figure 5: Determinants of Agricultural Productivity



While access to extension services increases agricultural productivity by 33 percent, only a few households have such access in Timor-Leste. In 2014, only about 5 percent of agricultural households had access to extension services, and the poor and FHHs had lower access than their non-poor and male-headed counterparts. Across regions, access is higher in the east (9 percent) than in the west (2 percent) and center (2 percent).

Agricultural mechanization also increases productivity. The estimates indicate that using a tractor in crop production increases productivity by 54 percent. However, less 10 percent of agricultural households used (either owned or rented) tractors and other mechanized equipment in crop cultivation in either 2007 or 2014. These findings reveal that the thousands of free tractors that were handed out as part of the 2009–10 Ministry of Agriculture and Fisheries mechanization policy could not be maintained. In general, the low use of mechanized inputs was more pronounced among poor and FHHs than among their non-poor and male-headed counterparts in both 2007 and 2014. In 2014, farmers residing in the west used more mechanized inputs (15 percent) than those in the east (7 percent) or center (2 percent). The low level of mechanization could be due to the lack of operational and maintenance skills, and the lack of market incentives to entice farmers to increase outputs (World Bank 2017).

Labor utilization (both hired and family labor) has a positive effect on agricultural productivity, since agricultural workers are needed to weed, mulch, fertilize, and control pests in order to increase yields. All else being equal, a one-percentage increase in the hours of labor increases agricultural productivity by 8 - 12 percent depending on the kind of labor.

Crop diversity and the share of cultivated land allocated to tree crops and plantations significantly affect agricultural productivity. Cultivating one additional crop increases agricultural productivity by 5 percent, and a one-percentage increase in the share of cultivated land allocated to high-value tree crops and plantations increases agricultural productivity by 49 percent and 39 percent respectively.

The estimates also indicate that a one-percentage increase in the area of land cultivated decreases agricultural productivity by 1.0 percent, indicating that households with larger farms are less productive. This lends credence to the common inverse relationship found between land size and productivity in the literature, which has been attributed to larger farms being worked less intensively (Carletto et al. 2013).

Having other sources of income and belonging to a farmer group both affect agricultural productivity. Households that receive remittances and off-farm wages have lower levels of agricultural productivity, perhaps due to a reduced incentive to invest in agriculture and less time available to spend on their farms. Membership in a farmer group increases agricultural productivity by 29 percent, likely because such groups exchange useful information about crop production and share mechanized inputs.

The estimates further indicate that FHHs are 12 percent less productive than MHHs. This finding echoes the pattern found by the UN and World Bank (2018) in Timor-Leste and by Kilic et al. (2013) in many other developing agrarian countries. UN Women and the World Bank (2018) estimated that the gender gap in agricultural productivity is 15 percent in Timor-Leste; 97 percent of the gender differential in productivity was attributed to the observation that females owned fewer less resources than males. As indicated above, FHHs have relatively limited access to mechanized inputs and extension services. There are also gender differences in access to the means of production (land, credit, technical advice and information, and government-provided inputs) (World Bank 2017). The gender gap may also be partly due to the fact that women tend to focus more on post-harvest operations including crop processing, storage, seed selection, and produce sale (World Bank 2017).

Among poor households, ownership of livestock increases agricultural productivity by 16.5 percent. This positive relationship between livestock ownership and agricultural productivity is potentially due to increase in capital as livestock is a source of income. Therefore, ownership of livestock increases the likelihood of households purchasing and using fertilizer and other modern inputs in crop production.

The age of the household head and region of residence also affect agricultural productivity. A one-year increase in the age of the household head increases productivity by 3 percent, likely due to having more experience in crop production. Rural households are also 17 percent more productive than urban households, probably because of the better-quality agricultural land available in rural areas.

Other Constraints to Increasing Agricultural Production and Productivity

In addition to the factors discussed above, the exploratory analyses indicate that agricultural production in Timor-Leste faces the following constraints:

1. *Size of landholding.* The estimates indicate that, on average, the total land per household available for crop production is very small – 0.48 ha in 2007 and 0.68 ha in 2014[7]. Such small landholdings limit the extent to which production can be improved through extensification (increase in land under cultivation).

