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A rural household perspective from the United Republic of Tanzania

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This publication has been prepared as part of a multi-country empirical investigation to re-assess the role of agriculture in poverty reduction in sub-Saharan Africa undertaken by the Africa Region of the World Bank and financed under the Norwegian Trust Fund for Environmentally and Socially Sustainable Development. Alexander Sarris is Director, Commodities and Trade Division, Food and Agriculture Organization of the United Nations (FAO) (alexander.sarris@fao.org). Sara Savastano is an economist at the Public Investment Evaluation Unit of the Italian Ministry of Economy and Finance (ssavastano@gmail.com). Luc Christiaensen (World Bank Task Team Leader of the project) is Senior Economist with the World Bank (lchristiaensen@worldbank.org).

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Abstract

This report explores how farm productivity affects poverty, and how various factor market constraints affect farm productivity. The empirical analysis draws on representative surveys of farm households in Kilimanjaro and Ruvuma, two cash crop growing regions in Tanzania. Poorer households were found not only to possess fewer assets, but also to be much less productive. Findings show that agricultural productivity directly affects household consumption and hence overall poverty and welfare. Stochastic production frontier analysis indicates that many farmers are farming well below best practice in the region. Holding inputs constant, they attain on average only 60 percent of the output obtained by their best counterparts. Analysis of allocative efficiency suggests that family labour is substantially overutilized, a sign of considerable excess labour supply. Use of intermediate inputs on the other hand is well below what is commensurate with the estimated value of their marginal productivities. An important reason for low input use is lack of credit to purchase inputs, but difficult access to the inputs themselves and being connected to the economy more broadly are also important impediments. Easy access to credit is positively associated with being a member of a savings association or being in a contractual arrangement with a cooperative or firm. Irrigation infrastructure facilitates access to credit. Together these findings support a continuing emphasis on increasing agricultural productivity in designing poverty reduction policies. Better agronomic practices and increased input use will be crucial in this strategy. Better access to inputs and improved roads and transport services will further help boost input application. Financial constraints might be relieved through fostering institutional arrangements facilitating contract enforcement (e.g. contract farming, marketing cooperatives) and institutions that facilitate saving by the households themselves. They may also be relieved by the provision of more adequate consumption safety nets. The overall results suggest that a pro-poor rural development strategy needs to be anchored around improvements in agricultural productivity.

1 Introduction and background

The overarching purpose of this study is to provide a robust empirical basis for the design of agricultural and rural development strategies effective in reducing (rural) poverty. Given that the bulk of the poor live in rural areas, and given that they earn most of their income from agriculture, effective agricultural and food policies are critical for reducing poverty in Africa. The empirical application is to rural Tanzania and particular attention will be paid to the role of agricultural technology and factor market constraints in improving agricultural productivity and reducing poverty.

The United Republic of Tanzania is among the world's poorest countries with an estimated per capita gross domestic product (GDP) of about US$313 in 2004[1] (World Bank, 2006). During most of its post-independence history, the country pursued socialist policies which resulted in extended periods with economic performance below its potential. In the mid-1980s, the country embarked on economic reforms. These were, however, not sustained, and after an initial period of economic growth in the late eighties, the early 1990s were again characterized by macro-economic disequilibria and poor economic growth.

In the mid-1990s, the Tanzania resumed its reform course with a clear and sustained commitment to macro-economic stability through sound fiscal and monetary policies as the foundation for economic growth. Macro-economic stabilization was accompanied by wide-ranging structural reforms, including privatization of state owned enterprises, liberalization of the agricultural sector, efforts to improve the business environment, and strengthening of public expenditure management. These reforms have resulted in sustained high growth – annual GDP growth rates all exceeded 5 percent during the past five years, resulting in a 3 to 5 percent annual per capita GDP growth.

Agriculture still plays a dominant role in the economy, accounting for nearly 45 percent of GDP in 2003, and employing around 70 percent of the labour force. Agriculture accounts for three quarters of merchandise exports and represents a source of livelihood for about 80 percent of the population. Agricultural income is still the main source of income for the rural poor, but households that rely heavily on such income tend to be extremely poor and a substantial number of them are actually net staple crop buyers.

Smallholder farming characterizes Tanzanian agriculture. Farmers' landholdings are usually less than 3 ha. The large majority of the crop area is cultivated by hand, and the use of ploughs and tractors is minimal. The main food crops are maize, rice, wheat, sorghum/millet, cassava and beans and they represent nearly 85 percent of the area cultivated. Bananas are grown mainly in the Kagera and Kilimanjaro area, and like cassava, have a low value-to-bulk ratio. They are generally retained for home consumption.

Export crops represent 12 percent of the value of crop production. From 1993 to present, there has been a continuous reduction of state participation and control over marketing and input supply (including the elimination of fertilizer subsidies which have however been reinstated very recently). The immediate consequence was an increase in the proportion of the market prices received by producers that have resulted in a stabilization of production despite falling world prices.

Nonetheless, agriculture continues to perform well below its potential, and earlier studies (Government of the United Republic of Tanzania, World Bank and IFPRI, 2000) indicate that Tanzania, despite low levels of technology, has a comparative advantage in all its export crops, and in several of the main food

[1] Expressed in constant 2000 US$.

crops. It was also found that there are significant linkages between increased production of exportables and overall rural incomes and growth. Hence, the issue of how to increase agricultural production and incomes is crucial to both growth and poverty alleviation. Factors contributing to low productivity include: (i) low use of inputs; (ii) low prices compared to production costs; (iii) full exposure to unfavourable weather conditions given the predominantly rain fed nature of production; (iv) pests and diseases; (v) poor knowledge of agronomic practices; (vi) low levels of capital use especially for small scale farmers.

Poverty levels are high in Tanzania, though implementation of the reforms since the mid 1990s has started to pay off. The national poverty level in 2000/01 was 35.7 percent compared with 38.6 percent in 1991/02. This relative limited decline despite decent performance since the mid 1990s is related to the poor economic performance in the early 1990s (Demombynes and Hoogeveen, 2004). Ndulu and O'Connell (2003) estimated that growth per worker recovered to 1.3 percent between 1995 and 2000, while it was negative during the 1990-94 period. The turnaround in economic growth in the mid 1990s was almost entirely driven by an increase in total factor productivity, while the contribution of human capital formation is small and that of physical capital formation is even negative. These numbers highlight the importance of total factor productivity in improving growth, while also raising the issues of why there has not yet been a stronger aggregate investment response to economic reforms and which factors explain the improvements in total factor productivity.

Further disaggregation of the evolution of poverty shows that while urban poverty incidence declined sharply between 1991/92 and 2000/01 (especially in Dar es Salaam), rural poverty incidence only declined by 2.4 percentage points (from 42.3 in 1991/92 to 39.9 percent in 2000/01). Nonetheless, this small decline in poverty headcount accounted for more than half the drop in the national poverty rate in Tanzania, as the rural poor made up 81 percent of the poor in Tanzania. Urban areas outside Dar es Salaam accounted for only 27 percent of the reduction in poverty during 1992-2001. At 39.9 percent, poverty levels remained highest in rural areas. Within agriculture, poverty levels are highest among households depending on livestock (59.1 percent), while the poverty level of those depending on sales of food crops is 40.6 percent, those who depend on cash crops[2] 38.6 percent and those who depend on sales of livestock products 33.3 percent. Overall, the limited decline in rural poverty is not so surprising given the modest expansion of the agricultural sector (3.5 percent per year over the past decade, which amounts to less than 1 percent per capita). The poverty profile further suggests that changes in agricultural production and farm gate prices have the potential to significantly impact on poverty in Tanzania.

There is considerable international evidence from low-income agriculture-dependent countries that broad based rural growth starts with increased labour productivity in small-farm agriculture. It deepens as rural demand for rural nonfarm goods and agricultural inputs is stimulated, and as labour and financial resources are mobilized and move between sectors (for a survey see Sarris, 2001). Increased integration of poor households and subregions into the larger economy is an essential part of this process. National and local governments have an important role in this process through the generation of a facilitating incentives environment and the provision of essential public goods such as tailored agricultural research, extension, physical infrastructure, laws necessary for the emergence of market institutions, and law and order.

[2] In Tanzania the term "cash crops" normally refers to exportable crops grown by farmers for cash, such as coffee, cotton, cashew nuts, tobacco, tea, etc.

In Tanzania, the relative contribution of agriculture to overall growth has been falling after 1999, not because its own growth rate fell, but because the rate of growth in non-agriculture increased significantly. It is noteworthy that the appreciation of the real exchange rate that occurred during the 1990s did not halt the upward trend in agriculture (although it may have reduced the rate of increase). Nevertheless, concerns have been raised about future growth prospects for agriculture and its role in poverty reduction. Past performance may not be durable because reform-induced reallocations within the sector may yield no further benefits. Moreover, past growth rates, while respectable, are not high enough to significantly reduce poverty or provide an adequate stimulation to the nonfarm sector.

Yet, it is not only the rate of agricultural growth which matters, but also its composition. Using computable general equilibrium (CGE) modelling, Levin and Mbamba (2004) concluded that expansion of agricultural production in Tanzania has the strongest employment and income effects, but the bulk of income increases would go to the non-poor in both rural and urban areas. Nevertheless, the poverty reducing impact of agricultural production growth is larger than the poverty reducing impact of growth in the non-agricultural sector. When simulations of total factor productivity (TFP) growth in different agricultural subsectors were undertaken, it was found that the best prospects were from TFP increases in exportable crops, as these could lead to larger exportable surpluses. On the contrary, TFP increases in food crops led to lower income growth, as the bulk of food crop production is nontradable, and hence a production expansion, in the face of slower domestic demand growth, would lead to domestic price declines for these products. This would negatively affect poor net sellers of food.[3]

Growth in agriculture and farm incomes can come about through 1) increases in the real prices producers receive for their products; 2) increases in their physical and/or human capital; and 3) increased productivity and efficiency of resource use by individual farmers. Improvements in producer prices may follow from an increase in domestic and/or international prices, or by a reduction in the marketing margin between producer and final consumer. These aspects of market organization and prospects will not be treated in this study. Instead the study will focus on the latter two channels, and try to assess the relative importance of the different factors affecting capital investments, as well as productivity and efficiency.

With limited access to credit most rural households will have to save to invest in profitable income-generating opportunities. Lack of rural growth – and hence poverty reduction – may then be caused by either 1) the absence of profitable investment opportunities or 2) the inability to save. Preliminary evidence suggests that it is mostly a lack of savings that hinders the rural poor from investing. Dercon (1998) notes for instance how poor households with little wealth typically engage in less profitable low-investment activities (such as brick or charcoal making) whereas wealthier households have the means to invest in more profitable activities such as cattle rearing. Kessy (2004) notes that poor rural households in Kagera rely on casual labour where households with access to resources can invest in trading shops, fishing boats and even pharmacies. It is worthwhile to further explore what prevents the poor from saving their way out of poverty and becoming part of the growth process. Carter and Zimmerman (2000) consider frequent exposure to risk an important element. Lack of appropriate savings mechanisms may be another. Kessy (2004) notes for instance how various poor people vented their frustration because their small savings – goats in these instances, were stolen. The paper will try to explore some of these factors.

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[3] Christiaensen and Demery (2006) provide a more elaborate theoretical and empirical discussion of this point.

For the empirical analysis, the paper uses a representative survey, conducted in November 2003, of 957 rural households in 45 villages in the Kilimanjaro region, and a representative survey of 892 rural households in 36 villages conducted in the Ruvuma region in February to March 2004. Kilimanjaro is a relatively prosperous region in north-eastern Tanzania. Its area is only 1.4 percent of the total of Tanzania, but its population of 1.38 million makes up 4 percent of the Tanzanian total – it is the region with the third highest population density in Tanzania, after Dar es Salaam and Mwanza. The region has four agro-ecological zones, namely the Kilimanjaro mountain peak, highland, intermediate and lowland plains zones. Coffee is grown in the intermediate and highland zones (between about 900 and 1 800 metres of altitude). About 75 percent of the population lives in rural areas. Coffee is the main cash crop in the region, and about 70 percent of the coffee area is held by smallholders, the remaining being cultivated by private and public plantations as well as large scale farmers. Coffee production in Kilimanjaro accounts for about 30 to 35 percent of Tanzania's coffee production, and the main national coffee auction market is in Moshi, the largest city in the region. Other cash crops include cotton, sugarcane, sisal, sunflower, beans and wheat - although these crops are largely produced by large scale farms and estates. The most important food crops are maize, bananas, and beans. The basic needs headcount poverty rate for Kilimanjaro was 31 percent in 2000/01, according to the 2000/01 Tanzanian Household Budget Survey (HBS), compared with 36 percent for mainland Tanzania as a whole.

Ruvuma is the southernmost region of Tanzania, and is 4.9 times larger than Kilimanjaro. At 1.12 million, its population is however smaller than Kilimanjaro's, indicating that the region is sparsely populated. In fact it has the second lowest population density among the 20 regions of Tanzania. The region has many agro ecological zones (the 1997 Ruvuma socioeconomic profile identifies 13 such zones, see United Republic of Tanzania (1997)), and grows a variety of agricultural products. About 90 percent of the population lives in rural areas and agriculture constitutes 77 percent of the regional GDP. There are three main exportable crops in the region: coffee, tobacco, and cashew nuts, each grown in a distinct geographical part of the region. Coffee is the main cash crop followed by cashew nuts. The basic needs headcount poverty rate for Ruvuma in 2000/01 was 41 percent, considerably higher than the country average of 36 percent. Ruvuma is acknowledged as one of the poorer regions of Tanzania. Comparison of the role of raising agricultural productivity in reducing poverty and the factors affecting agricultural productivity across these two regions - a poor, more remote and sparsely populated area and a richer, better connected and more densely populated area - will allow us to derive more refined policy recommendations which also account for the location specific characteristics.

The rest of the paper proceeds as follows. In Section 2, the key features of the survey are briefly discussed and the characteristics of the rural smallholder households in Kilimanjaro and Ruvuma are shown. Subsequently, the link between farm productivity, household consumption, and poverty is explored in Section 3. In Section 4 how the different factors affect farm output and farm productivity are analysed. Section 5 investigates whether farms are efficient in their allocation of production factors. The issue of technical efficiency of farm households is examined in Section 6, followed by a discussion in Section 7 of the determinants of input demand and access to credit, which is identified as one of the key constraints. Section 8 explores the policy implications of the empirical findings, followed by Section 9 which summarizes the main findings and concludes with key policy recommendations.

2 Main characteristics of farm households

The surveys were designed to be representative of rural farm households, both cash crop (coffee in Kilimanjaro, coffee, tobacco and cashew nuts in Ruvuma) and non-cash crop producers. They did not capture large-scale public and private coffee estates. In particular, the objective of the survey was to capture only agricultural households, which were defined as follows[4]:

- Having or operating at least 25 m^2 of arable land
- Owning or keeping at least one head of cattle or five goats/sheep/pigs or fifty chicken/ducks/turkeys during the relevant (for the survey) October to September agricultural year.

Tanzania is administratively divided into regions, districts, wards, and villages. The list of wards and villages available from the National Bureau of Statistics (NBS) classifies wards as rural, urban and mixed urban/rural. The sampling frame used for the design of the survey consisted of the villages in wards classified as rural. Consequently, this is not strictly speaking a frame of agricultural households. There can be households in rural wards that are not agricultural, and similarly there may be farm households in urban or mixed wards. However, this was the optimal approach in light of the available information.

The villages to sample within each district and ward were selected by a multistage stratified sampling procedure. Within each village, about 30 households were selected randomly from a village household list provided by village authorities. Of these, the actual questionnaire was administered to between 19 and 28 households, that were determined to be agricultural (according to the above criteria) during the first encounter. Given the sampling design, the selection probabilities of households in each village were different. Each household was hence assigned the same weight for all households in each village, equal to the inverse of its probability of being selected, so as to obtain district and region aggregates. These weightings are used for all the tabulated results and the regressions reported below.

The survey in Kilimanjaro covered 957 households, and this corresponds to a number of rural households represented in the 2003 survey, that is 190 744. This can be compared with the number of 199 391 rural households estimated for 2003 on the basis of the 1998/99 District Integrated Agricultural Survey (DIAS) in Kilimanjaro (United Republic of Tanzania, Ministry of Agriculture, 2001a) and the 2002 population census (Sarris 2003). For Ruvuma the actual sample of 892 households represents a population of 173 920 households, which can be compared with a figure of 196 300 rural households for 2002 as estimated by Sarris (2004) on the basis of the 1998/99 District Integrated Agricultural Survey (DIAS) in Ruvuma (United Republic of Tanzania, Ministry of Agriculture, 2001b) and the 2002 population census. The surveys were made in one pass and all questions were answered by recall.

The questionnaires, which were almost identical across both regions, were developed to permit a complete economic characterization of the households. Furthermore, special modules were added to help characterize households' exposure to risks and their capacity to cope with them, in order to analyse their overall vulnerability. A community-level questionnaire was administered concurrently to village focus groups consisting of leaders and other knowledgeable members of the community, with the aim of eliciting information about basic agro-ecological, social and demographic characteristics as well as the provision of public and private services and infrastructure at the village level.

[4] This definition is consistent with previous agricultural surveys administered in the regions by the National Bureau of Statistics (NBS).

The description of households presented below contains both the regional averages and the average characteristics by various groupings of households: poor and non-poor households, cash crop and non-cash crop producers and net buyers and sellers. A series of data manipulations were conducted to classify households by their poverty to ensure comparability with the HBS. Also, different poverty measures were obtained depending on the methodology used to account for own consumption (i.e. the amounts reported in the production section or the amounts consumed from own production in the consumption module of the questionnaire). While there is *a priori* no good reason to prefer one to the other, the literature was followed and auto-consumption accounted for, drawing on the consumption module of the questionnaire. This choice does not affect the subsequent econometric analysis. It only affects the descriptive averages reported below across poor and non-poor households as the different methodologies lead to somewhat different classification. A detailed discussion of the construction of the consumption and poverty measures is contained in Appendix 1.

In the descriptive statistics reported below, a distinction is also made between net food buyers and net food sellers. To do so, the value of each household's agricultural sales[5] (from the production module) was subtracted from its food cash expenditures (obtained from the consumption part of the survey). If this yielded a positive number, the household was classified as net food buyer; otherwise the household was classified as a net food seller.