   Non-poor and male-headed households own more land than their poor and female counterparts. Non-poor households cultivated about 9.3 percent and 15.9 percent more land than poor households in 2014 and 2007, respectively. MHHs cultivated 34.6 percent more land in 2014 and 108 percent more land in 2007 than FHHs. In 2007, agricultural households in the center of the country cultivated 47 percent and 450 percent more land than those in the east and west, respectively. In 2014 however, households in the east cultivated the most land—36 percent and 84 percent more than those in the center and west, respectively.

   Yet given the inverse relationship between farm size and agricultural productivity, larger farms, unless well managed, might not necessarily lead to higher production.

2. *Agricultural commercialization.* The ease with, and extent to, which farmers are able to sell their produce in the market has important implications for productivity. Because farmgate prices are generally lower than market prices, the higher the access to markets, the better their level of productivity. And because of transportation costs, the closer markets are to farmers, the higher the level of productivity.

   Only 47 percent and 32 percent of households sold farm produce in 2014 and 2007, respectively; among the households that sold farm produce, the average share of production value that was marketed was 10.2 – 47.1 percent in 2014 and 5.3 to 32.8 percent in 2007. This low level of commercialization is likely to be caused by two factors: (1) access to markets and (2) the subsistence nature of production. Among households that sold agricultural produce, about 65 percent of them sold in a market but had to travel a long distance (6 km, on average) to access a market. Among households that did not sell their produce, 61 percent indicated that they had nothing to sell and 33 percent indicated that markets were too far. Physical impediments due to poor infrastructure make it harder for farming households to market their produce (World Bank 2017). On average, just under half of all households in the country are accessible by compacted or sealed roads. The country's transportation system is also affected by heavy rainfall that renders a significant proportion of the roads inaccessible. Non-poor households are more likely to commercialize than poor households. The estimates also show that commercialization is highest in the west (49 percent) followed by the center (46 percent) and east (44 percent).

[7] The increase in landholdings from 0.48 ha in 2007 to 0.68 ha in 2014 could be due to a potential redistribution of land resulting from the decline in number of agricultural households from 72 percent in 2007 to 52 percent in 2014 (see figure 2).

3. *Access to credit.* There is very little access to credit for agricultural production, given the absence of collateral to qualify for conventional credit and micro-credit schemes. Fewer than one percent of agricultural households have accessed credit to purchase agricultural inputs and land. Since most farmers in Timor-Leste are poor, the limited access to credit could compromise their ability to purchase important inputs for crop production. This could explain why the use of fertilizer, pesticides, and mechanized inputs is very low, particularly among poor households.

4. *Access to chemical inputs.* The use of inorganic and organic fertilizers, pesticides, and herbicides in crop production is very low, primarily due to the high cost and/or low interest in using the input, as well as low market penetration (World Bank 2017). Only about 15 percent and 11 percent of households used these inputs in crop production in 2007 and 2014, respectively. Utilization of these inputs is very important for increasing agricultural productivity.

5. *Irrigation.* Only 7 percent of households use irrigation in crop production, likely due in part to the 1999 clashes that resulted in extensive destruction of infrastructure including roads and irrigation systems. Hence water availability is a chronic problem in most parts of Timor-Leste. Given the importance of irrigation for crop production, its limited use hampers agricultural production. The use of irrigation is lowest in the east (2 percent), followed by the center (6 percent) and the west (12 percent).

6. *Soil conditions.* Timor-Leste has poor topsoil, and almost half of the country's terrain is very steeply sloped, resulting in high levels of land degradation, soil erosion, and changes in land use that affect agriculture (World Bank 2017). As such, only a quarter of the country's land is suitable for agriculture (World Bank 2017). Other factors that contribute to land degradation include deforestation, inappropriate agricultural practices, forest fires, over-grazing, and demographic pressures (World Bank 2017)

7. *Low investment in the agriculture sector*. The level of public investment in agriculture is low given the sector's contribution to non-oil GDP. Coffee is the most important cash crop and export commodity and is grown by a significant proportion of the population who are mostly poor, and with extremely low outputs; yet public investment in the industry's development is negligible and do not correspond with local poverty levels (World Bank 2017). For example, while Ermera is the leading coffee producing and second poorest municipality, yet the municipality receives the lowest per capita level of public investment.