Tables 1a and 1b present a series of (average) demographic and livelihood characteristics of these different groups including their average per capita expenditures and incomes for Kilimanjaro and Ruvuma respectively. There are significant differences between the average household characteristics in Kilimanjaro and Ruvuma, with the former performing better on most counts. Average per capita total expenditure and income are higher in Kilimanjaro (214 000 versus 162 000 Tsh and 158 000 versus 148 600 Tsh respectively). The average household in Kilimanjaro obtains 43.2 percent of total income from non-cash sources (own production and gifts) while in Ruvuma the share is much higher (58.5 percent) suggesting that households in Ruvuma are more subsistence oriented and less well integrated in the broader monetary economy.

Consistent with this observation, households in Ruvuma get a larger share of their total cash income from cash crops (25.1 percent versus 5.4 percent in Kilimanjaro). Sales of other crops (mostly food) make up between one quarter and one third of total cash income (27.1 percent in Kilimanjaro and 28.1 percent in Ruvuma) with net food sellers having a much larger such share than other types of farmers. The share of wages and non-farm income make up almost half of total cash income in Kilimanjaro, while they account for about 40 percent in Ruvuma. Income from non-crop agriculture (largely livestock) also makes up a significant share of cash income in Kilimanjaro (14.6 percent on average with larger shares among the non-poor and much larger shares among the net food sellers), but a very small share in Ruvuma (only 3 percent on average, with small variations across groups). In sum, Kilimanjaro farm households are more cash income oriented, and within their cash income they are also more diversified than in Ruvuma, as reflected in the Herfindahl index.

[5] The sales of coffee, tobacco and cashew nuts - the only non-food cash crops produced in the two regions, were not included.

TABLE 1A: KILIMANJARO: GENERAL HOUSEHOLD CHARACTERISTICS

	All	Poor	Non-poor	Coffee producers	Tobacco producers	Net food buyers	Net food sellers
Number of households	190 744	63 171	128 351	116 320	74 424	146 578	44 166
Share of households (%)	100.0	32.98	67.02	60.74	39.26	75.71	24.29
Age of the head (years)	53.5	50.8	54.8	55.6	50.3	53.6	53.4
Education of the head (years)	6.3	5.8	6.3	6.2	6.3	6.0	7.1
Household size (number)	5.3	6.5	4.7	5.4	5.2	5.4	5.0
Number of adult equivalents (number)	4.4	5.3	4.0	3.9	4.2	4.5	4.1
Annual per capita total expenditure ('000 Tsh/per capita)	214	105	268	212	217	205	244
Annual per capita cash expenditure ('000 Tsh/per capita)	162	75	205	156	171	157	177
Annual per capita non cash expenditure ('000 Tsh/per capita)	52	30	63	57	46	48	68
Share of food (cash and non cash) in total expenditure (%)	73	76	71	73	74	74	68
Annual per capita total income ('000 Tsh/per capita)	158	80	204	157	158	123	271
Annual per capita cash income ('000 Tsh/per capita)	105	50	140	101	112	75	204
Annual per capita non cash income ('000 Tsh/per capita)	52	30	63	57	46	48	68
Share of non-cash income in total income (%)	43.3	46.5	41.7	45.7	39.5	47.2	31.1
Share in total cash income							
Coffee (%)	5.4	6.5	4.8	8.7	0.1	6.1	3.2
Other crops (%)	27.1	22.6	29.3	28.1	25.7	22.2	41.9
Non-crop agriculture (%)	14.6	12.4	15.8	15.0	14.1	10.9	25.9
Wages (%)	21.8	27.8	18.9	19.9	24.9	25.9	9.6
Other non-farm income (%)	31.0	30.7	31.2	28.3	35.3	34.9	19.4
Herfindahl Index of cash income concentration (index 0 to 1)	.483	.527	.461	.463	.5146	.523	.359
Average distance from parcels to household compound (km)	7.07	4.95	8.12	7.54	3.36	6.26	9.61
Average distance from parcels to road (km)	1.36	1.49	1.29	1.17	1.65	1.33	1.43

Source: Computed by authors.

TABLE 1B: RUVUMA: GENERAL HOUSEHOLD CHARACTERISTICS

	All	Poor	Non-poor	Coffee producers	Tobacco producers	Cashew nuts producers	Non cash crop producers	Net food buyers	Net food sellers
Number of households	173 921	96 897	77 024	52 916	7 091	43 938	71 250	99 035	74 320
Share of households (%)	100.0	55.71	44.29	30.43	4.08	25.26	40.97	56.94	43.06
Age of the head (years)	43.37	43.93	42.67	42.29	45.11	43.19	44.24	43.20	43.50
Education of the head (years)	8.14	8.26	8.00	7.45	7.56	9.18	8.08	8.03	8.30
Household size (number)	5.21	5.68	4.62	5.37	5.49	5.10	5.13	5.06	5.40
Number of adult equivalents (number)	4.24	4.58	3.80	4.39	4.44	4.13	4.17	4.12	4.39
Annual per capita total expenditure ('000 Tsh/per capita)	162	93	249	192	127	125	165	175	145
Annual per capita cash expenditure ('000 Tsh/per capita)	88	45	142	94	71	73	94	103	67
Annual per capita non cash expenditure ('000 Tsh/per capita)	74	48	107	97	56	53	71	71	78
Share of food (cash and non cash) in total expenditure (%)	73.8	74.7	72.8	74.2	70.0	74.0	73.8	74.2	73.4
Annual per capita total income ('000 Tsh/per capita)	148.6	85.7	227.9	173.1	133.6	115.6	151.6	147.6	149.9
Annual per capita cash income ('000 Tsh/per capita)	74.5	37.7	120.8	75.6	77.6	62.9	80.3	76.5	71.9
Annual per capita non cash income ('000 Tsh/pc)	74.2	48.0	107.1	97.5	56.0	52.7	71.2	71.2	78.1
Share of non-cash income in total income (%)	58.5	61.0	55.3	64.7	41.2	55.0	57.5	58.0	59.2
Share in total cash income									
Coffee (%)	13.5	12.2	15.2	44.0	0	0.4	0	14.5	12.3
Tobacco (%)	2.4	3.0	1.7	0	60.6	1.1	0	2.2	2.7
Cashew nuts (%)	9.2	13.0	4.6	0	0	36.8	0	10.0	8.3
Other crops (%)	28.1	26.6	29.9	18.4	20.0	23.3	38.9	17.6	41.7
Non-crop agriculture (%)	3.0	3.3	2.8	4.8	0.4	1.6	2.8	2.4	3.9
Wages (%)	15.5	18.0	12.4	8.3	2.5	17.6	20.7	19.7	9.9
Other non-farm income (%)	28.2	24.1	33.3	24.5	16.5	19.2	37.6	33.6	21.2
Herfindahl Index of cash income concentration (index 0 to 1)	.522	.547	.489	.489	.489	.564	.521	.566	.4637
Average distance from parcels to household compound (km)	17.8	16.8	19.1	12.77	15.59	31.74	13.1	16.1	20.1
Average distance from parcels to road (km)	2.03	2.03	2.03	1.45	2.609	2.86	1.8	2.1	1.94

Source: Computed by authors.

Nonetheless, the relatively high values of the Herfindahl indices of cash income concentration suggest[6] that farm households are not extremely diversified in their sources of cash income, with the poor in both regions exhibiting a more concentrated cash income pattern. Cash crop producers appear generally to be more diversified than non-cash crop producers. This high concentration does not appear to be reflected in the average shares of total income also reported in the table. The reason is that the Herfindahl indices are averages of the individual Herfindahl indices of each household, which are large, while the shares of income reported are averages of the individual shares.[7]

Somewhat surprisingly, the average household head in Kilimanjaro appears older but less well educated than in Ruvuma (6.3 years of education in Kilimanjaro versus 8.1 in Ruvuma). It is likely that this follows from out-migration of the more educated household members, consistent with the general perception that people from Kilimanjaro are among the most educated in Tanzania.

Average per capita expenditures of the poor are about 2.5 times smaller than those of the non-poor in both regions, though for both groups the levels are lower in Ruvuma than in Kilimanjaro. The poor tend to be more subsistence oriented (i.e. have a larger share of non-cash income) and they tend to rely more on wages for their cash income and less on income from non-farm sources.

There appear to be no major systematic differences in the average characteristics of coffee and non-coffee growers in Kilimanjaro with the exception that non-coffee growers tend to get a higher share of their cash income from wages and other non-farm incomes. In Ruvuma, on the other hand, coffee growers enjoy on average the highest living standard (as captured by per capita expenditures), while cashew crop growers are on average the poorest. Non-cash crop growers in Ruvuma are on average less well off than the coffee growers, though substantially richer than the cashew crop growers. Consistent with our earlier observation that the poor rely more on wages for their cash income, cashew crop growers also derive a higher share of their cash income from wages. Non-cash crop producers on the other hand have a larger cash income share from both wages and non-agricultural income.

Contrary to common belief, a substantial share of households are net food buyers in both regions (75.7 percent in Kilimanjaro and 56.9 percent in Ruvuma). The lower share of net food buyers in Ruvuma does not come as a surprise, given overall lower living standards and a greater subsistence orientation in Ruvuma. Rather, that more than half of all households are net food buyers even in these environments would be a surprise to many. In Kilimanjaro, net food sellers appear better off and less subsistence oriented than net food buyers, though the reverse holds true in Ruvuma. It is likely that the latter result follows from the fact that coffee growers in Ruvuma, who are among the richer households, also tend to buy more food. In both regions, net food sellers seem less dependent on cash income from wages as well as non-farm income, while they get about 40 percent of their cash income from the sale of other crops (mostly food), consistent with their classifying criterion.

Strikingly, in Kilimanjaro, which is considered the main coffee producing region in Tanzania, cash income from coffee is only a very small share (8.7 percent) of total cash income among coffee producing households. This suggests that coffee producers have considerably reduced coffee production in response to the substantial decline of coffee prices in recent years. This does not appear to be the case in Ruvuma, where the shares of the relevant cash crop in total cash

[6] A value of the Herfindahl index of 1 indicates full concentration.

[7] For instance, if there are two households in the survey each obtaining 100 percent of their cash income from a single source, but these sources are different, then the average shares indicated would be 0.5 for each of the sources, but the average Herfindahl index indicated would be 1, as each household would have an Herfindahl index equal to 1.

income among cash crop producers are much higher (44 percent for coffee producers, 61 percent for tobacco producers, and 37 percent for cashew nut producers). Consistent with this observation, farmers in Kilimanjaro have on average been found to be net uprooters of coffee trees (i.e. more uprooting than planting), while in Ruvuma they have been net planters of trees (i.e. more planting than uprooting). While not explicitly treated in this report, this different behavioural response across regions to the same overall slump in world coffee prices during the early 2000s deserves further investigation.

Tables 2a and 2b provide an overview of households' general asset ownership in the two regions. Asset ownership is strikingly higher among households in Kilimanjaro than in Ruvuma. The lack of access to amenities such as electricity and tap water is almost complete in Ruvuma, while a small but significant share of Kilimanjaro households have these services (15 percent have electricity and 31 percent tap water). The generally low level of ownership of productive assets across both regions is also striking, and even more pronounced in Ruvuma than in Kilimanjaro. Incidence of ownership of assets is higher among non-poor households in both regions, as expected. The most significant difference in asset ownership between poor and non-poor households in Kilimanjaro is the availability of electricity at home and the ownership of a wheelbarrow.

Tables 3a and 3b summarize the housing conditions of farm households. While more than 95 percent of households live in owner occupied houses in both regions, the average size of the housing compounds seem larger in Ruvuma, while the average value of the house is much larger in Kilimanjaro (on average by a factor of five). This suggests that the value of land is higher in Kilimanjaro, while the quality of housing is lower in Ruvuma.

Tables 4a and 4b give the average value of wealth of the different classes of households in Kilimanjaro and Ruvuma. This variable is computed by summing the values of different types of productive as well as non-productive assets, such as land, agricultural capital, non-agricultural capital, consumer durables, dwellings and animals. The prices at which these items are valued are usually median village prices, computed from individual prices reported by households. The value of average household wealth in Ruvuma is only about one quarter of that in Kilimanjaro. The bulk of household wealth in both regions consists of dwellings (58 and 45 percent of the total wealth value on average in Kilimanjaro and Ruvuma respectively), followed by consumer durables and land. Animals make up only 10 percent of total wealth. It is notable that agricultural and non-agricultural productive capital accounts for very small shares of total wealth, reflecting the limited capitalization of agriculture in both regions. Wealth is furthermore very concentrated in both regions, especially in Kilimanjaro with the average Herfindahl index estimated at 0.73. As expected, the poor are less wealthy than the non-poor in both regions (by approximately 40 to 50 percent), and coffee producers are on average generally wealthier than non-coffee producers, especially in Ruvuma. Note, however, that the major difference is between average wealth in Kilimanjaro and Ruvuma, and not between poor and non-poor within each region. The major wealth differentiating factors appear to be housing, followed by the value of consumer durables, land, and animals.

TABLE 2A: KILIMANJARO: ASSET OWNERSHIP OF RURAL HOUSEHOLDS (PERCENT)

	All	Poor	Non-poor	Coffee producers	Non coffee producers	Net food buyers	Net food sellers
Has radio	80.0	70.62	84.85	80.3	79.4	77.5	88.3
Has bike	23.5	23.50	23.43	15.2	36.3	22.9	25.2
Has tap water	30.8	25.67	33.26	35.7	23.0	29.0	36.4
Has electricity	15.3	5.59	20.15	15.4	15.3	13.7	20.7
Has wheel barrow	20.7	12.19	25.06	23.5	16.4	17.5	31.3
Has plough	2.2	1.65	2.44	1.5	3.2	2.1	2.3
Has tractor	0.2	0	0.31	0.2	0.3	0.1	0.5
Has sprayer	31.9	23.78	36.0	41.7	16.8	27.8	44.8
Has milling machine	1.4	0.5	1.7	1.2	1.4	1.1	1.9
Has coffee pulping machine	27.3	21.79	30.0	41.1	05.9	23.6	39.0

Source. Computed by authors

TABLE 2B: RUVUMA: ASSET OWNERSHIP OF RUVUMA RURAL HOUSEHOLDS (PERCENT)

	All	Poor	Non-poor	Coffee producers	Tobacco producers	Cashew nut producers	Non cash crop producers	Net food buyers	Net food sellers
Has radio	62.0	54.8	71.1	60.7	84.5	53.5	66.0	64.3	58.9
Has bike	40.9	37.4	45.3	29.1	65.3	42.0	46.6	39.3	43.1
Has tap water	4.6	3.7	5.8	9.1	0	1.8	3.4	4.7	4.5
Has electricity	0.1	0	0	0	0	1	0	0.2	0
Has wheel barrow	2.7	1.4	4.3	5.1	0	1.2	2.0	3.2	2.0
Has plough	0	0	0	0	0	0	0	0	0
Has tractor	0	0	0	0	0	0	0	0	0
Has sprayer	20.3	12.7	29.9	54.0	3.8	3.6	7.1	19.9	20.8
Has milling machine	2.6	0.7	4.9	5.9	0	0.6	1.6	2.5	2.7
Has coffee pulping machine	14.3	12.1	17.0	45.3	0	0.5	1.2	14.9	13.5
Has tobacco processing machine	0.1	0	0.2	0	0	0	0.3	0.0	0.3
Has cashew nut machine	0.3	0.3	0.3	0	0	1.3	0	0.5	0.1
Has tobacco curing huts	4.0	4.6	3.2	0.9	49.3	1.4	3.6	3.0	5.3

Source. Computed by authors

TABLE 3A: KILIMANJARO: HOUSING CONDITION OF RURAL HOUSEHOLDS

	All	Poor	Non-poor	Coffee producers	Non coffee producers	Net food buyers	Net food sellers
Has own house (%)	95	96	94	98	89	94	96
Number of rooms	3.2	2.9	3.3	3.3	3.0	3.1	3.5
Size of the house compound (acres)	1.3	1.2	1.4	1.6	1.12	1.32	1.63
Value of house ('000 Tsh)	1 531	1 266	1 664	1 844	1 023	1 480	1 684

Source. Computed by authors

TABLE 3B: RUVUMA: HOUSING CONDITION OF RURAL HOUSEHOLDS

	All	Poor	Non poor	Coffee producers	Tobacco producers	Cashew nuts producers	Non cash crop producers	Net food buyers	Net food sellers
Has own house (%)	96	95	96	99	92	96	93	94	98
Number of rooms	3.7	3.6	3.8	4.3	3.6	3.3	3.5	3.6	3.8
Size of the house compound (acres)	1.9	1.9	2.0	2.9	1.5	1.1	1.8	1.6	2.3
Value of house ('000 Tsh)	299	268	339	475	200	165	260	305	291

Source. Computed by authors

TABLE 4A: KILIMANJARO: VALUE OF HOUSEHOLD WEALTH

	All	Poor	Non-poor	Coffee producers	Non coffee producers	Net food buyers	Net food sellers
Value of wealth[1] ('000 Tsh)	3 375	2 334	3 888	3 598	3 031	3 114	4 236
Value of agriculture capital ('000 Tsh)	50	20	65	55	42	51	35
Value of non agriculture capital ('000 Tsh)	60	41	69	60	61	57	224
Value of consumer durables ('000 Tsh)	867	389	1101	752	1045	872	591
Value of land ('000 Tsh)	662	442	766	782	515	615	807
Value of dwellings ('000 Tsh)	1 504	1 259	1 624	1 845	977	1 497	1 893
Value of animals ('000 Tsh)	453	339	508	412	516	427	1 915
Share in total wealth							
Share of agriculture capital (%)	1.6	1.2	1.8	1.9	1.3	1.3	2.6
Share of non agriculture capital (%)	1.4	1.0	1.6	1.4	1.4	1.1	2.4
Share of consumer durables (%)	28.0	23.2	30.4	23.2	35.5	27.0	29.9
Share of land (%)	18.4	21.3	17.0	12.9	26.9	17.9	20.1
Share of dwelling (%)	58.2	63.3	55.8	64.3	48.9	60.0	52.8
Share of animals(%)	10.2	10.8	10.0	8.9	12.3	9.7	11.9
Herfindahl Index of wealth concentration (Index from 0 to 1)	0.732	0.817	0.690	0.654	0.853	0.743	0.698

[1]Value of wealth is the sum of the following variables: value of agriculture capital, value of non agriculture capital, value of consumer durables, value of land, value of dwellings, value of animals.
Source. Computed by authors