   The government has heavily invested in rehabilitating the irrigation infrastructure to increase rice production, but irrigation use remains low. Poor coordination across government ministries has resulted in double subsidies of both demand and supply, which generates negative incentives for farmers to produce commercially (World Bank 2017).

4. Conclusions and Policy Recommendations

The analyses provide insight into the extent to which increases in agricultural productivity can contribute to poverty reduction, and the determinants of and constraints to increasing agricultural productivity in Timor-Leste. Improvements in agricultural productivity are found to reduce the probability of being poor among agricultural households, and agricultural productivity is significantly determined by the area of land under cultivation, share of cultivated land allocated to tree crops and plantation, access to extension services, age and gender of household head, mechanization, crop diversification, and access to other sources of income and labor. Production is found to be impeded by small landholdings; low levels of commercialization; limited access to credit, chemical inputs, and irrigation; poor soil, and low levels of investment in the sector.

Thus in order for agriculture to help lift the poor out of poverty, enhance food security, and provide sufficient livelihoods in Timor-Leste, improving its productivity is a key. Yet, improving productivity goes beyond the confines of raising yield or decreasing cost to include enhancing food quality and promoting higher value products. To do so, the following aspects should be considered:

1. *Facilitate mechanization.* The use of tractors (owned or hired) and other mechanized equipment is very low across all groups of farmers and all areas of the country. Hence mechanized inputs should be used more in agricultural production. Learning from more developed agrarian countries, the government should introduce innovations in mechanization to farmers, such as the use of smaller machinery, which will enable small farms to substitute for labor inputs. At the same time, facilitating mechanization should include training on the operation and maintenance of such equipment.

2. *Improve the use of chemical (fertilizer, pesticides, and herbicides) inputs.* Only about 15 percent of households currently use these inputs. Therefore, access to them should be encouraged across all (geographic area, gender, and income) groups of farmers, such as through subsidies or credit purchasing. However, because high levels of chemical input use may exacerbate nutrient runoff into water bodies and reduce air quality (Key et al. 2011), improvement in the use of these inputs should be done in a sustainable and environmentally responsible manner to reduce or prevent environmental degradation. Equally important to increasing the level of fertilizer usage is the know-how of fertilizer usage, such as when to apply, how much to apply, and which crop to apply to etc. This important knowledge can be integrated into efforts in improving extension services.

3. *Enhance access to credit and extension.* Only 5 percent and less than 1 percent of agricultural households have access to extension services and credit, respectively. Yet without credit most farmers cannot afford necessary inputs; extension services are also needed for farmers to be able to access and effectively utilize information on improved ways of farming. The limited access to credit can be improved through government-financed micro-credit programs with flexible collateral arrangements. It should however be noted there is not much information about the kind of inputs that farmers purchase with credit and also the profitability of those inputs in Timor-Leste. As such, the recommendation about enhancing access to credit should be adhered to with this caveat in mind. Access to extension services can be enhanced by investing in extension infrastructure to make the government-led services more vibrant as well as embracing participation of

non-government actors. The extension system can also be enhanced by using modern information and communication technologies (ICT) such as mobile phones. Such technologies ensure greater penetration of farming and marketing knowledge by reducing the cost of sharing information and by offering new platforms for extension agents and farmers to exchange targeted, frequent and timely information, especially in remote areas. ICT has been identified to have impact on market efficiency and farm productivity in developing countries (Deichmann et al. 2016). For instance, information provided via mobile phones to farmers in rural India enhanced their knowledge of available options for seeds, fertilizers and other inputs as well as choices of different crops which eventually lead them to planting more profitable crops (Cole and Fernando, 2012).

4. *Encourage farmers to join farmer groups.* Although membership in farmer groups increases agricultural productivity by 33.64 percent, less than 10 percent of farming households belong to such groups. As such, farmers should be encouraged to join these groups, and the groups should be better equipped with quality information on agriculture production and marketing, as well as mechanized inputs that members can rent and use. To increase the potential benefits of joining farmer groups, it is important that the structure and type of services provided to members are managed and tailored to meet the needs of members.