TABLE 4B: RUVUMA: VALUE OF HOUSEHOLD WEALTH

	All	Poor	Non poor	Coffee producers	Tobacco producers	Cashew nuts producers	Non cash crop producers	Net food buyers	Net food sellers
Value of wealth[1] ('000 Tsh)	820	671	1 006	1 388	462	521	613	838	795
Value of agriculture capital ('000 Tsh)	46	29	67	107	3	16	22	43	50
Value of non agriculture capital ('000 Tsh)	14	5	26	7	0	11	23	15	13
Value of consumer durables ('000 Tsh)	147	99	208	204	136	103	133	168	119
Value of land ('000 Tsh)	289	279	301	488	104	218	162	276	309
Value of dwellings ('000 Tsh)	300	269	339	475	200	166	260	306	292
Value of animals ('000 Tsh)	81	56	113	142	49	43	64	79	84
Share in total wealth									
Share of agriculture capital (%)	2.9	2.0	4.1	6.3	0.7	1.1	1.7	2.9	2.9
Share of non agriculture capital (%)	1.0	0.7	1.3	0.5	0	0.7	1.6	1.1	0.9
Share of consumer durables (%)	17.3	17.0	17.8	10.4	27.3	19.5	20.2	17.6	17.0
Share of land (%)	23.3	23.9	22.6	32.5	13.7	29.7	13.5	22.8	23.9
Share of dwelling (%)	45.0	48.1	43.1	39.8	48.2	42.1	52.3	46.8	44.7
Share of animals (%)	9.5	8.3	11.0	10.3	10.1	6.8	10.8	8.7	10.6
Herfindahl Index of wealth concentration (Index from 0 to 1)	0.423	0.442	0.400	0.379	0.415	0.431	0.452	0.425	0.421

[1]Value of wealth is the sum of the following variables: value of agriculture capital, value of non agriculture capital, value of consumer durables, value of land, value of dwellings, value of animals.
Source. Computed by authors

TABLE 5A: KILIMANJARO: AGRICULTURAL PRODUCTION

	All	Poor	Non-poor	Coffee producers	Non coffee producers	Net food buyers	Net food sellers
Area of land cultivated acres	2.7	2.4	2.8	2.6	2.7	2.3	3.8
Number of plots cultivated	2.0	1.9	2.0	2.0	1.9	1.9	2.3
Soil is poor quality (%)	4.3	5.5	3.7	3.4	6.3	5.1	2.7
Soil is medium quality (%)	46.8	48.9	45.8	47.6	45.7	47.6	44.3
Soil is good quality (%)	48.9	45.6	50.5	49.1	48.0	47.4	53.0
Share of land irrigated (%)	20.7	17.5	22.3	17.2	26.3	18.1	28.7
Yield from maize (kg/acre)	217	160	245	181	233	178	279
Yield from beans (kg/acre)	41	41	41	26	60	38	44
Yield from coffee (kg/acre)	20	17	21	23		19	34
Yield from banana (kg/acre)	756	727	771	922	385	635	977
Number of banana trees	392	238	470	458	214	299	651
Number of coffee trees	440	260	532	441	0	375	612
Value added from crop production/acre ('000 Tsh/acre)	84	75	89	90	76	66	143
Value of input for crop production/acre ('000 Tsh/acre)	32	25	35	29	28	26	39
Has used fertilizers (%)	78.3	77.0	78.9	90.1	58.9	76.7	81.9
Has used chemicals (%)	31.8	22.8	36.3	34.6	27.0	28.3	42.6
Value of agric. capital ('000 Tsh)	50	19	65	55	42	39	84
Value of non agric. capital ('000 Tsh)	60	41	69	60	61	57	224
Number of animals in cattle equivalent[1]	2.4	2.0	2.7	2.1	2.9	2.3	9.4
Number of oxen, cows and male cattle	1.9	1.4	2.1	1.6	2.4	1.7	10.1

[1] Number of equivalent animals = number of oxen +Number of cows + 0.3*number of pigs +0.2*(number of sheep + number of goats).
Source. Computed by authors

TABLE 5B: RUVUMA: AGRICULTURAL PRODUCTION

	All	Poor	Non poor	Coffee producers	Tobacco producers	Cashew nuts producers	Non cash crop producers	Net food buyers	Net food sellers
Number of plots cultivated	6.1	6.0	6.2	5.8	5.8	9.1	4.6	5.7	6.7
Soil is poor quality (%)	2.6	2.9	3.0	3.0	3.0	2.5	2.4	2.5	2.8
Soil is medium quality (%)	5.2	5.2	3.6	4.4	3.9	6.4	5.6	6.8	3.2
Soil is good quality (%)	37.7	33.4	40.2	37.1	30.9	41.1	36.3	37.8	37.3
Share of land irrigated (%)	57.1	61.3	56.2	58.5	65.2	52.4	58.1	55.3	59.4
Yield from maize (kg/acre)	3.9	3.6	4.1	3.8	2.5	1.5	5.5	3.7	4.1
Yield from beans (kg/acre)	203	167	248	158	256	69	313	182	232
Yield from coffee (kg/acre)	13	10	18	18	11	4	16	11	17
Yield from banana (kg/acre)	17	9	26	54	0	0	0	18	15
Yield from tobacco (kg/acre)	45	31	64	92	7	12	35	37	56
Yield from cashew (kg/acre)	3	3	2	0	63	1	0	2	3
Number of banana trees	6	6	5	0	0	23	0	6	6
Number of coffee trees	72	59	85	98	21	31	58	48	99
Number of cashew trees	1 258	1 255	1 261	1 292	0	650	834	1 373	1 116
Value added from crop production/acre ('000 Tsh/ acre)	310	300	329	9	17	310	49	288	345.
Value of input for crop production/acre ('000 Tsh/acre)	37	31	43	48	24	19	40	32	43
Has used fertilizers (%)	9.8	4.4	11.6	8.4	16.9	3.9	13.7	9.6	9.9
Has used chemicals (%)	53.5	56.8	63.6	60.5	97.0	35.2	55.4	50.5	57.4
Value of agric. capital ('000 Tsh)	9.6	16.6	17.2	16.9	5.2	9.1	4.7	7.4	12.5
Value of non agric. capital ('000 Tsh)	14	5	26	7	0	11	23	15	13
Number of animals in cattle equivalent [1]	1.0	.7	1.4	1.8	0.8	0.6	0.8	1.0	1.1
Number of oxen, cows and male cattle	0.4	0.2	0.6	0.9	0.2	0.2	0.2	.4	.3

[1] Number of equivalent animals = number of oxen +Number of cows + 0.3*number of pigs +0.2*(number of sheep + number of goats).
Source. Computed by authors

Tables 5a and 5b present the key defining factors of the agricultural production process in the two regions. The average size of cultivated land is much larger in Ruvuma, though surprisingly there are no major differences in the average size of land cultivated among the poor and the non-poor within each region. There is not much difference in the amount of land cultivated among cash crop producers and non-cash crop producers in Kilimanjaro, but in Ruvuma cash crop producers cultivate on average larger amounts of land with cashew nut producers in Ruvuma cultivating the largest amounts. Consistent with expectations, net food sellers cultivate on average more land than net food buyers. The number of plots cultivated is quite similar across farm households (about 2 in Kilimanjaro, and about 2.5 to 3 in Ruvuma). The incidence of poor soil is quite small, and most farmers declare that the soil on their farms is either of medium or good quality. Average soil quality is only slightly lower among poor farmers compared with non-poor farmers. In Kilimanjaro a significant share of the land (21 percent) is irrigated (mostly gravitation irrigation), while this share is insignificant in Ruvuma (3.9 percent). This may have to do with the fact that rainfall is less reliable in Kilimanjaro, but also with the difference in wealth between the regions. The poor tend to have slightly less irrigated land than the non-poor. In sum, poor farmers appear not significantly less endowed in terms of land and land quality than their richer counterparts, while they have somewhat less access to irrigation. This may suggest that poverty follows from low productivity due to limited input and capital use (as well as poorer water management) rather than from a lack of endowments.

Indeed, average maize yields are very low in Kilimanjaro and Ruvuma (estimated at about half a tonne per ha). This is likely to be partially related to intercropping with beans. Maize yields are especially low among poor households, with those of non-poor households on average 50 percent higher than of poor households. Non-cash crop producers and net food sellers also experience much higher maize yields. The situation with beans is similar, though the differences between poor and non-poor households are less pronounced (at least in Kilimanjaro). Coffee and banana yields appear to be higher among the non-poor but this does not seem to be the case for tobacco and cashew nuts. The enormous difference between banana yields in Kilimanjaro and Ruvuma (more than 15 times higher in Kilimanjaro) is quite striking, and possibly due to the higher value bananas fetch as a food cash crop in the north of Tanzania. Banana yields are also higher among coffee producers in both regions. As bananas and coffee are often intercropped, bananas may benefit from the typically higher use of fertilizers in coffee production.

In order to account for differences in input costs when comparing productivity across farmers, the agricultural crop value added per acre was calculated.[8] Agricultural crop value added per acre is on average more than twice as high in Kilimanjaro as in Ruvuma. Within each region there appear to be significant differences between the productivity of poor and non-poor farmers, with the value added of non-poor farmers about 25 percent higher than that of the poor in Kilimanjaro and 54 percent higher in Ruvuma. Coffee producers have higher overall land productivity than non-coffee producers in both regions, and net food sellers have considerably higher land productivity than net food buyers.

These findings regarding the substantial differences in crop yields and crop value added per acre among poor and non-poor rural households suggest that land productivity is a major factor in explaining poverty, especially given that the

[8] Household value added from crop production is computed as the gross value of output, minus the value of all intermediate inputs, including hired labour. The gross value of output is computed by using the same prices for all producers, namely the regional average prices received (from the survey reported prices). This is done in order to measure farm productivity, and to avoid problems arising from different prices received by farmers due to seasonal patterns of sales, etc.

poor are only slightly less endowed with land than the richer households. Hence raising overall agricultural land productivity among smallholders appears an important factor in the development of effective poverty reducing rural growth strategies.

The difference in productivity seems further related to the use of intermediate inputs and capital. The average value of intermediate inputs utilized per acre is quite different between Kilimanjaro and Ruvuma (more than three times as large in Kilimanjaro) and between poor and non-poor, with the non-poor spending considerably more on inputs. Interestingly, the average value of total agricultural capital per household (value of machines, implements, etc.) is only slightly higher in Kilimanjaro compared with Ruvuma, but since the average amount of cultivated land is lower in Kilimanjaro, the capital/land ratios are much higher there. The non-poor have higher agricultural capital than the poor, and coffee producers appear to have higher agricultural capital on average than non-coffee producers in both regions.

The value of non-agricultural capital (value of non-farm enterprise) is much higher in Kilimanjaro compared with Ruvuma, and as expected, higher among the non-poor. However, it appears that non-cash crop producers have higher amounts of non-agricultural capital, compared with cash crop producers. The number of total animals owned (in cattle equivalents), as well as the number of cattle, is more than twice as high in Kilimanjaro compared to Ruvuma.

In sum, the descriptive analysis in Tables 1 to 5 suggests that farm-households in Kilimanjaro are considerably wealthier than those in Ruvuma, despite smaller landholdings, and despite lower overall levels of education of household heads. Furthermore, poorer households are only slightly less endowed with landholdings, though they own much less capital, both farm and non-farm, and use lower amounts of intermediate agricultural inputs. The result appears to be significant differences in agricultural land productivity.

As intermediate input (and capital) use appear to be major differentiating factors in land productivity, farmers' access to credit, often an important constraint in gaining access to inputs, was explored. Tables 6a and 6b show various credit related data for the households of the survey. A very small share of the households are members of the local Savings and Credit Cooperatives (SACCO), (12.4 percent in Kilimanjaro and 13.6 percent in Ruvuma) and only a few households have a bank account (12.4 percent in Kilimanjaro and 9.9 percent in Ruvuma). The incidence is, however, higher among non-poor households in both regions. At the same time, more than 80 percent of all households, without much differentiation among various groups (with the important exception of tobacco producers) declared that it was difficult to get seasonal credit from any source for purchasing inputs, and less than 15 percent declared that it was easy to obtain formal seasonal credit (again except tobacco producers). The difference among tobacco producers may be due to the fact that many of these grow tobacco on contract with tobacco companies, and these companies make available some production inputs. An even smaller share (8.2 percent in Kilimanjaro and 9.3 percent in Ruvuma) declared that it was easy to obtain credit for farm investments. Between 40 and 60 percent of the households in Kilimanjaro and 30 to 40 percent in Ruvuma declared that they borrowed from friends or relatives if money was needed for emergency or seasonal inputs. The lack of seasonal credit, as well as the small amount of accumulated agricultural capital, emerge as potentially important constraints to increase agricultural productivity among the farmers in our sample. This finding holds across both (quite diverse) regions.

TABLE 6A: KILIMANJARO: ACCESS TO FINANCE AND CREDIT BY RURAL FARM HOUSEHOLDS (PERCENT)

	All	Poor	Non-poor	Coffee producers	Non coffee producers	Net food buyers	Net food sellers
Belongs to SACCO	12.4	10.5	13.4	12.0	13.0	11.0	17.0
Has a banking account	12.4	5.9	15.6	13.7	10.4	10.7	18.1
Difficult to get seasonal credit for inputs on the farm	84.4	90.8	82.1	84.7	84.1	85.2	81.7
Easy access to formal credit for inputs from banks and other institutions	13.2	9.5	15.1	13.4	12.9	12.1	16.9
Easy to get credit for farm investment	8.2	6.3	9.2	9.2	6.6	7.9	9.1
Borrow from relatives and friends if money needed for emergency	49.5	55.6	46.8	49.4	49.7	51.9	41.8
Borrow from relatives and friends if money is needed for seasonal credit for inputs on the farm	58.3	61.1	57.2	58.6	57.9	59.3	55.0

Source. Computed by authors

TABLE 6B: RUVUMA: ACCESS TO FINANCE AND CREDIT BY RURAL FARM HOUSEHOLDS (PERCENT)

	All	Poor	Non poor	Coffee producers	Tobacco producers	Cashew nuts producers	Non cash crop producers	Net food buyers	Net food sellers
Belongs to SACCO	13.6	10.3	17.9	13.5	48.9	5.2	15.2	12.0	15.8
Has a banking account	9.9	7.1	13.5	13.6	22.9	5.2	8.7	10.1	9.7
Difficult to get seasonal credit for inputs on the farm	79.8	79.5	80.0	78.4	49.4	87.0	79.2	80.7	78.6
Easy access to formal credit for inputs from banks and other institutions	11.4	11.7	11.1	10.7	30.7	8.6	11.6	8.9	14.7
Easy to get credit for farm investment	9.3	8.8	9.9	8.8	12.9	6.5	11.2	9.1	9.5
Borrow from relatives and friends if money needed for emergency	40.9	41.2	40.5	39.9	29.4	45.3	39.6	44.1	36.7
Borrow from relatives and friends if money is needed for seasonal credit for inputs on the farm	29.5	27.3	32.2	27.7	14.8	33.3	29.5	31.6	26.6

Source. Computed by authors

Tables 7a and b and 8a and b provide information on the allocation of households' labour across different activities for Kilimanjaro and Ruvuma respectively. Total labour supply was calculated by considering all members of the household who declare their main activity as work of some type[9] (hence students, people who are too old and/or are not looking for work, etc. were excluded). The average farm household in Kilimanjaro has 2.6 workers (about half its total average household size), and this is almost identical to the average farm household in Ruvuma (2.5 workers), with very little differentiation among different types of households. Assuming 12 months work per worker, the labour supply in months was calculated by multiplying the number of workers by 12. This yielded an average of about 31 months per household in Kilimanjaro and 30 months in Ruvuma.

The sum of time spent on agriculture as primary or secondary activity is equal to 25.1 months in Kilimanjaro, and 21 months in Ruvuma. While this constitutes 80 to 70 percent of the total time available to workers per households in Kilimanjaro

[9] As workers we classify all members of the household who are engaged in the following types of activities: regular wage earner in private sector, regular wage earner in public sector, irregular wage earner, self employed, unpaid family worker, looking for work, and household worker.

and Ruvuma respectively, it still leaves considerable time for other activities as well, especially in Ruvuma. It is not clear how much of this time is spent in productive activities, but the last column of Tables 7a and 8a suggest that the amount of time absent from the household seems very small among these working members. To obtain an estimate of the amount of time spent on other activities, the total household cash income from wages and non-wage, non-farm income (Tables 1a and 1b) was divided by the average daily wages observed in the survey (including non-cash payments) which were equal to 1 500 Tsh in Kilimanjaro, and 1 100 Tsh in Ruvuma).[10] These gross calculations indicate that the average household in Kilimanjaro spends 3.9 months of labour of active members on wage and non-farm non-wage cash earning activities, while in Ruvuma the average household spends an average of 3.1 months on such activities. When these are added to the amount of time spent on agriculture, an (over)estimate of the total amount of time spent by all active household members per household in all activities (29 months in Kilimanjaro, and 24.1 months in Ruvuma) is obtained. When compared with the 31 and 30 months of labour time available per household in Kilimanjaro and Ruvuma respectively, these figures suggest that there is some excess labour in Kilimanjaro, but much more in Ruvuma.

Tables 9a and 9b indicate the amount of time per household per year, as well as the amount of time per household and per acre cultivated, spent on crop production. This type of information was compiled from a different section of the questionnaire, where questions on crop production activities were asked. There is a significant difference between family time spent on crop production in Kilimanjaro and Ruvuma. The average farm household in Kilimanjaro spends 280 days a year on crop production activities, while in Ruvuma the amount of time for crop production is 510 days. This contrasts with the average amount of time declared as spent on primary and secondary agricultural activities by household workers (25.1 months per household in Kilimanjaro or 630 days[11], and 21 months or 525 days in Ruvuma. Albeit not all of this time is spent on crop production activities, it can serve as an upper boundary of household time spent on agricultural activities. This suggests that in Ruvuma almost all agricultural work time of households is occupied in crop production, while in Kilimanjaro a substantial amount of time is spent on other agricultural activities (such as livestock and food processing).

However, the labour intensity in terms of total labour time (family and hired labour) devoted to crop production is much higher in Kilimanjaro compared to Ruvuma. On average, farm households in Kilimanjaro devote 170 days per acre per year to crop production, while in Ruvuma they devote only 116 days per year per acre. Almost all labour devoted to agricultural activities by households is family labour. Households in Kilimanjaro hired on average only 13 labour days, while those in Ruvuma hired even less labour days (6 per household).