5. *Expand the commercialization of farm produce*. Over 50 percent of agricultural households do not participate in the agricultural output market. This limited commercialization likely results from the short and poorly developed value chains of agricultural produce, the weak marketing channels, and the limited value-added activities such as drying, storage, processing, and packaging. Yet there are opportunities to improve the commercialization of agricultural products by substituting existing imports and increasing the demand for local products on international markets (World Bank 2017). For instance, access to niches of external markets for agricultural produce, such as premium-grade coffee and vanilla, can facilitate the transition from subsistence to commercial farming. Exportable forestry products such as high-value hard woods, candlenuts and coconut, legumes, and spices have the potential to be commercially developed. Maize production could also be commercialized due to the growing demand for maize for human consumption and in the production of animal feed. Commercialization can be enabled by expanding access to markets via road development and maintenance, and through the promotion of mechanics, platforms, and schemes that link producers to traders. Besides increase in the quantity produce, commercialization also requires increase in the quality produce. It is therefore important to ensure that the quality of farmers' produce meet the taste and preference of consumers in the domestic and international markets. Commercialization of farm produce can also be improved through the development of agricultural value chain which gives farmers to higher-value markets. It should however be noted that starting value chains in a country like Timor-Leste with little infrastructure and value-added crops is challenging and especially so when there are no incentives to upgrade. Therefore, rural infrastructure investments should also consider market access constraints for smallholder farmers. Investments in ICT connectivity would also be of fundamental importance. There is a need to strengthen the enabling environment to allow Timor-Leste access international markets and benefit from imported technology.

6. *Reduce the gender gap in agricultural productivity*. Although FHHs account for only 10 percent of agricultural households, it is important to close the 12.75 percent gender gap in productivity. Doing so will help improve overall productivity. Since almost all of the gender gap is attributable to females having fewer resources, it can be closed by improving their access to resources such as mechanized inputs, extension services, and credit.

While there is a common inverse relationship between farm size and agricultural productivity, farmers' efficiency may not vary by farm size if overall input use is considered. Also, new technologies and institutional arrangements may give rise to significant farm economies of scale, hence any differences in productivity driven by farm size, may be diminished with advancement in technology and movements into high value-added crops.

The recommendations outlined above echo those from Myanmar's lessons. Improvements in Myanmar's agriculture sector accounted for over 46 percent of the country's poverty reduction recorded between 2005 and 2015 (World Bank, 2019). Over this period, the poverty rate among agricultural households declined from 60 to 41 percent. The factors that contributed to that process included crop diversification, increased use of chemical inputs (fertilizers, pesticides, and herbicides), improved management of irrigation infrastructure, increased mechanization, enhanced access to markets through improved rural infrastructure, and increased access to credit for smallholder farmers (World Bank, 2019).

For Timor-Leste, agriculture is likely to retain a major role in the livelihood of the poor, and the overall economic growth, in the years to come. The success of the agricultural transformation process depends on policy decisions which should be guided by an understanding of the potential drivers of the agricultural sector growth. The findings of this study provide evidence which complement existing works on Timor-Leste's agriculture sector that identifies increasing agricultural productivity is a policy necessary for sustaining economic growth of the country. Investment in the sector can be improved by crowding in private sector financing and by using the limited public funds more strategically. Yet, further study and new data are needed to conduct a more detailed analyses on where and how specifically investments on agriculture sector could be effectively allocated to reap its highest potential impact in increasing rural income which can lead to poverty reduction. It is expected the upcoming agriculture census will provide an opportunity to do so.

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Appendix A: Tables

Table 1a: Descriptive statistics of key variables

Key Variables	2007	2014	2014						
			Poverty Status		Sex Head of Household		Region		
			Poor	Non-poor	MHH	FHH	East	Center	West
Poverty rate (%)	57.5	50.3			51.9	33.5	39.8	51.3	60.5
Agricultural productivity (Dollars/ha)	49.9	66.5	61.5	76.3	67.2	62.2	41.8	65.9	94.0
Average landholding (ha)	0.4	0.6	0.6	0.7	0.7	0.5	0.9	0.7	0.5
Commercialization (% of households who sold)	32.2	46.6	44.2	48.0	44.1	44.3	43.9	46.4	49.4
Access to extension (% of households)	--	4.5	4.5	4.6	4.6	4.2	9.0	3.4	1.6
Access to credit (% of households)	0.5	0.2	4.4	4.5	4.7	2.7	3.3	5.0	4.4
Access to mechanized inputs (% of households)	7.7	6.9	7.8	6.3	7.5	2.9	6.6	1.8	16.0
Access to fertilizer (% of households)	14.6	10.5	11.1	10.1	10.1	9.6	10.9	11.3	8.7
Access to pesticides (% of households)	15.1	11.2	11.1	11.2	11.1	12.0	10.7	11.5	11.2
Access to herbicides (% of households)	14.7	10.8	10.2	11.2	10.9	10.3	11.8	11.2	9.0