The picture that emerges from the above descriptive analysis is of farm households that have a low overall asset base (total and agricultural), use mostly labour intensive technology, but have excess family labour. They also seem to have very little access to formal credit, both seasonal and for investments, potentially limiting the use of modern inputs and capital investment. Agricultural productivity is substantially lower among poor households, which appears to be related to lower agricultural and total capital availability as well as to poorer access to farm inputs.

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[10] It was further assumed that non-farm activities earn on average the same per day as wage labour and a 25 working day month was assumed.

[11] It was assumed that a month implies 25 working days.

TABLE 7A: LABOUR SUPPLY OF FARM HOUSEHOLDS IN KILIMANJARO TO MAIN AND SECONDARY ACTIVITIES

	Number of workers	Total labour supply per each household (=workers*12)	Total labour supply to main activity per household	Labour supply to main activity/ worker	Total labour supply to second activity per household	Labour supply to second activity/ worker	Number of months of absence
		months/year/ household	months/ year/ household	months/ year/worker	months/ year/ household	months/year/ worker	months/year
All	2.6	31.2	16.0	6.3	7.8	3.2	0.7
Poor	2.7	33.5	17.5	6.4	8.0	3.1	1.5
Non-poor	2.5	30.1	15.3	6.2	7.7	3.2	0.3
Coffee producers	2.6	31.9	16.5	6.3	8.2	3.2	1
Non coffee producers	2.5	30.1	15.2	6.2	7.2	3.0	0.3
Net food buyers	2.6	31.0	16.0	6.2	7.8	3.1	0.7
Net food sellers	2.6	31.0	15.5	7.1	9.9	4.9	0.6

Source. Computed by authors

TABLE 7B: HOUSEHOLD LABOUR SUPPLY IN KILIMANJARO TO MAIN AND SECONDARY ACTIVITY WHEN THIS IS AGRICULTURE

	Total labour supply to agriculture as main activity per household	Labour supply to agriculture as main activity /worker	Total labour supply to agriculture as second activity per household	Labour supply to agriculture as second activity/worker
	months/ year/ household	months/ year/ worker	months/ year/ household	months/year/ worker
All	15.9	6.2	7.4	3.0
Poor	17.4	6.3	7.4	2.9
Non-poor	15.1	6.1	7.3	3.1
Coffee producers	16.4	6.3	7.4	2.9
Non coffee producers	15.0	6.1	6.5	2.8
Net food buyers	15.9	6.2	7.3	3.0
Net food sellers	15.5	7.1	9.6	4.6

Source. Computed by authors

TABLE 8A: HOUSEHOLD LABOUR SUPPLY BY FARM HOUSEHOLDS IN RUVUMA TO MAIN AND SECONDARY ACTIVITIES

	Number of workers	Total labour supply per each household (=workers*12)	Total labour supply to main activity per household	Labour supply to main activity/ worker	Total labour supply to second activity per household	Labour supply to second activity/ worker	Number of months of absence
		months/year/ household	months/year/ household	months/ year/worker	months/year/ household	months/year/ worker	months/year
All	2.5	30	16.0	6.5	4.4	2.7	0.2
Poor	2.6	31	17.0	6.5	3.9	2.4	0.1
Non-poor	2.4	28	14.8	6.4	5.1	3.1	0.2
Coffee producers	2.5	29	16.4	6.6	5.3	3.0	0.1
Tobacco producers	2.5	30	16.29	6.4	5.4	2.5	0
Cashew nut producers	2.6	31	16.1	6.4	3.2	2.0	0.1
Non cash crop producers	2.5	29	15.73	6.4	4.5	2.9	0.3
Net food buyers	2.4	29	15.5	6.4	4.0	2.6	0.2
Net food sellers	2.6	31	16.81	6.5	5.0	2.8	0.1

Source. Computed by authors

TABLE 8B: LABOUR SUPPLY IN RUVUMA TO MAIN AND SECONDARY ACTIVITY WHEN THIS IS AGRICULTURE

	Total labour supply to agriculture as main activity per household	Labour supply to agriculture as main activity/worker	Total labour supply to agriculture as second activity per household	Labour supply to agriculture as second activity/worker
	months/ year/ household	months/ year/ worker	months/ year/ household	months/year/ worker
All	16.1	6.5	4.0	2.7
Poor	17.0	6.5	3.6	2.4
Non-poor	14.8	6.4	4.5	3.1
Coffee producers	16.4	6.6	4.9	3.0
Tobacco producers	15.7	6.1	5.2	2.5
Cashew nut producers	16.1	6.4	2.9	2.0
Non cash crop producers	15.7	6.4	3.8	2.9
Net food buyers	15.5	6.4	3.7	2.6
Net food sellers	16.7	6.5	4.3	2.8
All	16.1	6.5	4.0	2.7

Source. Computed by authors

TABLE 9A: KILIMANJARO: USE OF FAMILY AND HIRED LABOUR AMONG SMALLHOLDER FARMS FOR AGRICULTURAL CROP PRODUCTION (MEANS ACROSS THE REPORTED GROUPS)

	All	Poor	Non-poor	Coffee producers	Non coffee producers	Net food buyers	Net food sellers
Family labour for crop production							
Days per year per household	280	284	278	323	213	280	274
Hired labour for total agricultural production							
Number of days per year	13.2	5.8	16.8	12.0	15.0	13.0	14.0
Family labour/acre for crop production							
Days per year per household/acre	170	194	158	188	142	169	201
Hired labour/acre for total agriculture production							
Days per year /acre	5.0	2.4	6.1	4.2	6.0	4.9	5.1

Source. Computed by authors

TABLE 9B: RUVUMA: USE OF FAMILY AND HIRED LABOUR AMONG SMALLHOLDER FARMS (MEANS ACROSS THE REPORTED GROUPS)

	Family labour for crop production	Hired labour for total agricultural production	Family labour/acre for crop production	Hired labour/acre for total agricultural production
	days per year per household	days per year	days per year per household/acre	days per year /acre
All	510	6	116	1.0
Poor	501	3	115	0.5
Non-poor	522	10	117	2.0
Coffee producers	638	3	135	0.7
Tobacco producers	564	8	107	1.1
Cashew nut producers	541	6	95	0.6
Non cash crop producers	394	7	117	1.6
Net food buyers	483	6	120	1.2
Net food sellers	546	7	112	0.9

Source. Computed by authors

3 Household welfare and farm productivity

The descriptive analysis suggests that agricultural productivity, welfare and poverty are closely related. This section explores this relationship directly by regressing per capita total (cash and non-cash) expenditures on agricultural land productivity, and a set of other variables. To facilitate comparison of the simulated poverty impact of agricultural productivity changes, the analysis utilizes a measure of consumption that is compatible with that utilized by the HBS of 2001/02 (National Bureau of Statistics, 2002).[12]

The estimated coefficients are reported in Tables 10a and 11a for Kilimanjaro and Ruvuma respectively. As the objective was to explore the influence of land productivity, and in order to avoid spurious effects due to different sales prices by various farmers, the gross value of crop production was computed applying unique regional median prices for each product to the production of each farmer. To eliminate concerns about endogeneity, gross crop value per acre was instrumented using the proportion of area irrigated, the availability of rainfall, the number of plots, and whether the household had used fertilizer and chemicals in the preceding agricultural season. These instruments proved to have sufficient explanatory power to eliminate potential weak instrumentation issues and passed the test for overidentifying restrictions. Tables 10b and 11b, indicate the first stage regression for (the log of) gross crop value.

The regression displays high explanatory power (R^2 is around 0.5) and the signs and statistical significance of the estimated coefficients are very consistent with what is found in the literature.[13] Furthermore, *ceteris paribus*, agricultural productivity significantly affects household consumption. The elasticity of total consumption per capita with respect to (the log) of gross crop value per acre is equal to 0.15 in Kilimanjaro and 0.57 in Ruvuma. The larger elasticity in Ruvuma follows numerically from the fact that a larger share of income is derived from agriculture in Ruvuma. Clearly the welfare gains from increasing agricultural productivity are likely to be substantial, especially in Ruvuma where households are still less diversified and depend more on agriculture for their livelihoods.

[12] In the poverty analysis of the HBS, expenditures on medical care, education, water and postage, and expenditures on rarely purchased large durable items were excluded so as to make the data comparable to earlier surveys carried out in periods where most of the above items were provided free. In any case, such expenditures in the HBS amounted to less than 4 percent of rural household expenditures. In this survey they amount to about 10 percent of total expenditures. Regressions using the full consumption expenditures produced similar or stronger results.

[13] Variables which were found to affect consumption include the size of cultivated land (positive), the age of the household head (negative), the size of the household (negative), some education variables in Kilimanjaro, the dummy of whether the household has electricity, some of the asset variables, the receipt of remittances (categorical variable, 1 if yes, 0 if not) (positive in Ruvuma), and the ease of access to seasonal credit (categorical variable, 1 if easy, 0 if not) (positive in Kilimanjaro).

TABLE 10A: KILIMANJARO: IMPACT OF AGRICULTURAL CROP PRODUCTIVITY ON HOUSEHOLD PER CAPITA CONSUMPTION EXPENDITURES

Dependent variable log of total consumption expenditures per capita	OLS Regression	IV Regression
Log gross value of crop production per acre	0.0354***	0.1458**
	(2.89)	(2.08)
Log size of land three years ago	0.1892***	0.2045***
	(5.76)	(5.53)
Dependency ratio	0.3133**	0.2756**
	(2.22)	(1.97)
Log age of the head	-0.1193*	-0.0911
	(1.74)	(1.25)
Head belongs to Pare ethnic group	0.0071	-0.0472
	(0.12)	(0.67)
Household size	-0.1228***	-0.1271***
	(13.54)	(12.48)
Years of education of most educated male	0.0196***	0.0183**
	(2.65)	(2.32)
Years of education of most educated female	0.0013	-0.0010
	(0.13)	(0.10)
Dummy=1 if most educated male has post secondary education	-0.0516	-0.0531
	(0.81)	(0.79)
Dummy=1 if most educated female has post secondary education	0.0576	0.0590
	(0.73)	(0.72)
Dummy: household has electricity	0.2182***	0.1932***
	(4.48)	(3.82)
Dummy: household has tap water	0.0210	0.0193
	(0.59)	(0.53)
Value of durables	0.0194	0.0184
	(1.58)	(1.63)
Value of dwelling	-0.0090	-0.0060
	(0.55)	(0.38)
Number of small animals	0.0032**	0.0034**
	(2.26)	(2.27)
Number of medium animals	0.0037	0.0044
	(1.16)	(1.28)
Number of large animals	0.0087	0.0082
	(1.42)	(1.25)
Dummy=1 if household received remittances	0.0188	0.0156
	(0.54)	(0.43)
Dummy=1 if it is easy to get seasonal credit for inputs on the farm	0.1251**	0.1198**
	(2.52)	(2.26)
Constant	5.6712***	5.0661***
	(19.16)	(10.14)
Observations	940	940
R-squared	0.469	0.469
Test Results:		
Anderson canon. corr. LR statistic (identification/IV relevance test)[1]		
Chi-sq		45.865
P-value		0.0000
Sargan statistic (overidentification test of all instruments) [2]		
Chi-sq		7.472
P-value		0.1878

Absolute value of z statistics in parentheses.
 * significance at 10 percent; ** significance at 5 percent; *** significance at 1 percent.
Dummies for wards estimated but not reported.
[1]Anderson canonical correlation likelihood-ratio test of whether the equation is identified, i.e., that the excluded instruments are relevant. The null hypothesis of the test is that the equation is underidentified. Under the null of underidentification, the statistic is distributed as chi-squared with degrees of freedom=(L-K+1), where L=number of instruments. Rejection of the null indicates that the model is identified.
[2] The Hansen-Sargan test is a test of overidentifying restrictions. The joint null hypothesis is that the instruments are valid instruments, i.e. uncorrelated with the error term, and that the excluded instruments are correctly excluded from the estimated equation. Under the null, the test statistic is distributed as chi-squared in the number of overidentifying restrictions. A rejection casts doubt on the validity of the instruments.
Source: Computed by authors

TABLE 10B: KILIMANJARO: RESULTS OF THE FIRST STAGE REGRESSION OF THE IV ESTIMATION OF CROP PRODUCTION VALUE PER ACRE

	Log gross value of crop production per acre
Log size of land three years ago	-0.1993**
	(2.31)
Dependency ratio	0.3481
	(1.01)
Log age of the head	-0.1633
	(0.99)
Head belongs to Pare ethnic group	0.4792***
	(2.74)
Household size	0.0451***
	(2.61)
Years of education of most educated male	0.0076
	(0.38)
Years of education of most educated female	0.0102
	(0.53)
Dummy=1 if most educated male has post secondary education	-0.0023
	(0.01)
Dummy=1 if most educated female has post secondary education	0.0321
	(0.18)
Dummy: household has electricity	0.1521
	(1.22)
Dummy: household has tap water	0.0364
	(0.45)
Value of durables	0.0067
	(0.44)
Value of dwelling	-0.0462
	(1.09)
Number of small animals	-0.0023
	(0.90)
Number of medium animals	-0.0064
	(0.82)
Number of large animals	0.0026
	(0.30)
Dummy received remittances	0.0622
	(0.77)
Easy to get seasonal credit for inputs on the farm	-0.0010
	(0.01)
Number of plots	0.0999**
	(2.06)
Proportion of land irrigated	0.2535**
	(1.98)
Dummy =1 if average rain on land parcels is below normal	-0.3060***
	(3.81)
Dummy=1 if average rain on land parcels is much below normal	-0.5437***
	(4.68)
Dummy=1 if used chemical fertilizer previous year	0.1610
	(1.45)
Dummy=1 if used chemicals last year	0.1332
	(1.42)
Constant	5.3014***
	(8.01)
Observations	951
R-squared	0.25

Absolute value of t statistics in parentheses.
* significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent.
Dummies for ward estimated but not reported.
Source: Computed by authors

TABLE 11A: RUVUMA: IMPACT OF AGRICULTURAL CROP PRODUCTIVITY ON HOUSEHOLD PER CAPITA CONSUMPTION EXPENDITURES

Dependent variable log of total consumption expenditures per capita		OLS Regression	IV Regression
Log gross value of crop production per acre		0.1751***	0.5720***
		(6.98)	(2.61)
Log size of land three years ago		0.2634***	0.3698***
		(8.28)	(5.14)
Dependency ratio		0.2060	0.1240
		(1.10)	(0.57)
Log age of the head		-0.2139***	-0.1217
		(3.16)	(1.29)
Dummy for ethnicity: Ngoni		-0.0893	-0.0661
		(1.55)	(0.88)
Household size		-0.1331***	-0.1436***
		(14.78)	(11.79)
Years of education of most educated male		0.0119	0.0050
		(1.33)	(0.43)
Years of education of most educated female		0.0111	0.0017
		(1.38)	(0.15)
Dummy=1 if most educated male has post secondary education		0.1080	0.1064
		(1.40)	(1.17)
Dummy=1 if most educated female has post secondary education		0.0355	0.1460
		(0.39)	(1.27)
Dummy: household has electricity		0.4433***	0.5875***
		(3.82)	(3.53)
Dummy: household has tap water		-0.0887	-0.0929
		(1.24)	(1.13)
Value of durables		0.2179***	0.2111***
		(4.32)	(3.69)
Number of small animals		0.0036***	0.0009
		(3.30)	(0.46)
Value of dwelling		-0.0705	*(1)*
		(0.53)	
Number of medium animals		0.0110***	0.0063
		(2.84)	(1.14)
Number of large animals		0.0259**	0.0047
		(2.33)	(0.24)
Dummy household received remittances		0.1517***	0.1308**
		(3.41)	(2.44)
Dummy=1 if it is easy to get seasonal credit for inputs on the farm		-0.0357	-0.0515
		(0.90)	(1.11)
Constant		5.0629***	3.2555***
		(16.76)	(3.19)
Observations		889	889
R-squared		0.4901	0.2952
Test Results:			
Anderson canon. corr. LR statistic (identification/IV relevance test):			
	Chi-sq		10.668
	P-value		0.0992
Sargan statistic (overidentification test of all instruments)			
	Chi-sq		2.275
	P-value		0.8099

Absolute value of z statistics in parentheses
*significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent. Dummies for villages estimated but not reported.
(1) This variable was rejected by stata in the IV regression because of collinearity.
Source: Computed by authors

TABLE 11B: RUVUMA: RESULTS OF THE FIRST STAGE REGRESSION OF THE IV ESTIMATION OF CROP PRODUCTION VALUE PER ACRE

	Log gross value of crop production per acre
Log size of land three years ago	-0.2936***
	(4.97)
Dependency ratio	0.2156
	(0.97)
Log age of the head	-0.2323**
	(2.09)
Head belongs to Pare ethnic group	-0.0583
	(0.58)
Household size	0.0269**
	(2.00)
Years of education of most educated male	0.0170
	(1.30)
Years of education of most educated female	0.0185
	(1.34)
Dummy=1 if most educated male has post secondary education	-0.0014
	(0.01)
Dummy=1 if most educated female has post secondary education	-0.2607**
	(2.24)
Dummy: household has electricity	-0.3613*
	(1.81)
Dummy: household has tap water	0.0120
	(0.11)
Value of durables	0.0048
	(0.10)
Value of dwelling	0.5148*
	(1.76)
Number of small animals	0.0067***
	(3.93)
Number of medium animals	0.0112**
	(2.00)
Number of large animals	0.0552**
	(2.34)
Dummy if household received remittances	0.0498
	(0.71)
Dummy=1 if it is easy to get seasonal credit for inputs on the farm	0.0226
	(0.38)
Number of plots	0.0126
	(0.52)
Proportion of land irrigated	0.2474
	(1.29)
Dummy=1 if average rain on land parcels is below normal	-0.0169
	(0.22)
Dummy=1 if average rain on land parcels is much below normal	-0.0581
	(0.67)
Dummy=1 if used chemical fertilizer previous year	0.1428**
	(2.19)
Dummy=1 if used chemicals last year	0.0587
	(1.01)
Constant	4.3631***
	(9.95)
Observations	892
R-squared	0.43

Absolute value of z statistics in parentheses
* significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent
Dummies for villages estimated but not reported.
Source: computed by authors

To explore further how changes in agricultural productivity would affect poverty (as opposed to household welfare), several simulations relating to different increases in agricultural land productivity were performed. In the first simulation, all households produced at least at the median level of agricultural productivity, i.e. the gross value of crop production per acre for every household was increased to the median value for the sample.[14] In this simulation, the least productive farmers are in essence brought up to par with the median productivity of all farmers. The results are shown in Table 12. For each region, the first column indicates the average value of the relevant poverty measure as computed from the actual survey. The second column indicates the average value of the same indicator based on the predicted consumption measures utilizing the consumption IV regressions in Tables 10a and 11a. The difference in poverty measures follows from the difference in the distributions between the observed and predicted consumption measures. The third column indicates the average indicators using the simulated consumption from the regressions under the assumptions of the simulation. The last column indicates the percentage differences between the averages of the simulations and the predicted values (columns 2 and 3). To assess the effect of an increase in agricultural productivity, the simulated poverty measures, which are based on the predicted consumption whereby all farmers produce at least at the median level of agricultural productivity, must be compared with the predicted poverty measures.