Table 2: Effect of Agriculture Productivity on Poverty and Welfare

VARIABLES	Poor/Non -poor (Logit)	Log Cons Exp (OLS)	Log Rel deprivation (OLS)	Poverty Gap (two-part)	Poverty Severity (two-part)
Log of agricultural productivity	-0.029***	0.012**	0.032**	-0.007***	-0.003***
	(0.006)	(0.005)	(0.013)	(0.001)	(0.000)
Income from wages	-0.001***	0.000***	0.001***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Income from forestry products	-0.000	0.000*	0.000	-0.000**	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Income from other sources	-0.000***	0.000*	0.000*	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Profit from off-farm business	-0.000	0.000	0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Hectares of land cultivated	-0.078***	0.042**	0.063**	-0.014***	-0.005***
	(0.017)	(0.016)	(0.022)	(0.002)	(0.001)
Dependency ratio (%)	-0.003***	0.003***	-0.001*	-0.001***	-0.000***
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Household size	0.115***	-0.103***	-0.175***	0.028***	0.011***
	(0.007)	(0.006)	(0.009)	(0.001)	(0.000)
Age of household head	-0.003***	0.002**	0.009***	-0.001***	-0.000**
	(0.001)	(0.001)	(0.002)	(0.000)	(0.000)
Gender of household head (Female)	-0.069**	0.093***	0.131***	-0.015**	-0.007**
	(0.030)	(0.010)	(0.040)	(0.006)	(0.003)
Proficiency in Indonesian (omitted = very good)					
Head is proficient in Indonesian (Good)	0.059**	-0.076***	-0.091***	0.021***	0.010***
	(0.028)	(0.020)	(0.027)	(0.006)	(0.003)
Head is proficient in Indonesian (A little)	0.007	-0.037*	-0.033	-0.005	-0.003
	(0.042)	(0.018)	(0.053)	(0.008)	(0.004)
Head is proficient in Indonesian (NO)	0.032	-0.117***	-0.089	0.012	0.006
	(0.048)	(0.034)	(0.091)	(0.008)	(0.004)
Proficiency in Portuguese (omitted = very good)					
Head is proficient in Portuguese (Good)	0.133***	-0.097***	-0.043	0.023***	0.007*
	(0.032)	(0.031)	(0.037)	(0.008)	(0.004)
Head is proficient in Portuguese (A little)	0.163**	-0.117**	-0.104	0.036**	0.014
	(0.075)	(0.043)	(0.120)	(0.016)	(0.009)
Head is proficient in Portuguese (NO)	0.304***	-0.209***	-0.402**	0.080***	0.036***
	(0.096)	(0.057)	(0.148)	(0.018)	(0.011)
Proficiency in English (omitted = very good)					
Head is proficient in English (Good)	0.380***	-0.346***	-0.440***	0.082***	0.035***
	(0.076)	(0.082)	(0.079)	(0.017)	(0.009)
Head is proficient in English (A little)	0.151*	-0.165	-0.111	0.053**	0.024*
	(0.089)	(0.102)	(0.192)	(0.026)	(0.015)
Head is proficient in English (NO)	0.267***	-0.264**	-0.444	0.088***	0.034**
	(0.101)	(0.112)	(0.250)	(0.030)	(0.017)
Education (omitted category = no education)					
Education of head (PRE-SCHOOL)	-0.382***	0.272*	0.983***	-0.072**	-0.022
	(0.056)	(0.126)	(0.199)	(0.033)	(0.014)
Education of head (PRIMARY)	-0.050	0.048*	0.107*	-0.013*	-0.004
	(0.040)	(0.025)	(0.050)	(0.008)	(0.004)
Education of head (ESKOLA BASIKU)	-0.112**	0.070	0.115	-0.016	-0.004
	(0.047)	(0.041)	(0.067)	(0.011)	(0.005)
Education of head (PRE-SECONDARY)	-0.106**	0.071**	0.093	-0.023**	-0.007
	(0.047)	(0.030)	(0.066)	(0.010)	(0.005)
Education of head (SECONDARY)	-0.081	0.063	0.183	-0.012	-0.003
	(0.061)	(0.047)	(0.109)	(0.012)	(0.006)
Education of head (ACADEMY)	-0.085	0.102*	0.102	-0.027	-0.008
	(0.096)	(0.048)	(0.144)	(0.023)	(0.012)
Education of head (UNIVERSITY)	-0.084	0.089	0.306*	-0.043*	-0.026***
	(0.098)	(0.057)	(0.166)	(0.022)	(0.007)
Education of head (VOCATIONAL)	0.015	0.022	-0.097	0.053	0.037
	(0.174)	(0.106)	(0.468)	(0.051)	(0.026)
Household head can write	0.072	0.028	0.032	-0.017	-0.018
	(0.082)	(0.048)	(0.131)	(0.024)	(0.012)
Household head can read	-0.104	0.005	-0.021	0.005	0.012

	(0.089)	(0.052)	(0.146)	(0.026)	(0.015)
Area of residence (omitted category = East)					
Center	0.268***	-0.068	-0.133**	0.076***	0.032***
	(0.050)	(0.046)	(0.048)	(0.004)	(0.002)
West	0.316***	-0.076*	-0.281***	0.087***	0.037***
	(0.064)	(0.038)	(0.060)	(0.005)	(0.002)
Household resides in urban area	-0.135***	0.249***	0.260***	-0.036***	-0.015***
	(0.047)	(0.054)	(0.068)	(0.004)	(0.002)
Hectares of land owned	-0.035**	0.025*	0.061**	-0.015***	-0.009***
	(0.016)	(0.012)	(0.023)	(0.004)	(0.002)
Number of crops cultivated	-0.021***	0.025***	0.009	-0.008***	-0.004***
	(0.020)	(0.007)	(0.009)	(0.001)	(0.001)
Household owns livestock	-0.387***	0.084***	0.204***	-0.033***	-0.011***
	(0.110)	(0.021)	(0.040)	(0.007)	(0.004)
Household cultivates forestry products	-0.182	-0.023	-0.059	-0.012	-0.002
	(0.121)	(0.031)	(0.046)	(0.011)	(0.005)
Household has treated drinking water	0.386***	-0.109***	-0.169***	0.044***	0.020***
	(0.070)	(0.024)	(0.028)	(0.005)	(0.002)
Household has access to credit	-0.425***	0.155***	0.150***	-0.044***	-0.019***
	(0.104)	(0.028)	(0.044)	(0.010)	(0.005)
Year = 2014	0.009	0.609***	0.033	-0.017	0.000
	(0.392)	(0.138)	(0.213)	(0.040)	(0.024)
Constant	-3.814***	4.043***	5.127***		
	(0.580)	(0.162)	(0.256)		
Observations	7,846	7,846	7,844	7,846	7,846
R-squared		0.624	0.276		

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3: Determinants of Agricultural Productivity