The results indicate a reduction in the poverty headcount by six percentage points (or 21.4 percent) in Kilimanjaro and a reduction in headcount poverty of 19 percentage points (or by 34.1 percent) in Ruvuma. These figures are consistent with the observed negative correlation between agricultural productivity and poverty. Similar large reductions in the other poverty indices are indicated. Average per capita consumption would increase by 6.3 percent in Kilimanjaro and by 21.5 percent in Ruvuma.

TABLE 12: SIMULATION OF THE POVERTY IMPACT OF RAISING THE FARM PRODUCTIVITY OF HALF OF THE LEAST PRODUCTIVE FARMERS TO THE MEDIAN LEVELS OF FARM PRODUCTIVITY

	A. KILIMANJARO				B. RUVUMA			
	Observed value	Predicted value	Simulation result	Average percent change between simulated and predicted	Observed value	Predicted value	Simulation result	Average percent change between simulated and predicted
Poverty headcount rate (percent)	34.3	29.4	23.1	-21.4	57.3	55.6	36.7	-34.1
Average poverty gap index	0.0268	0.0174	0.0117	-32.5	0.0561	0.0523	0.0207	-60.3
Severity of poverty index (percent)	0.36	0.16	0.10	-37.9	0.85	0.81	0.19	-77.0
Value of total consumption from IV regression ('000 Tsh per capita)		183.0	194.6	6.3		144.7	175.8	21.5

Source: Computed by authors

[14] The median value of crop productivity in Kilimanjaro is equal to 65 percent of the average value of gross crop income per acre in the same region, while in Ruvuma the median is equal to 85 percent of the average.

TABLE 13: SIMULATION OF THE POVERTY IMPACT OF RAISING THE FARM PRODUCTIVITY OF ALL FARMERS BY 10 PERCENT

	A. Kilimanjaro				B. Ruvuma			
	Observed value	Predicted value	Simula-tion result	Average percent change between simulated and predicted	Observed value	Predicted value	Simula-tion result	Average percent change between simulated and predicted
Poverty headcount rate (percent)	34.3	29.4	28.2	-4.3	57.2	55.6	40.7	-26.8
Average poverty gap index	0.0268	0.0174	0.0144	-17.0	0.0561	0.0523	0.035 9	-31.4
Severity of poverty index (percent)	0.36	0.16	0.12	-23.2	0.85	0.81	0.56	-30.9
Value of total consumption from IV regression ('000 Tsh per capita)		183.0	183.8	0.4		144.7	179.5	24.0

Source: Computed by authors

TABLE 14: CLASSIFICATION OF RURAL HOUSEHOLDS BY QUINTILE ACCORDING TO WHETHER THEY ARE NET FOOD BUYERS OR SELLERS

	A. Kilimanjaro		B. Ruvuma	
Quintile of expenditure	Net food buyers (percent of total)	Net food sellers (percent of total)	Net food buyers (percent of total)	Net food sellers (percent of total)
Q1	88.9	11.1	47.2	52.8
Q2	80.9	19.1	61.2	38.8
Q3	71.6	28.4	52.8	47.2
Q4	75.7	24.3	60.7	39.3
Q5	72.5	27.5	68.0	32.0

Source: Computed by authors

Table 13 presents the results of another simulation. In this case, the gross value of crop output is increased by 10 percent for all producers, i.e. interventions are not targeted to the poor. As a result, the poverty impact is smaller than under the previous simulation, but relatively larger in Ruvuma, because households in Ruvuma are poorer and more reliant on agriculture for their income. Irrespective of this, the simulations support the view that improvements in agricultural productivity can have substantial direct impacts on poverty reduction in rural Tanzania.

Further analysis is necessary, however, to justify more definite statements about the poverty impact of an increase in farm productivity. These estimates most likely capture the direct/first order effects. However, a widespread increase in agricultural productivity is likely to also affect prices and wages, and these second order effects can be substantial (see Christiaensen and Demery, 2006). Increases in agricultural production of partly traded or non traded products may depress prices. On the other hand increases in incomes following an increase in productivity tend to spill over into demand for other products and activities, thereby generating employment and putting upward pressure on rural wages.

Depending on the price elasticity of demand, the ensuing price effects may actually erode the benefits from increased agricultural productivity for net sellers, while they may well benefit net buyers. The net welfare effect will depend on whether households are net food buyers or sellers. Table 14 shows this classification of rural households in Kilimanjaro and Ruvuma by expenditure quintile. Given that the majority of the poor in Kilimanjaro are net food buyers, the poor are on average likely to gain from an increase in agricultural productivity. While there are more net food sellers among the poor in Ruvuma, many are still net buyers. More care will need to be taken in Ruvuma that food crop productivity increases do not result in steep price declines. This could be facilitated through better market integration, in particular through the strengthening of rural infrastructure in Ruvuma. On the other hand, when the increase in agricultural productivity concerns traditional cash crops such as coffee, tobacco or cashew nuts, this will not only generate a direct income effect for the cash crop farmers, but is also likely to increase the demand for wage labourers and will thus put upward pressure on wages for unskilled workers, who are often poorer.

This analysis leads to the conclusion that agricultural productivity is a significant determinant of household consumption, and hence an important determinant of household poverty. Nevertheless, agricultural productivity is still quite low in rural Tanzania, triggering the question of how it could be increased.

4 Analysis of farm production and total factor productivity

This section explores the issue of total factor productivity of crop and aggregate agricultural production of households. A primary definition of productivity is the ratio of outputs to inputs used in production. Total factor productivity (TFP) refers to that part of total production that is not accounted for by the normal basic primary production factors, such as labour and capital.

To analyse farm production a standard Cobb-Douglas production function was fitted, using instrumental variables for the endogenously determined right hand variables. [15] A variety of potential productivity determining variables was introduced on the right hand side in order to explore the determinants of TFP. The estimations take the following general form

$$\ln Q = \alpha + \sum \beta_i \log X_i + \sum \gamma_j Z_j + u \qquad (1)$$

where Q is a measure of the value of production of the farm, X_i is a set of factors of production such as land, labour and inputs, β_i are the estimated coefficients of each factor (the elasticities, if the log specification is chosen), Z_j is a vector of TFP determinants such as household characteristics, and u is an identically and independent distributed error term.

In this setting, explanatory variables such as inputs of land and labour may be considered as endogenous variables, i.e. they could be jointly determined with Q and could thus be dependent on the stochastic disturbance. For this reason, equation (1) should not be estimated directly by the OLS method. This potential correlation between the land and labour variables and the stochastic error term (u) violates the assumption of OLS and the OLS method will give biased estimates (Green 1997, Wallis 1973). To avoid biases in the estimates, instrumental variables are used here to estimate the endogenous ones.

For the production function analysis, several sets of explanatory variables are used. First, the standard factors of production, namely land, labour, capital, and intermediate inputs are utilized, as well as a dummy variable which is equal to 1 if the household hires labour for crop production. This variable is intended to capture whether the household is facing supervision constraints in hired labour. If this is the case the sign of this variable should be negative.

Second, household and farm characteristics such as age and education of the head, land quality variables such as soil quality, proportion of the land cultivated that is irrigated, etc. are utilized. Third, we check for current and past shock variables that may have affected current farm production. Such variables include the household’s assessment of whether rainfall in the plot was below normal, and whether the household has experienced different types of shocks in the past few years.

To control for endogeneity of intermediate inputs, land and labour, lagged values of these factors are used. These include the size of land area cultivated three years ago, the number of months spent by household members and hired labourers working on the farm during the previous year and a dummy indicating whether fertilizers were used during the previous year, as well as two dummies for specific crop production (coffee and bananas). Finally, variables related to credit access are used, because of the long standing hypothesis that credit

[15] More flexible functional forms such as translog were also tried, but there was no significance in any of the higher order explanatory variables.

constraints affect production and amount of land cultivated (Feder, 1995; Eswaran and Kotwal, 1986). The basic assumption used in all studies is that assets, including land, affect in a positive way the availability of credit and through this the availability of inputs and hired labour, and hence should affect land and agricultural productivity positively. The capital factor, being a fixed factor, was instrumented and is not considered endogenous.

The logic for the choice of these instruments is that they are correlated with the factor inputs, but not with the overall error of the value of production. An issue arises regarding the use of lagged factors as instruments. While these variables are expected to be related to the use of current factors, and to be exogenous to current production, it may be that they incorporate household heterogeneity that is constant from year to year. While a comprehensive inclusion of household characteristics substantially reduces the risk of biased estimation due to unobserved household heterogeneity, in the absence of panel data this risk cannot be fully avoided. The same holds true for the dummies for coffee and banana production, as the mere production of these crops may entail some specific factor input unrelated to other product outputs.

Table 15a indicates the IV estimation of the crop production function for Kilimanjaro under two assumptions concerning the effect of village characteristics. The results in the first column control for village effects through dummy variables. While this methodology protects the other estimated coefficients against potential bias due to correlation with unobserved village characteristics, it does not provide much insight into the importance of village characteristics (such as road access, the presence of extension agents, etc.). A specification was therefore also estimated whereby the village characteristics were explicitly modelled (column 2).[16] Table 15b indicates the results of the first stage regressions for the production function in the first column of Table 15a, while Table 15c indicates the results of the first stage regression for the production function in the second column of Table 15a. The first stage regression results are included for completeness only since a more detailed analysis of input use is presented in Section 7. Tables 16a, b and c show these results for Ruvuma.

The tests for endogeneity in both Kilimanjaro and Ruvuma suggest that the OLS model is rejected by both the Durbin-Wu-Hausman test and the Wu-Hausman test, which indicates the need for an IV procedure. For Ruvuma, the same tests do not reject the OLS model for the simple village effects model, but reject it in the model with village variables. In this case, the IV regressions are reported, as well as the OLS regression for the first case, and it can be seen that the results are almost identical.

The dependent variable is equal to the gross value of crop output, where for each household the unique median producer price of Kilimanjaro and Ruvuma, respectively, has been used. In this way, only differences in quantities of production were accounted for, while differences in value of production from disparities in realized prices due to seasonality were avoided. Also, all home production can be valued using the same prices.

For Kilimanjaro all factors of production are significant, except for agricultural capital (which is, however, significant in the regressions with village variables), and have the expected signs. The limited statistical significance and low elasticity (estimated at 0.04) of agricultural capital may be due to the fact that the amount of capital used for farm production is quite small, thereby limiting variation in the sample. The dummy for whether the household hires labour is negative and significant in the simple fixed effects regression, suggesting that supervision constraints may exist. The output-input elasticities are largest with

[16] Given that some of these variables were derived from the village questionnaire and given that not all villages were covered, there are fewer observations in the second column (821 instead of 951).

respect to land use, followed by the value of inputs. In particular, it was estimated that a 10 percent increase in the value of inputs used would increase the gross value of outputs by 4 percent, underscoring the importance of input use. The F test for the hypothesis that the sum of the coefficients on the land, inputs, labour and capital variables is equal to 1 is strongly rejected, and the sum of these coefficients is larger than 1, suggesting increasing economies of scale.

In Kilimanjaro, age and education do not appear to affect the value of total crop output. Neither is production affected by the various land quality or land improvement variables. Production is, however, negatively affected by bad rainfall, as expected. Major shocks such as serious illness and death in the household in the five years before the survey do not seem to have affected crop production. However, the dummy of the existence of drought in these five years seems to negatively affect the value of current crop production. This is in addition to the current rainfall conditions which, as already discussed, negatively affect current crop production, suggesting that droughts may have long lasting effects on crop production. These results for the negative influence of bad weather are compatible with the significant and positive impact of the irrigation variable, which measures the share of land irrigated, and which is substantial in Kilimanjaro.

The unbundling of the village effects indicates that only two variables affect crop production in a positive manner, namely the availability of electricity in the village and the availability of an agricultural input supply shop. Surprisingly, the availability of a bus service to nearby villages seems to negatively affect crop production, and it is not clear why that should be the case. The availability of an input supply shop also has a positive effect on productivity, in addition to its effect on input use (see Section 7 below).

The results for Ruvuma in Table 16a indicate significance with the expected signs for all basic factors of production, land, labour, intermediate inputs and capital. Note also that, as in Kilimanjaro, the sum of the coefficients of the four main variables (land, inputs, labour and capital) is significantly larger than 1, suggesting again economies of scale. Here, education of household head is a significant positive determinant of crop production. As in Kilimanjaro, land improvement variables appear to be not significant, but soil quality appears to be negatively correlated with crop production. This is somewhat surprising and it may be connected with overuse of good quality land. The current rainfall variables do not seem to affect current crop production, compatible with the fact that, in contrast to Kilimanjaro, there were very few rainfall shocks during the survey year in Ruvuma. In contrast to Kilimanjaro, illness shocks also do not seem to affect crop production. However, the dummy for a drought shock since 1998 seems to positively affect crop production, which seems counterintuitive.

The above regressions pertain only to crop production. This is because there is much better and more detailed data available for crop than for livestock production. Nevertheless, the gross value of livestock production was computed using a similar pricing technique as for crop production, and hence total agricultural production was arrived at. Tables 17a and 17b present the IV production function regressions and the associated first stage regressions, for the total gross value of agricultural production (crop and livestock) for Kilimanjaro. Table 18 does the same for Ruvuma, although first stage results are not presented because the test of endogeneity rejects the IV procedure for Ruvuma.

As livestock is much more important in Kilimanjaro, the results could be different from the results for crop production only. However, for both regions the results are quite similar to those when crop production only is utilized, for both the main regressions and for the first stage. For Kilimanjaro the major difference is the significance of capital in the total production relation, as well as the significance (negative) of the hired labour dummy in both regressions. Notice that the dummy for share of land improved with soil bunds seems to be significantly positive, while it was not significant in the crop production function regressions. Rainfall dummies are significant as in the crop production function, but the overall past drought dummy is not significant. Note finally that the sums of the coefficients on the main primary inputs (land, labour, capital) plus intermediate inputs are again greater than one, suggesting increasing economies of scale. The first stage results differ only for the level of total inputs, rather than for inputs for crop production that were utilized in the crop production regressions. The results, however, appear to be quite similar to those found for crop production. For Ruvuma the results are similar to those for crop production, without any differences in significant variables. Again, all regressions exhibit production with increasing economies of scale.

These results confirm the expected role of standard production primary inputs. They partially support the importance of education and irrigation for TFP improvement, and point to the negative and potentially lasting damage of weather shocks, the role of education and formal credit in intermediate inputs, and the importance (positive or negative) of specific types of cash or food crop growing in affecting the total value of output. This latter effect may also reflect historical or institutional contexts pertaining to producers of specific crops.