VARIABLES	Full sample (OLS)	Poor (OLS)	Non-poor (OLS)
Hectares of land cultivated	-1.011***	-1.212***	-0.931***
	(0.085)	(0.088)	(0.099)
Used some irrigation	0.050	0.091	0.030
	(0.056)	(0.066)	(0.104)
Access to extension services	0.326***	0.279*	0.338**
	(0.098)	(0.138)	(0.119)
Education (omitted category = no education)			
Household head is pre-secondary educated	-0.017	-0.085	0.028
	(0.076)	(0.120)	(0.069)
Household head is at least secondary educated	0.143	-0.003	0.227*
	(0.091)	(0.124)	(0.107)
Age of household head (years)	0.027***	-0.003	0.043***
	(0.007)	(0.009)	(0.010)
Age of household head (squared)	-0.000***	0.000	-0.000***
	(0.000)	(0.000)	(0.000)
Household size	0.023*	0.074***	0.010
	(0.011)	(0.014)	(0.013)
Household head is female	-0.116**	-0.272*	-0.104
	(0.052)	(0.127)	(0.078)
Tractor was used in crop cultivation	0.543***	0.687***	0.514***
	(0.125)	(0.132)	(0.122)
Fertilizer was used in crop production	0.157	0.834	-0.172
	(0.274)	(0.581)	(0.427)
Household used pesticide in crop production	0.127	0.170	0.107
	(0.145)	(0.133)	(0.207)
Household used manure in crop production	-0.108	-0.309	0.131
	(0.193)	(0.324)	(0.176)
Household used herbicide in crop production	-0.038	0.012	-0.059
	(0.118)	(0.185)	(0.155)
Household received loan	-0.025	-0.102	0.031
	(0.078)	(0.228)	(0.079)
Household wealth index	-0.089**	-0.067	-0.115
	(0.040)	(0.047)	(0.066)
Log of days of male hired labor	0.091***	0.081**	0.105**
	(0.025)	(0.037)	(0.038)
Log of days of female hired labor	0.114***	0.088*	0.108***
	(0.019)	(0.046)	(0.025)
Log of days of child hired labor	0.118*	0.054	0.165**
	(0.062)	(0.097)	(0.069)
Log of hours of female own labor	0.176***	0.198***	0.167***
	(0.019)	(0.025)	(0.033)
Log of hours of make own labor	0.078***	0.086***	0.060*
	(0.020)	(0.028)	(0.031)
Number of crops cultivated	0.051***	0.087***	0.035**
	(0.012)	(0.020)	(0.012)
Share of land allocated to tree crops	0.493***	0.480**	0.458**
	(0.153)	(0.199)	(0.178)
Share of land allocated to plantation	0.392***	0.387***	0.347***
	(0.093)	(0.084)	(0.104)
Share of flat land	0.070	0.051	0.077
	(0.081)	(0.089)	(0.087)
Household participated in farmers' group	0.286***	0.188	0.344***
	(0.051)	(0.113)	(0.096)
Average distance to plot	0.017***	0.015	0.018***
	(0.004)	(0.010)	(0.003)
Household received remittance	-0.210***	-0.253**	-0.184***
	(0.035)	(0.098)	(0.044)

Household raised livestock	0.039	0.165**	-0.105
	(0.046)	(0.068)	(0.069)
Household engaged in fishing	-0.179	-0.453***	0.012
	(0.136)	(0.145)	(0.174)
Household reside in rural area	0.173*	0.111	0.224**
	(0.097)	(0.149)	(0.081)
Household head is a wage worker	-0.133*	-0.197	-0.117*
	(0.065)	(0.115)	(0.059)
Household head is Catholic	-0.200	-0.291	-0.222
	(0.199)	(0.248)	(0.228)
Region (omitted category = East)			
Centre	7.410***	7.578***	7.367***
	(0.256)	(0.395)	(0.345)
West	7.318***	7.677***	7.128***
	(0.263)	(0.421)	(0.275)
Observations	3,443	1,202	2,204
R-squared	0.986	0.988	0.986

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix B: Methodology

As noted in the main text, agricultural productivity is measured here as the value of crop output per hectare ($/ha), defined as the monetary value of all crops produced by the household per hectare of land cultivated. Productivity is measured in this way because the data available for the study does not have information on farm size, but rather total land cropped by the household.

The poverty indicators used in the analyses include a binary variable (1= poor; 0 otherwise), per capita annual consumption expenditure, poverty gap, poverty severity, and relative deprivation in terms of per capita consumption expenditure. The annual consumption expenditure variable includes aggregate expenditures on food and non-food products. Poverty gap and severity of poverty are measured using the Foster-Greer-Thorbecke index (Foster et al. 1984), where the latter is the square of the former. The Foster-Greer-Thorbecke index is typically a summary statistic but, following Mason and Smale (2013), this study constructed a household-specific version of the index for use in a regression model. Both poverty gap and poverty severity take values of zero for non-poor households and a fraction for poor households. Relative deprivation in terms of consumption expenditure—which compares a household's mean consumption expenditure to that of better-off households—was measured using Stark and Taylor's (1989) index. Higher values on this index indicate greater deprivation relative to other households.