TABLE 15A: KILIMANJARO: ESTIMATION OF THE CROP PRODUCTION FUNCTION

Dependent variable log of gross value of crop production	(1) IV estimation with village dummies	(2) IV estimation with village variables
Log acres of land cultivated [1]	0.737***	0.794***
	(3.95)	(4.39)
Log value of inputs for crop production [1]	0.465***	0.401***
	(3.46)	(3.50)
Log total (hired family) labour (number of days) [1]	0.272**	0.263**
	(2.03)	(2.01)
Dummy for hired labour	-0.301*	-0.259
	(1.76)	(1.53)
Log value of agricultural capital	0.021	0.042*
	(0.95)	(1.75)
Log age of the head	0.077	0.056
	(0.53)	(0.36)
Log mean years of education of the head	0.048	0.084
	(0.70)	(1.16)
Share of land improved with rock bund	0.311	0.205
	(1.15)	(0.76)
Share of land improved with soil bund	0.274	0.227
	(1.52)	(1.23)
Share of land improved with mulching	0.170	0.161
	(1.22)	(1.17)
Share of land improved with terraces	0.018	0.085
	(0.12)	(0.55)
Share of land improved with grass lines	-0.115	0.075
	(0.74)	(0.42)
Share of land with soil of medium good quality	0.150	0.154
	(0.78)	(0.75)
Share of land with gentle or steep slope	-0.083	-0.061
	(0.44)	(0.31)
Dummy: 1=death since 1998 affected living conditions	0.047	-0.036
	(0.52)	(0.37)
Dummy: 1=illness since 1998 affected living conditions	0.108	0.057
	(1.15)	(0.57)
Dummy average rain on parcel is below normal	-0.362***	-0.357***
	(4.26)	(4.21)
Dummy average rain on parcel is much below normal	-0.593***	-0.597***
	(4.95)	(4.78)
Dummy: 1=drought since 1998 affected living conditions	-0.193**	-0.196**
	(2.08)	(2.12)
Proportion of land irrigated	0.206*	0.225*
	(1.67)	(1.88)
Dummy senior secondary school available in the village		-0.078
		(0.43)
Dummy hospital available in the village		0.011
		(0.03)
Dummy bore hole for water available in the village		-0.121
		(0.48)
Dummy community well water available in the village		-0.097
		(0.54)
Dummy market available in the village		-0.176
		(1.32)
Dummy all weather road (tarmac) available in the village		0.068
		(0.26)
Dummy electricity available in the village		0.248*
		(1.77)
Dummy public telephone available in the village		0.128
		(1.18)
Dummy availability of bus services to nearby village		-0.204*
		(1.92)
Dummy agricultural extension agent available in the village		-0.032
		(0.34)
Dummy veterinary service available		-0.049
		(0.46)
Dummy agricultural input supply shop available		0.363***
		(2.65)
Constant	1.448	0.870
	(1.54)	(0.88)
Observations	951	821
R-squared	0.37	0.34

TABLE 15A (CONTINUED): KILIMANJARO: ESTIMATION OF THE CROP PRODUCTION FUNCTION

Dependent variable log of gross value of crop production		(1) IV estimation with village dummies	(2) IV estimation with village variables
Test for return to scale			
Test H0= land + inputs + total labour + agricultural capital= 1			
	F-value	11.05	2668.70
	P value	0.0009	0.0000
Test for exogeneity of regressors H0=Regressors are exogenous			
Wu-Hausman			
	F Test	3.55864	2.45149
	P-Value	0.01398	0.06223
Durbin-Wu-Hausman			
	Chi-sq test Chi-sq(3)	11.36073	7.62037
	P-Value	0.00993	0.05455

Robust t statistics in parentheses
 * significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent
Column 1- Dummies for ward estimated but not reported
[1] variables instrumented
Source: Computed by authors

TABLE 15B: KILIMANJARO: RESULTS OF THE FIRST STAGE REGRESSIONS OF THE IV ESTIMATION OF CROP PRODUCTION WITH VILLAGE EFFECTS

	(1) Value of purchased Inputs	(2) Acres of land cultivated	(3) Total crop labour
Dummy for hired labour	1.029***	0.073***	0.174***
	(12.99)	(3.48)	(4.22)
Log value of agricultural capital	0.059***	0.014**	0.013
	(3.35)	(2.31)	(1.21)
Log age of the head	-0.277**	-0.062*	-0.022
	(2.05)	(1.91)	(0.34)
Log mean years of education of the head	0.146**	-0.016	0.036
	(2.53)	(1.09)	(1.25)
Share of land improved with rock bund	-0.506	0.005	-0.007
	(1.52)	(0.84)	(0.10)
Share of land improved with soil bund	-0.228*	-0.044	-0.011
	(1.67)	(0.10)	(0.08)
Share of land improved with mulching	0.108	-0.048*	0.008
	(0.81)	(1.88)	(0.15)
Share of land improved with terraces	0.043	0.020	-0.121**
	(0.34)	(0.62)	(2.32)
Share of land improved with grasslines	0.010	0.037	0.061
	(0.08)	(1.04)	(0.74)
Share of land with soil of medium good quality	0.232*	-0.001	-0.109*
	(1.80)	(0.02)	(1.67)
Share of land with gentle or steep slope	0.179	0.052	-0.007
	(0.90)	(1.21)	(0.09)
Dummy for coffee trees	-0.056	0.074***	0.002
	(0.52)	(2.96)	(0.02)
Dummy for banana trees	-0.022	0.018	0.285***
	(0.16)	(0.34)	(3.31)
Dummy average rain on parcel is below normal	0.117	0.011	-0.035
	(1.48)	(0.55)	(0.87)
Dummy average rain on parcel is much below normal	0.063	-0.008	0.085**
	(0.61)	(0.28)	(1.99)
Dummy 1= drought since 1998 affected living conditions	0.166**	0.020	-0.106**
	(2.14)	(0.84)	(2.41)
Proportion of land irrigated	-0.055	-0.011	0.160**
	(0.48)	(0.35)	(2.58)
Log size of land three years ago	0.497***	0.708***	0.014
	(5.86)	(20.99)	(0.31)
Log total labour lagged	-0.081**	-0.011	0.288***
	(2.44)	(1.06)	(5.70)
Dummy for chemical fertilizer used lagged	0.379***	0.104***	0.153***
	(4.02)	(3.78)	(3.19)
Dummy for chemicals used lagged	0.364***	0.019	-0.018
	(4.70)	(0.89)	(0.47)
Dummy for improved seeds lag	0.298***	0.005	0.024
	(3.80)	(0.22)	(0.47)
Dummy: 1=death since 1998 affected living conditions	0.013	-0.020	-0.018
	(0.16)	(0.92)	(0.36)
Dummy: 1=illness since 1998 affected living conditions	0.042	0.004	-0.117**
	(0.55)	(0.19)	(2.55)
Dummy: 1=belong to SACCO	0.041	0.033	0.083
	(0.36)	(1.09)	(1.61)
Has an individual banking account	0.166*	-0.037	-0.070
	(1.79)	(1.08)	(0.76)
Easy to get seasonal credit for inputs on the farm	0.083	-0.017	-0.006
	(1.04)	(0.76)	(0.16)
Constant	2.871***	0.514***	3.704***
	(4.33)	(3.27)	(9.42)
Observations	951	951	951
R-squared	0.57	0.74	0.53

Dummies for ward estimated but not reported
Robust t statistics in parentheses
* significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent
Source: Computed by authors

TABLE 15C: KILIMANJARO: RESULTS OF THE FIRST STAGE REGRESSIONS OF THE IV ESTIMATION OF CROP PRODUCTION WITH UNBUNDLED VILLAGE EFFECTS

	(1) Value of purchased Inputs	(2) Acres of land cultivated	(3) Total crop labour
Dummy for hired labour	1.065***	0.054**	0.160***
	(12.18)	(2.25)	(3.59)
Log value of agricultural capital	0.057***	0.020***	0.017
	(2.98)	(2.80)	(1.59)
Log age of the head	-0.217	-0.067*	-0.047
	(1.51)	(1.95)	(0.63)
Log mean years of education of the head	0.141**	-0.021	0.026
	(2.27)	(1.26)	(0.91)
Share of land improved with rock bund	-0.189	-0.006	0.111
	(0.60)	(0.12)	(0.82)
Share of land improved with soil bund	-0.177	-0.000	0.040
	(1.22)	(0.00)	(0.53)
Share of land improved with mulching	0.083	-0.033	-0.022
	(0.58)	(1.29)	(0.41)
Share of land improved with terraces	0.077	0.058	-0.014
	(0.58)	(1.64)	(0.28)
Share of land improved with grass lines	0.269	0.052	0.079
	(1.62)	(1.09)	(0.90)
Share of land with soil of medium good quality	0.163	0.014	-0.094
	(1.24)	(0.26)	(1.20)
Share of land with gentle or steep slope	0.260	0.069	-0.001
	(1.27)	(1.54)	(0.01)
Dummy for coffee trees	-0.169	0.060**	0.252***
	(1.44)	(0.55)	(0.09)
Dummy for banana trees	0.090	-0.028	0.009
	(0.72)	(2.12)	(3.50)
Dummy average rain on parcel is below normal	0.133	-0.002	-0.022
	(1.61)	(0.07)	(0.52)
Dummy average rain on parcel is much below normal	0.005	-0.003	0.121**
	(0.05)	(0.08)	(2.57)
Dummy: 1=drought since 1998 affected living conditions	0.134	0.007	-0.119***
	(1.58)	(0.28)	(2.71)
Proportion of land irrigated	0.002	-0.020	0.018
	(0.02)	(0.61)	(0.28)
Log size of land three years ago	0.420***	0.712***	-0.016
	(4.44)	(18.71)	(0.34)
Log total labour lagged	-0.065*	-0.016	0.345***
	(1.71)	(1.19)	(5.75)
Dummy for chemical fertilizer used lagged	0.457***	0.049*	0.095**
	(5.20)	(1.94)	(2.08)
Dummy for chemicals used lagged	0.363***	0.032	-0.037
	(4.52)	(1.40)	(0.90)
Dummy for improved seeds lag	0.308***	0.010	0.015
	(3.70)	(0.48)	(0.29)
Dummy: 1=death since 1998 affected living conditions	-0.020	-0.020	-0.054
	(0.23)	(0.86)	(1.04)
Dummy: 1=illness since 1998 affected living conditions	0.060	0.003	-0.120**
	(0.73)	(0.14)	(2.52)
Dummy: 1=belong to SACCO	-0.016	0.030	0.010
	(0.13)	(0.98)	(0.20)
Has an individual banking account	0.068	-0.047	-0.019
	(0.62)	(1.25)	(0.20)
Easy to get seasonal credit for inputs on the farm	0.125	-0.018	0.014
	(1.41)	(0.78)	(0.35)
Dummy senior secondary school available in the village	-0.031	0.029	-0.013
	(0.20)	(0.72)	(0.16)
Dummy hospital available in the village	0.359	-0.325***	-0.188
	(1.08)	(2.77)	(0.99)
Dummy bore hole for water available in the village	0.137	0.070	0.125
	(0.74)	(1.09)	(0.95)
Dummy community well water available in the village	-0.478***	0.122***	0.047
	(2.98)	(2.93)	(0.64)
Dummy market available in the village	0.234**	-0.018	-0.109*
	(2.10)	(0.58)	(1.90)
Dummy all weather road (tarmac) available in the village	-0.270	-0.032	-0.214*
	(1.45)	(0.44)	(1.72)

TABLE 15C (CONTINUED): KILIMANJARO: RESULTS OF THE FIRST STAGE REGRESSIONS OF THE IV ESTIMATION OF CROP PRODUCTION WITH UNBUNDLED VILLAGE EFFECTS

	(1) Value of purchased Inputs	(2) Acres of land cultivated	(3) Total crop labour
Dummy electricity available in the village	-0.301**	-0.053	-0.086
	(2.06)	(1.34)	(0.98)
Dummy public telephone available in the village	-0.148	0.040*	0.103**
	(1.43)	(1.77)	(2.03)
Dummy availability of bus services to nearby village	0.151	0.006	-0.061
	(1.53)	(0.23)	(1.22)
Dummy agricultural extension agent available in the village	-0.092	0.025	0.107**
	(1.06)	(1.10)	(2.46)
Dummy veterinary service available	0.115	-0.077***	0.001
	(1.12)	(2.90)	(0.02)
Dummy agricultural input supply shop available	0.137	0.008	-0.085
	(1.26)	(0.23)	(1.36)
Constant	2.747***	0.598***	3.737***
	(4.17)	(3.88)	(8.40)
Observations	821	821	821
R-squared	0.52	0.71	0.50

Robust t statistics in parentheses
Significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent
Source. Computed by authors

TABLE 16A: RUVUMA: ESTIMATION OF THE CROP PRODUCTION FUNCTION

Dependent variable log of gross value of crop production	(1) IV estimation with village fixed effects	(2) OLS estimation	(3) IV estimation with village variables
Log acres of land cultivated [1]	0.582***	0.565***	0.372***
	(6.79)	(9.53)	(4.91)
Log value of inputs for crop [1]	0.136**	0.183***	0.259***
	(2.49)	(7.21)	(5.37)
Log total labour on farm [1]	0.465***	0.429***	0.471***
	(4.33)	(5.50)	(4.37)
Dummy hired labour	-0.009	-0.062	-0.112
	(0.10)	(0.87)	(1.21)
Log value of capital	0.044***	0.042***	0.047***
	(2.97)	(2.90)	(3.26)
Log age of the head	-0.061	-0.054	0.051
	(0.62)	(0.56)	(0.51)
Dummy for corrections on age of the head [2]	0.099	0.117	0.029
	(0.40)	(0.48)	(0.12)
Log average years of education of head	0.117**	0.108**	0.111**
	(2.58)	(2.45)	(2.37)
Share of land improved with rock bund	0.331	0.317	0.211
	(1.45)	(1.34)	(0.94)
Share of land improved with soil bund	0.048	0.057	0.108
	(0.46)	(0.55)	(1.11)
Share of land improved with mulching	-0.052	-0.050	0.063
	(0.31)	(0.30)	(0.37)
Share of land improved with terraces	-0.084	-0.084	-0.064
	(1.41)	(1.41)	(1.01)
Share of land improved with grass lines	-0.248	-0.254	-0.118
	(1.23)	(1.25)	(0.56)
Share of land with soil of medium good quality	-0.138***	-0.133**	-0.119**
	(2.64)	(2.57)	(2.24)
Share of land with gentle or steep slope	0.038	0.038	0.127**
	(0.61)	(0.63)	(2.02)
Dummy: 1=death shock since 1998	0.066	0.069	0.102
	(0.93)	(0.98)	(1.43)
Dummy: 1=illness shock since 1998	-0.038	-0.031	-0.004
	(0.60)	(0.48)	(0.06)
Dummy average rain on parcel is below normal	0.075	0.071	0.049
	(0.98)	(0.95)	(0.62)
Dummy average rain on parcel is much below normal	0.035	0.023	-0.034
	(0.40)	(0.27)	(0.40)
Dummy: 1=drought shock since 1998	0.219**	0.247***	0.209**
	(2.26)	(2.66)	(2.11)
Proportion of land irrigated	0.276	0.277	0.334*
	(1.44)	(1.42)	(1.67)
Dummy for junior secondary school available in the village			0.160*
			(1.69)
Dummy for hospital available in the village			0.346*
			(1.89)
Dummy for village well available in the village			-0.303***
			(3.89)
Dummy for public water tap available in the village			0.186**
			(2.28)
Dummy for market available in the village			0.147**
			(2.04)
Dummy for all weather road (tarmac) available in the village			-0.053
			(0.25)
Dummy for bus service to nearby town available in the village			0.128
			(1.06)
Dummy for bank or other formal credit society or association available in village			0.307***

TABLE 16A (CONTINUED): RUVUMA: ESTIMATION OF THE CROP PRODUCTION FUNCTION

	(1) IV estimation with village fixed effects	(2) OLS estimation	(3) IV estimation with village variables
Dummy for agricultural extension agent available in the village			0.194*
			(1.88)
Dummy for veterinary service available in the village			-0.191**
			(1.97)
Dummy for primary society available in the village			-0.284***
Constant	0.861	0.914	0.357
	(1.15)	(1.47)	(0.47)
Observations	892	892	892
R-squared	0.55	0.55	0.48
Chi-sq test Chi-sq(3)	3.21539		8.85240
P-Value	0.35959		0.03132
Test for Return to scale			
Test H0= land + inputs + total labour + agri. capital = 1			
F-value	5.82	8.26	2.73
P value	0.0161	0.0042	0.0989
Test for exogeneity of regressors H0=Regressors are exogenous			
Wu-Hausman			
F Test	1.00332		2.86009
P-Value	0.39065		0.03603
Durbin-Wu-Hausman			
Chi-sq test Chi-sq(3)	3.21539		8.85240
P-Value	0.35959		0.03132

Robust t statistics in parentheses
* significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent
Column 1- Dummies for villages estimated but not reported
[1] Variables instrumented
[2]To recover 11 missing observations, the age of the head was replaced by the average age of the head in the sample and a dummy for the changed observations added.
Source: Computed by authors

TABLE 16B: RUVUMA: RESULTS OF THE FIRST STAGE REGRESSIONS OF THE IV ESTIMATION OF CROP PRODUCTION WITH SIMPLE VILLAGE EFFECTS

Dependent variable log of gross value of crop production	(1) Value of purchased inputs	(2) Acres of cultivated land	(3) Total labour used
Dummy hired labour	0.946***	0.025	0.061*
	(10.24)	(1.10)	(1.67)
Log value of capital	0.056**	0.008*	0.013*
	(2.34)	(1.74)	(1.68)
Log age of the head	-0.266*	0.038	-0.052
	(1.85)	(1.00)	(0.94)
Dummy for corrections on age of the head [1]	-0.259	-0.088*	0.045
	(0.90)	(1.83)	(0.22)
Log average years of education of head	0.108	0.015	0.041
	(1.64)	(1.13)	(1.62)
Share of land improved with rock bund	0.113	0.046	-0.096
	(0.41)	(0.52)	(0.76)
Share of land improved with soil bund	-0.175	0.023	0.024
	(1.01)	(0.48)	(0.34)
Share of land improved with mulching	0.027	-0.075	-0.028
	(0.10)	(1.38)	(0.35)
Share of land improved with terraces	0.090	-0.026	0.072*
	(1.03)	(1.15)	(1.85)
Share of land improved with grass lines	0.115	0.011	0.161
	(0.43)	(0.13)	(1.45)
Share of land with soil of medium good quality	-0.058	0.002	0.022
	(0.75)	(0.09)	(0.66)
Share of land with gentle or steep slope	0.013	-0.026	0.065
	(0.15)	(1.07)	(1.62)
Dummy tobacco production	0.563***	0.149***	0.248***
	(2.87)	(2.62)	(3.28)
Dummy cashew nut production	-0.163	0.007	0.190**
	(1.09)	(0.12)	(2.09)
Dummy coffee production	0.069	0.097**	0.431***
	(0.39)	(2.54)	(5.02)
Dummy banana production	0.089	0.048**	0.165***
	(1.11)	(2.02)	(4.37)
Dummy average rain on parcel is below normal	0.048	0.042	-0.057
	(0.45)	(1.59)	(1.22)
Dummy average rain on parcel is much below normal	0.170	0.065**	-0.016
	(1.43)	(2.06)	(0.31)
Dummy: 1=drought shock since 1998	-0.379**	-0.036	0.066
	(2.12)	(0.79)	(0.89)
Proportion of land irrigated	0.235	0.068	-0.013
	(1.03)	(0.88)	(0.15)
Log size of land three years ago	0.652***	0.810***	0.098***
	(8.29)	(31.70)	(3.10)
Log total labour lagged	-0.112***	-0.082***	0.171***
	(2.62)	(5.09)	(5.88)
Dummy for chemical fertilizer used lagged	1.080***	-0.004	-0.064*
	(11.71)	(0.17)	(1.88)
Dummy for chemicals used lagged	0.141	0.026	0.035
	(1.38)	(1.34)	(0.95)
Dummy for improved seeds lag	0.096	-0.047*	-0.140*
	(0.60)	(1.65)	(1.79)
Dummy: 1=death shock since 1998	-0.009	0.015	-0.064
	(0.09)	(0.61)	(1.64)
Dummy: 1=illness shock since 1998	-0.017	0.004	0.059
	(0.17)	(0.18)	(1.49)
Dummy: 1=belong to SACCO	-0.064	0.022	0.058
	(0.53)	(0.80)	(1.24)
Dummy: 1=have bank account	0.498***	0.050	-0.068
	(3.41)	(1.44)	(1.11)
Easy to get seasonal credit for inputs on the farm	-0.032	-0.031	-0.079**
	(0.32)	(1.23)	(2.04)
Constant	2.946***	0.554***	4.737***
	(4.67)	(3.17)	(17.08)
Observations	892	892	892
R-squared	0.59	0.82	0.46

Dummies for villages estimated but not reported Robust t statistics in parentheses. * significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent.