Following Christiaensen and Demery (2006), in order to estimate the effect of agricultural productivity on the welfare of rural agricultural households, the indirect utility function of an agricultural household is defined as:

$$V(p,w,A) = \max_{q,L}[u(q,L)|\pi(p,w,A,B) + wL = p.q] \quad (1)$$

where $U(q,L)$ is the utility of an agricultural household defined based on the consumption of a vector of goods, q, and a vector of labor variables, L; $\pi(p,w,A,B)$ is the profit obtained from all (farm and off-farm) household enterprises, and depends on p (a vector of prices for goods q), w (vector of wage rates), A (agricultural productivity), and B (productivity of off-farm income-generating activities). The change in welfare resulting from a one-unit increase in agricultural productivity, A, is given by:

$$\alpha = \frac{dV}{\varphi dA} = [Q-q]\frac{dp}{dA} + [L-(L_f + L_{of})]\frac{dw}{dA} + p\frac{dQ}{dA} \quad (2)$$

where φ is the marginal utility of income; $[Q-q]$ is the difference between what the household produces and what it consumes; L_f and L_{of} denote the optimal levels of farm and off-farm labor, respectively; $\frac{dp}{dA}$ is the change in (food) prices resulting from a one-unit increase in agricultural productivity; $\frac{dw}{dA}$ is the change in agricultural wages resulting from the shift in agricultural productivity; and $p\frac{dQ}{dA}$ is the monetary value resulting from a change in output caused by the change in agricultural productivity.

In this Policy Note, we estimate α using the following empirical model:

$$W_i = \alpha A_i + \boldsymbol{X}_i\beta + \boldsymbol{H}_i\gamma + \varepsilon_i \quad (3)$$

where i indexes household; W represents various measures of poverty; A denotes agricultural productivity; X is a vector of variables measuring other sources of household income including income from wages, income from forestry products, income from off-farm businesses, and income from other sources; H is a vector of household characteristics, consisting of household size, landholding in hectares, age of household head, gender of household head, education of household head, area of residence of household (rural/urban; west/east/center), whether the household owns livestock, and whether the household cultivates forestry products; and ε is the stochastic error term. α, β and γ are parameters; α is the parameter of interest—the effect of agricultural productivity on household welfare.

Depending on the poverty indicator, the effect of agricultural expenditure on welfare is estimated using a logit estimator, ordinary least squares (OLS) estimator, a two-part estimator, or ordered-probit estimator. The household logit estimator is used when poverty is measured with a binary indicator (1 = poor; 0 otherwise); OLS is used when poverty is measured by per capita annual consumption expenditure and relative deprivation in terms of consumption expenditure; and the two-part estimator is used when it is measured using either poverty gap or poverty severity.[8] The first part of the two-part estimator estimates the probability of being poor using a logit estimator, while the second part estimates the extent of poverty conditional on being poor using the fractional logit estimator (Belotti and Manning, 2015).

Exploratory analyses are used to identify the constraints to increasing agricultural productivity and a simple household-level OLS specification to assess the determinants of agricultural productivity. The OLS model is specified as follows:

$$Y_i = \alpha + C_i\beta + H_i\gamma + M_i\rho + L_i\delta + S_i\vartheta + A_i\tau + I_i\sigma + \epsilon_i \qquad (4)$$

where C is a vector of binary variables indicating whether a household used chemicals (organic fertilizers, manure, pesticides, or herbicides) in crop production; H is a vector of household characteristics that affect crop production: household size, access to durable goods, gender of household head, age of household head, education of household head, household participation in farmers' group, access to remittance, and household residence (urban/rural, west/east/center); M is a vector of binary variables representing the utilization of mechanized inputs like tractors and irrigation in crop production; L is a vector of labor variables (male, female, child hired and family labor), S is a vector of variables indicating a household's access to services including extension and credit; A is vector of variables on plot allocation including the share of land allocated to tree crops and plantations; I is a vector of variables representing a household's engagement in other economic activities including livestock, fishing, and wage-earning jobs. $\alpha, \beta, \gamma, \rho, \delta, \vartheta, \tau$ *and* σ are parameters to be estimated. ε is the stochastic error term, representing variables that the model could not control for.

[8] The two-part estimator is implemented using the *twopm* command in stata (Belotti and Manning, 2015). *twopm* has a variety of estimators that can be used for the first and second parts depending on the research interest. More importantly, marginal effects for the combined model can be easily recovered using the margins command.