[1] To recover 11 missing observations, the age of the head was replaced with the average age of the head in the sample and a dummy for the changed observations added.

Source: Computed by authors

TABLE 16C: RUVUMA: RESULTS OF THE FIRST STAGE REGRESSIONS OF THE IV ESTIMATION OF CROP PRODUCTION WITH UNBUNDLED VILLAGE VARIABLES

	(1) Value of purchased inputs	(2) Acres of cultivated land	(3) Total labour used
Dummy hired labour	0.975***	0.028	0.059*
	(10.70)	(1.27)	(1.65)
Log value of capital	0.061***	0.008*	0.007
	(2.66)	(1.77)	(1.00)
Log age of the head	-0.229*	0.021	-0.048
	(1.68)	(0.61)	(0.88)
Dummy for corrections on age of the head [1]	-0.368	-0.061	0.048
	(1.25)	(1.63)	(0.24)
Log average years of education of head	0.091	0.010	0.045*
	(1.41)	(0.83)	(1.83)
Share of land improved with rock bund	-0.147	0.009	-0.078
	(0.45)	(0.10)	(0.75)
Share of land improved with soil bund	-0.259	0.005	0.032
	(1.49)	(0.11)	(0.46)
Share of land improved with mulching	-0.095	-0.075	0.014
	(0.31)	(1.53)	(0.19)
Share of land improved with terraces	0.061	-0.031	0.078**
	(0.70)	(1.41)	(1.97)
Share of land improved with grass lines	0.011	-0.000	0.206*
	(0.04)	(0.00)	(1.87)
Share of land with soil of medium good quality	0.003	0.001	0.010
	(0.04)	(0.03)	(0.31)
Share of land with gentle or steep slope	0.030	-0.023	0.047
	(0.36)	(1.00)	(1.25)
Dummy tobacco production	0.590***	0.137**	0.260***
	(3.25)	(2.48)	(3.73)
Dummy cashew nut production	-0.257**	0.104***	0.215***
	(2.18)	(2.85)	(3.99)
Dummy coffee production	-0.019	0.046	0.250***
	(0.14)	(1.54)	(4.44)
Dummy banana production	0.114	0.036	0.159***
	(1.44)	(1.60)	(4.27)
Dummy average rain on parcel is below normal	-0.003	0.029	-0.039
	(0.03)	(1.15)	(0.86)
Dummy average rain on parcel is much below normal	0.125	0.049	0.001
	(1.04)	(1.61)	(0.02)
Dummy: 1=drought shock since 1998	-0.345**	-0.038	0.090
	(1.99)	(0.87)	(1.22)
Proportion of land irrigated	0.116	0.067	0.045
	(0.52)	(0.88)	(0.57)
Log size of land three years ago	0.682***	0.817***	0.095***
	(8.94)	(33.13)	(3.19)
Log total labour lagged	-0.131***	-0.080***	0.172***
	(3.10)	(5.17)	(5.88)
Dummy for chemical fertilizer used lagged	1.066***	-0.017	-0.024
	(12.73)	(0.84)	(0.77)
Dummy for chemicals used lagged	0.184*	0.031	0.007
	(1.84)	(1.63)	(0.21)
Dummy for improved seeds lag	0.137	-0.054*	-0.161**
	(0.82)	(1.96)	(2.24)
Dummy: 1=death shock since 1998	-0.023	0.012	-0.044
	(0.23)	(0.50)	(1.13)
Dummy: 1=illness shock since 1998	-0.021	-0.001	0.059
	(0.21)	(0.05)	(1.49)
Dummy: 1=belong to SACCO	-0.112	0.015	0.072
	(0.90)	(0.57)	(1.64)
Dummy: 1=have bank account	0.534***	0.052	-0.067
	(3.49)	(1.54)	(1.13)
Easy to get seasonal credit for inputs on the farm	-0.034	-0.026	-0.082**
	(0.33)	(1.06)	(2.21)
Dummy for junior secondary school available in the village	0.302**	-0.055*	-0.050
Dummy for hospital available in the village	0.157	0.019	-0.233*
	(0.74)	(0.45)	(1.68)
Dummy for village well available in the village	-0.268**	-0.015	0.004
	(2.32)	(0.53)	(0.07)
Dummy for public water tap available in the village	0.038	-0.080**	0.026
	(0.30)	(2.10)	(0.52)
Dummy for market available in the village	-0.040	0.019	-0.040
	(0.39)	(0.80)	(0.96)
Dummy for all weather road (tarmac) available in the village	-0.229	0.171**	-0.432***
	(0.73)	(2.25)	(3.41)
Dummy for bus service to nearby town available in the village	0.689***	-0.010	-0.081
	(4.88)	(0.29)	(1.28)

TABLE 16C (CONTINUED): RUVUMA: RESULTS OF THE FIRST STAGE REGRESSIONS OF THE IV ESTIMATION OF CROP PRODUCTION WITH UNBUNDLED VILLAGE VARIABLES

	(1) Value of purchased inputs	(2) Acres of cultivated land	(3) Total labour used
Dummy for village bank or other formal credit society or association available	0.283	-0.036	0.118
	(1.64)	(0.92)	(1.63)
Dummy for agricultural extension agent available in the village	-0.229	-0.009	-0.103*
	(1.46)	(0.22)	(1.71)
Dummy for veterinary service available in the village	0.289*	-0.005	0.082
	(1.92)	(0.17)	(1.39)
Dummy for primary society available in the village	-0.120	0.012	0.020
	(1.16)	(0.48)	(0.43)
Constant	2.341***	0.678***	4.837***
	(3.85)	(4.04)	(17.69)
Observations	892	892	892
R-squared	0.56	0.81	0.44

Robust t statistics in parentheses
* significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent
[1]To recover 11 missing observations, the age of the head was replaced with the average age of the head in the sample and a dummy for the changed observations added.
Source. Computed by authors

TABLE 17A: KILIMANJARO: ESTIMATION OF TOTAL AGRICULTURAL PRODUCTION FUNCTION

Dependent variable log gross value of total agricultural production	(1) IV regression with dummies for ward	(2) IV regression with village variables
Log acres of land cultivated [1]	0.649***	0.621***
	(4.08)	(3.70)
Log value of total inputs used [1]	0.420***	0.449***
	(3.72)	(4.11)
Log total (hired family) labour (number of days) [1]	0.334**	0.266**
	(2.51)	(2.06)
Dummy for hired labour	-0.278*	-0.311*
	(1.87)	(1.91)
Log value of agricultural capital	0.047**	0.063***
	(2.14)	(2.80)
Log age of the head	0.162	0.148
	(1.10)	(0.92)
Log mean years of education of the head	0.015	0.032
	(0.23)	(0.43)
Share of land improved with rock bund	0.354	0.299
	(1.38)	(1.21)
Share of land improved with soil bund	0.281**	0.244*
	(1.99)	(1.71)
Share of land improved with mulching	0.224	0.239
	(1.56)	(1.61)
Share of land improved with terraces	-0.061	0.015
	(0.35)	(0.08)
Share of land improved with grass lines	-0.066	0.109
	(0.44)	(0.59)
Share of land with soil of medium good quality	0.058	-0.007
	(0.32)	(0.03)
Share of land with gentle or steep slope	0.457*	0.508*
	(1.78)	(1.90)
Dummy: 1=death since 1998 affected living conditions	0.042	0.025
	(0.46)	(0.26)
Dummy: 1=illness since 1998 affected living conditions	0.075	0.042
	(0.81)	(0.42)
Dummy average rain on parcel is below normal	-0.394***	-0.393***
	(4.69)	(4.47)
Dummy average rain on parcel is much below normal	-0.483***	-0.409***
	(4.36)	(3.45)
Dummy: 1=drought since 1998 affected living conditions	-0.115	-0.119
	(1.21)	(1.24)
Proportion of land irrigated	0.233*	0.263**
	(1.88)	(2.25)
Dummy senior secondary school available in the village		-0.077
		(0.45)
Dummy hospital available in the village		-0.099
		(0.25)
Dummy bore hole for water available in the village		0.001
		(0.01)
Dummy community well water available in the village		0.101
		(0.56)
Dummy market available in the village		-0.112
		(0.92)
Dummy all weather road (tarmac) available in the village		0.100
		(0.44)
Dummy electricity available in the village		0.093
		(0.67)
Dummy public telephone available in the village		0.089
		(0.82)
Dummy availability of bus services to nearby village		-0.084
		(0.79)
Dummy agricultural extension agent available in the village		-0.049
		(0.53)
Dummy veterinary service available		-0.024
		(0.23)
Dummy agricultural input supply shop available		0.180
		(1.49)
Constant	0.575	0.640
	(0.60)	(0.62)
Observations	925	798
R-squared	0.39	0.33

TABLE 17A (CONTINUED): KILIMANJARO: ESTIMATION OF TOTAL AGRICULTURAL PRODUCTION FUNCTION

	(1) IV regression with dummies for ward	(2) IV regression with village variables
Test for return to scale		
Test H0= land + inputs + total labour + agricultural capital= 1		
F-value	10.14	1782.36
P value	0.0015	0.0000
Test for exogeneity of regressors H0=Regressors are exogenous		
Wu-Hausman		
F Test	2.53307	1.74897
P-Value	0.05578	0.15555
Durbin-Wu-Hausman		
Chi-sq test Chi-sq(3)	8.13010	5.45723
P-Value	0.04340	0.14122

Robust t statistics in parentheses
 * significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent
Column 1- Dummies for ward estimated but not reported
[1] variables instrumented
Source: Computed by authors

TABLE 17B: KILIMANJARO: RESULTS OF THE FIRST STAGE REGRESSIONS OF THE IV ESTIMATION OF TOTAL AGRICULTURAL PRODUCTION WITH SIMPLE VILLAGE EFFECTS

	(2) Acres of cultivated land	(3) Total labour used	(4) Value of total purchased Inputs
Dummy for hired labour	0.073***	0.174***	1.009***
	(3.48)	(4.22)	(12.65)
Log value of agricultural capital	0.014**	0.013	0.077***
	(2.31)	(1.21)	(4.10)
Log age of the head	-0.062*	-0.022	-0.323**
	(1.91)	(0.34)	(2.31)
Log mean years of education of the head	-0.016	0.036	0.121*
	(1.09)	(1.25)	(1.92)
Share of land improved with rock bund	0.005	-0.007	-0.285
	(0.84)	(0.10)	(0.87)
Share of land improved with soil bund	-0.044	-0.011	-0.171
	(0.10)	(0.08)	(1.20)
Share of land improved with mulching	-0.048*	0.008	0.098
	(1.88)	(0.15)	(0.70)
Share of land improved with terraces	0.020	-0.121**	0.014
	(0.62)	(2.32)	(0.11)
Share of land improved with grasslines	0.037	0.061	0.049
	(1.04)	(0.74)	(0.33)
Share of land with soil of medium good quality	-0.001	-0.109*	0.259*
	(0.02)	(1.67)	(1.92)
Share of land with gentle or steep slope	0.052	-0.007	-0.058
	(1.21)	(0.09)	(0.28)
Dummy for coffee trees	0.074***	0.002	-0.006
	(2.96)	(0.02)	(0.05)
Dummy for coffee trees	0.018	0.285***	-0.108
	(0.34)	(3.31)	(0.80)
Dummy average rain on parcel is below normal	0.011	-0.035	0.169**
	(0.55)	(0.87)	(2.06)
Dummy average rain on parcel is much below normal	-0.008	0.085**	0.111
	(0.28)	(1.99)	(1.03)
Dummy: 1=drought since 1998 affected living conditions	0.020	-0.106**	0.184**
	(0.84)	(2.41)	(2.31)
Proportion of land irrigated	-0.011	0.160**	0.049
	(0.35)	(2.58)	(0.40)
Log size of land three years ago	0.708***	0.014	0.435***
	(20.99)	(0.31)	(4.90)
Log total labour lagged	-0.011	0.288***	-0.084**
	(1.06)	(5.70)	(2.46)
Dummy for chemical fertilizer used lagged	0.104***	0.153***	0.441***
	(3.78)	(3.19)	(4.54)
Dummy for chemicals used lagged	0.019	-0.018	0.374***
	(0.89)	(0.47)	(4.88)
Dummy for improved seeds lag	0.005	0.024	0.304***
	(0.22)	(0.47)	(3.76)
Dummy: 1=death since 1998 affected living conditions	-0.020	-0.018	-0.017
	(0.92)	(0.36)	(0.21)
Dummy: 1=illness since 1998 affected living conditions	0.004	-0.117**	0.062
	(0.19)	(2.55)	(0.79)
Dummy: 1=belong to SACCO	0.033	0.083	0.030
	(1.09)	(1.61)	(0.25)
Has an individual banking account	-0.037	-0.070	0.254***
	(1.08)	(0.76)	(2.69)
Easy to get seasonal credit for inputs on the farm	-0.017	-0.006	0.045
	(0.76)	(0.16)	(0.55)
Constant	0.514***	3.704***	3.514***
	(3.27)	(9.42)	(5.07)
Observations	951	951	951
R-squared	0.74	0.53	0.54

Dummies for villages estimated but not reported
Robust t statistics in parentheses
* significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent
Source: Computed by authors

5 Allocative efficiency

Allocative efficiency relates to the issue of whether farmers use resources in line with market signals. In particular, it determines whether the factors of production are used in proportions that ensure maximum profit given the prices for output and inputs. In this study, allocative efficiency was explored by using the estimated production functions to calculate the value of marginal product of factors *i* (VMP_i) as in Lerman and Grazhdaninova (2005) and Carter and Wiebe (1990).

For each farmer (to simplify notation an index of the farmer has been omitted) the marginal product of factor X_i can be calculated as follows:

$$MPX = \frac{\partial Q}{\partial X_i} = \left(\frac{\partial \ln Q}{\partial \ln X_i}\right)\frac{Q}{X_i} = \beta_i \frac{Q}{X_i} \qquad (2)$$

Where β_i is the estimated Cobb-Douglas regression coefficient for factor X_i .

Allocative efficiency is determined by comparing the value of marginal product of factor X_i (VMP_i) with the marginal factor cost (MFC_i). We assume that farmers are price takers in input markets, so that the price of factor $X_i(P_i)$ approximates (MFC_i). If $VMP_i > P_i$, factor *i* is underused and farm profits or efficiency can be raised by increasing the use of this factor. If, conversely $VMP_i < P_i$, the input is overused and to raise farm profits its use should be reduced. Maximum profit or minimum cost (and thus allocative efficiency) is obtained when $VMP_i = P_i$.

From the results of the IV regressions for total agricultural production (shown in Tables 17a and 18[17]) we can compute the value of the marginal products of the four basic factors of production for each household and compare them with the respective market prices.[18] Tables 19a and 19b report the averages of these marginal products for Kilimanjaro and Ruvuma, and the comparisons with the respective market values. As a measure of the market value of land, the average crop value added per acre as reported in Tables 5a and 5b was used. It would have been more appropriate to use land rental values, or land sales prices multiplied by some discount rate, but there are no rentals and very few land sales reported in the survey, and hence averaging these would not be reliable. In any case the land market in Tanzania operates largely under a traditional tenure system, where sales and purchases are not common. Concerning intermediate inputs the marginal products must be compared to one, as the variables used for inputs and output are expressed in thousand Tsh. Concerning capital, the variables for capital and output are expressed in thousand Tsh. Rental values of capital and local interest rates are not known. Nevertheless, if the discount rate is smaller than one, the VMP of capital should be compared to a value smaller than one. For lack of any better value, a value of 0.2 was utilized for the comparisons in the tables, in effect assuming a depreciation rate of 20 percent. Finally, concerning labour, there are direct observations from each household regarding the wage rates paid for hired labour (both in cash and in kind), which were averaged across the sample).

[17] The crop production functions were also utilized, with similar results.

[18] Note that since the dependent variable in the production functions is the gross value of total agricultural output, the marginal product of X (MPX) is in effect the value of the marginal product.

TABLE 18: RUVUMA: ESTIMATION OF TOTAL AGRICULTURAL PRODUCTION FUNCTION

Dependent variable log gross value of total agricultural production	(1) IV with dummies for villages	(2) OLS with dummies for villages	(3) IV with village variables	(4) OLS with village variables
Log acres of land cultivated [1]	0.523***	0.493***	0.310***	0.250***
	(5.91)	(8.19)	(4.14)	(4.41)
Log total inputs used [1]	0.169***	0.225***	0.286***	0.274***
	(3.13)	(9.02)	(6.23)	(12.42)
Log total labour on farm [1]	0.443***	0.421***	0.479***	0.375***
	(4.22)	(5.16)	(4.43)	(5.03)
Dummy hired labour	0.017	-0.045	-0.089	0.025
	(0.20)	(0.66)	(1.06)	(0.36)
Log value of capital	0.064***	0.061***	0.066***	0.083***
	(4.28)	(4.15)	(4.71)	(6.36)
Log age of the head	-0.007	0.003	0.098	0.196*
	(0.07)	(0.03)	(0.98)	(1.94)
Dummy for corrections on age of the head [2]	-0.127	-0.102	-0.195	-0.464**
	(0.53)	(0.43)	(0.79)	(2.28)
Log average years of education of head	0.102**	0.090*	0.096*	0.143***
	(2.15)	(1.94)	(1.96)	(2.86)
Share of land improved with rock bund	0.665*	0.641*	0.627**	0.618*
	(1.88)	(1.82)	(2.45)	(1.86)
Share of land improved with soil bund	0.092	0.104	0.152*	0.223**
	(1.03)	(1.18)	(1.81)	(2.43)
Share of land improved with mulching	0.148	0.143	0.256	0.356*
	(0.82)	(0.84)	(1.41)	(1.89)
Share of land improved with terraces	-0.059	-0.060	-0.036	0.031
	(1.02)	(1.05)	(0.60)	(0.51)
Share of land improved with grass lines	-0.251	-0.265	-0.173	-0.073
	(1.32)	(1.38)	(0.90)	(0.40)
Share of land with soil of medium good quality	-0.161***	-0.155***	-0.155***	-0.189***
	(3.01)	(2.94)	(2.84)	(3.35)
Share of land with gentle or steep slope	0.005	0.004	0.091	0.139**
	(0.08)	(0.06)	(1.49)	(2.20)
Dummy: 1=death shock since 1998	0.097	0.102	0.122*	0.152**
	(1.41)	(1.50)	(1.76)	(2.24)
Dummy: 1=illness shock since 1998	-0.029	-0.023	-0.009	0.007
	(0.45)	(0.35)	(0.13)	(0.09)
Dummy average rain on parcel is below normal	0.035	0.032	0.006	-0.010
	(0.50)	(0.45)	(0.09)	(0.13)
Dummy average rain on parcel is much below normal	0.046	0.034	-0.029	-0.045
	(0.57)	(0.43)	(0.37)	(0.55)
Dummy: 1=drought shock since 1998	0.199**	0.230**	0.177*	0.158*
	(2.10)	(2.57)	(1.87)	(1.65)
Proportion of land irrigated	0.294	0.302	0.367**	0.306*
	(1.62)	(1.62)	(1.97)	(1.70)
Dummy for junior secondary school available in the village			0.189**	
			(1.99)	
Dummy for hospital available in the village			0.396**	
			(2.48)	
Dummy for village well available in the village			-0.320***	
			(4.31)	
Dummy for public water tap available in the village			0.169**	
			(2.10)	
Dummy for market available in the village			0.211***	
			(3.12)	
Dummy for all weather road (tarmac) available in the village			-0.071	
			(0.36)	
Dummy for bus service to nearby town available in the village			0.182	
			(1.63)	
Dummy for village bank or other formal credit society or association available			0.139	
			(1.24)	
Dummy for agricultural extension agent available in the village			0.257**	
			(2.56)	

TABLE 18 (CONTINUED): RUVUMA: ESTIMATION OF TOTAL AGRICULTURAL PRODUCTION FUNCTION

	(1) IV with dummies for villages	(2) OLS with dummies for villages	(3) IV with village variables	(4) OLS with village variables
Dummy for veterinary service available in the village			-0.166*	
			(1.80)	
Dummy for primary society available in the village			-0.309***	
			(4.59)	
Constant	1.111	1.057	0.348	0.547
	(1.48)	(1.64)	(0.47)	(0.85)
R-squared	0.58	0.58	0.52	0.46
Test for return to scale				
Test H0= land + inputs + total labour + agricultural capital= 1				
F-value	4.77	6.17	2.42	0.07
P value	0.0292	0.0132	0.1201	0.7935
Test for exogeneity of regressors H0=Regressors are exogenous				
Wu-Hausman			1.86753	
F Test	0.90184		0.13350	
P-Value	0.43976			
Durbin-Wu-Hausman				
Chi-sq test Chi-sq(3)	2.89350		5.80256	
P-Value	0.40834		0.12162	

Robust t statistics in parentheses
* significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent
[1] Variables instrumented
[2] To recover 11 missing observations, the age of the head was replaced with the average age of the head in the sample and a dummy for the changed observations added
Column 1- Dummies for villages estimated but not reported
Source: Computed by authors

TABLE 19A: KILIMANJARO: MARGINAL PRODUCTS OF PRODUCTION FACTORS COMPARED TO MARKET PRICES OF THE FACTORS (MEANS ACROSS THE REPORTED GROUPS)

	All	Poor	Non-poor	Coffee producers	Non coffee producers	Net food buyers	Net food sellers
Marginal product of land	130	143	104.6	133.9	125.4	103.8	218.9
Value added crop prod./acre ('000 Tsh/acre)	*84*	*75*	*89*	*90*	*76*	*66*	*143*
Marginal product of purchased inputs *(compared to 1)*	13.9	14.0	13.5	9.2	21.1	14.5	11.6
Marginal product of labour (*'000 Tsh/day/man)*	0.64	0.72	0.49	0.54	0.8	0.45	1.2
Market price of labour ('000 Tsh/day/man)	*1.5*	*1.3*	*1.6*	*1.49*	*1.66*	*1.55*	*1.61*
Marginal product of capital *(Compared to 0.2)*	1.11	1.24	1.06	0.98	1.46	0.85	1.71

Source. Computed by authors

TABLE 19B: RUVUMA: MARGINAL PRODUCTS OF PRODUCTION FACTORS COMPARED TO MARKET PRICES OF THE FACTORS (MEANS ACROSS THE REPORTED GROUPS)

	All	Poor	Non poor	Coffee producers	Tobacco producers	Cashew nuts producers	Non cash crop producers	Net food buyers	Net food sellers
Marginal product of land	29.5	22.9	37.7	35.7	25.4	14.6	34.3	26.9	32.9
Value added crop prod./acre ('000 Tsh/acre)	*37*	*31*	*43*	*48*	*24*	*19*	*40*	*32*	*43*
Marginal product of purchased inputs *(compared to 1)*	5.06	5.50	4.50	5.56	0.56	5.33	4.96	5.57	4.38
Marginal product of labour (*'000 Tsh/day/man)*	0.28	0.21	0.37	.28	0.22	0.16	0.36	0.24	0.34
Market price of labour ('000 Tsh/day/man)	1.10	1.09	1.10	.94	1.50	1.12	1.17	1.09	1.10
Marginal product of capital *(Compared to 0.2)*	2.21	3.96	1.08	1.41	2.40	2.23	3.48	0.91	3.88

Source. Computed by authors

The results suggest that agricultural households in Tanzania utilize some resources efficiently but others very inefficiently. The marginal product of land in Kilimanjaro is on average larger than its "optimal" value as proxied by the crop value added per acre. This holds across all groups and suggests that farm sizes are too small and that there must be some constraints to acquiring additional land to cultivate in Kilimanjaro. In Ruvuma, the average marginal products of land are slightly below the optimal market values (the VMP of land is about 20 percent below its average value added per acre), indicating a slight land overuse and suggesting that acquiring additional land is not a constraint. This suggests that households use more land than justified. These results seem to be in line with conventional wisdom in Tanzania, whereby good agricultural land is perceived to be in short supply in Kilimanjaro, while it is generally thought to be more abundant in Ruvuma. As expected, and as suggested by the earlier descriptive tables, the marginal product of land is much higher in Kilimanjaro than in Ruvuma (about four times higher on average) and the same holds true for the estimated value added per acre (in Kilimanjaro it is a little more than twice as large as the value in Ruvuma). This difference between the ratios of the marginal product of land and the value added per acre suggests that land is more intensively cultivated in Kilimanjaro and is consistent with the hypothesis of greater scarcity of agricultural land in Kilimanjaro.

Concerning intermediate inputs, the marginal products for all groups and in both regions are substantially larger than 1, which suggests that intermediate inputs are used far below their optimum amount. There appears to be considerable room for input use expansion to boost farm profits, with the striking exception of the tobacco producers in Ruvuma. This is the only group for whom the average value of the marginal product of inputs is below 1, which means that they are in fact overutilizing inputs, contrary to the experience of other households. The reason for this could be that tobacco producers in Ruvuma operate largely under contract with tobacco companies, who supply inputs as part of their contracting arrangements. Other farmers, who do not operate under contracts, have to finance input purchases from their own resources, which may limit their use of inputs because of either lack of access to credit or inability to pay back the costs incurred should harvests fail.

The differing experience between tobacco and other farmers in their use of inputs draws attention to the importance of interlinked markets in facilitating access to inputs. In Tanzania the government abolished the export marketing boards that used to link the purchase of the output of exportable crops from the farmers with advance financing and provision of inputs to the farmers. As farmers depended on the marketing boards to sell their output after the harvest, default on these loans was limited and the enforcement of the contracts relatively inexpensive. Now farmers must finance any inputs they purchase from their own resources, or through credit. Given the difficulties in obtaining seasonal credit and the limited participation in formal financial institutions, the break in the link between marketing and finance may have induced farmers to reduce the amount of inputs utilized to below their optimal levels. While this study does not have data on earlier use of inputs, i.e. during the period when the marketing boards were in function, the very low current use of productive inputs, and the inefficiency revealed by the above analysis, support such a hypothesis.

As regards labour, the results show that the marginal products of labour used on farms are much lower than market wages, which suggests considerable excess labour use in farm production. In fact, as reported earlier, the average amount of family labour days spent by households on their farms is very high. These results are consistent with those reported earlier which alluded to considerable excess supply of family labour in farm households, especially in Ruvuma, where the ratio of VMP of labour to wage is about four (and twice as high as in

Kilimanjaro). This excess labour may be the result of a lack of off-farm wage earning opportunities, or of credit constraints to expanding labour-intensive production.

Concerning the marginal product of capital, the overall average marginal product appears to be much higher than 0.2. It is close to 1 in Kilimanjaro, and far above one in Ruvuma. This suggests that much less than the optimal agricultural capital is utilized and it follows that capital is used much below its marginal productivity. There are significant differences between poor and non-poor farmers, with the average value of the marginal product of capital for the poor much lower than for the non-poor in both regions, indicating that the poor are much more constrained on the capital side. It thus appears that there are capital accumulation constraints, particularly among the poor.

These results, which show that capital appears on average to be inefficiently utilized, coupled with a very low overall capital intensity of production (as indicated in Tables 4a and b) may be due to limited possibilities for capital accumulation, or to quite real investment credit constraints (as illustrated in Tables 6a and b). If farmers do not have enough capital and cannot obtain formal or informal credit, then the development issue is one of facilitating the savings of farmers, in order for them to invest more using their own resources, or facilitating the provision or conditions for more formal investment capital. This issue is explored later in this paper.

6 Analysis of technical efficiency

Technical efficiency is a measure of how the output generated by a farm given a certain amount of inputs relates to the maximum amount which could be generated with the same amount of inputs. A technically efficient farm produces the maximum amount of output attainable from a given input level, resulting in an efficiency ratio of one. A production frontier can thus be traced whereby each point on the frontier represents the maximum output given a certain combination of inputs. In practice, the maximum amount possible given a certain input level is typically based on observed best practice among peers. In other words, in practice efficiency measures are in effect measures of relative efficiency, i.e. in relation to best practice among peers. The maximum possible amount could also be based on the output generated under experimental conditions. However, no judgement is made about whether the amount of inputs used is also the optimal amount to maximize profits. An outward shift in the frontier can be induced through technological innovation, though this usually takes time.

There are two main approaches to estimating technical efficiency, 1) a parametric approach using Stochastic Frontier Analysis (SFA), and 2) a non-parametric approach using Data Envelopment Analysis (DEA). Both approaches allow one to define an efficiency index which measures how far a farm is from the production or cost frontier given its use of inputs. The degree of inefficiency of a farm is represented by the distance by which it lies below its production function or above its cost function. Technically efficient farms lie on the production frontier. In this paper we estimate technical efficiency using a stochastic production frontier approach. As indicated above, "production frontier" refers to the maximum output attainable through a given technology and input bundle. A stochastic frontier also allows for random deviations from the frontier due to undetermined production factors (e.g. rainfall shocks). The estimation procedure takes this into account through a white noise term, while inefficiency is captured through an additional one-sided error term representing the factors that account for farms distancing themselves from the boundary. A more detailed explanation of the estimation procedure is provided in Appendix 2.

Tables 20a, b and c present the results of the study's technical efficiency analysis for Kilimanjaro using the gross value of total agricultural production as dependent variable and the Battese-Coelli approach and programmes. Two functions are estimated, one with fixed village effects, and the other with village specific infrastructure variables replacing the single village effects. Tables 21a, b and c present the results for Ruvuma.[19] In order to investigate differences in technical efficiency of physical production, the same regional prices were used to calculate for all producers and products the total value of agricultural production, using a procedure similar to that followed in the estimation of the production function. Differences in efficiency could not then be attributed to marketing inefficiencies of farmers or other factors that could lead to different prices of products received by each farmer.

[19] The efficiency analysis was also carried out using the fitted variables from the IV regressions rather than the original variables. The results are similar to those indicated in the tables.

TABLE 20A: KILIMANJARO: STOCHASTIC FRONTIER ESTIMATION

Dependent variable log total gross value of agricultural production	With dummies for ward	With village variables
Log acres of land cultivated	0.739***	0.682***
	(8.70)	(7.53)
Log value of total inputs used	0.168***	0.195***
	(5.34)	(5.96)
Log total (hired and family) labour (number of days)	0.228***	0.183***
	(4.11)	(3.14)
Dummy for hired labour	0.040	0.080
	(0.51)	(0.92)
Log value of agricultural capital	0.052***	0.071***
	(2.98)	(3.73)
Log age of the head	0.050	0.041
	(0.27)	(0.21)
Log mean years of education of the head	0.024	0.085
	(0.29)	(1.06)
Share of land improved with rock bund	-0.068	-0.075
	(0.30)	(0.32)
Share of land improved with soil bund	0.145	0.092
	(1.14)	(0.67)
Share of land improved with mulching	0.203*	0.231**
	(1.83)	(1.97)
Share of land improved with terraces	0.091	0.206
	(0.74)	(1.61)
Share of land improved with grass lines	-0.122	0.085
	(0.95)	(0.58)
Share of land with soil of medium good quality	0.265*	0.124
	(1.81)	(0.80)
Share of land with gentle or steep slope	0.204	0.286
	(1.15)	(1.52)
Dummy: 1=death since 1998 affected living conditions	0.050	0.039
	(0.68)	(0.50)
Dummy: 1=illness since 1998 affected living conditions	0.011	0.047
	(0.15)	(0.59)
Dummy average rain on parcel is below normal	-0.313***	-0.298***
	(4.47)	(4.00)
Dummy average rain on parcel is much below normal	-0.296***	-0.196**
	(3.30)	(2.04)
Dummy: 1=drought since 1998 affected living conditions	-0.058	-0.061
	(0.77)	(0.77)
Proportion of land irrigated	0.212**	0.309***
	(1.99)	(2.76)
Dummy senior secondary school available in the village		-0.211
		(0.93)
Dummy hospital available in the village		-0.199
		(0.56)
Dummy bore hole for water available in the village		0.130
		(0.74)
Dummy community well water available in the village		0.090
		(0.63)
Dummy market available in the village		-0.098
		(0.90)
Dummy all weather road (tarmac) available in the village		0.027
		(0.13)
Dummy electricity available in the village		0.119
		(0.98)
Dummy public telephone available in the village		-0.006
		(0.06)
Dummy availability of bus services to nearby village		-0.051
		(0.52)
Dummy veterinary service available		0.047
		(0.50)
Dummy agricultural input supply shop available		0.167
		(1.57)
Constant	2.989***	2.829***
	(3.37)	(3.04)
Observations	922	795

Dummies for ward estimated but not reported
Absolute value of z statistics in parentheses
* significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent
Source. Computed by authors

TABLE 20B. KILIMANJARO: DETERMINANTS OF TECHNICAL INEFFICIENCY OF TOTAL AGRICULTURAL PRODUCTION USING VILLAGE FIXED EFFECTS

Determinants of agriculture technical efficiency	Coefficient	z-value	P>|z|
Log head age	-0.205	-0.44	0.661
Log head education	0.217	1.09	0.278
Log nb adult equivalent	-1.116	-3.35	0.001
Has electricity	-0.506	-1.08	0.280
Has tap water	-0.230	-1.05	0.295
Has bike	-0.248	-0.90	0.370
Average distance parcels from household compound in km	-0.000	-0.08	0.936
Average weighted distance from parcel to road	-0.191	-1.79	0.073
Number of years out of the past 10, when total household income fell far below average	-0.019	-0.32	0.747
Dummy SACCO	0.221	0.70	0.482
Dummy banking account	-0.703	-1.60	0.110
Dummy easy access to formal credit from bank & institutions	-0.820	-2.27	0.023
Has consulted an extension	-0.236	-0.88	0.378
Dummy for remittances	-0.219	-0.82	0.415
Dummy for non farm business	-0.442	-1.97	0.049
Share of time to non agricultural activities	-0.247	-0.36	0.717
Dummy if 1 adult female completed primary education	0.030	0.13	0.896
Dummy if 2 adult female completed primary education	-0.162	-0.65	0.513
Dummy if more than 2 adult female completed primary education	-0.870	-2.07	0.039
Constant	2.837	1.34	0.181

A negative sign of the coefficient increases farmer's efficiency; shaded variables are significant.
Source: Computed by authors.

TABLE 20C: KILIMANJARO: DETERMINANTS OF TECHNICAL INEFFICIENCY OF TOTAL AGRICULTURAL PRODUCTION USING VILLAGE VARIABLES

Determinants of agriculture technical efficiency	Coefficient	z-value	P>|z|
Log head age	-.258	-0.62	0.538
Log head education	.251	1.32	0.188
Dummy senior secondary school available in the village	-.336	-0.62	0.534
Dummy agricultural extension agent available in the village	.287	1.54	0.123
Log nb adult equivalent	-.884	-3.34	0.001
Has electricity	.058	0.19	0.848
Has tap water	-.203	-1.01	0.312
Has bike	-.217	-1.04	0.298
Average distance parcels from household compound in km	-.0004	-0.08	0.937
Average weighted distance from parcel to road	-.197	-3.08	0.002
Number of years out of the past 10, when total household income fell far below average	-.005	-0.10	0.923
Dummy Sacco	.510	1.99	0.047
Dummy banking account	-.588	-1.77	0.077
Dummy easy access to formal credit from bank & institutions	-.835	-2.93	0.003
Has consulted an extension	-.029	-0.16	0.873
Dummy for remittances	-.182	-0.69	0.491
Dummy for non farm business	-.239	-1.38	0.167
Share of time to non agricultural activities	-.401	-0.64	0.522
Dummy if 1 adult female completed primary education	-.081	-0.37	0.710
Dummy if 2 adult female completed primary education	-.174	-0.77	0.440
Dummy if more than 2 adult female completed primary education	-.720	-2.45	0.014
Constant	2.974	1.58	0.114

A negative sign of the coefficient increases farmer's efficiency; shaded variables are significant.
Source: Computed by authors.

TABLE 21A: RUVUMA: STOCHASTIC FRONTIER ESTIMATION

Dependent variable log total gross value of agricultural production	With dummies for villages	With village variables
Log acres of land cultivated	0.465***	0.432***
	(8.26)	(7.83)
Log value of total inputs	0.213***	0.223***
	(10.53)	(11.27)
Log total labour on farm	0.308***	0.314***
	(6.57)	(6.61)
Dummy hired labour	-0.037	-0.036
	(0.59)	(0.57)
Log value of capital	0.065***	0.069***
	(4.79)	(5.79)
Log age of the head	-0.029	-0.037
	(0.23)	(0.30)
Dummy for corrections on age of the head [1]	-0.770***	-0.351
	(4.44)	(1.02)
Log average years of education of head	-0.014	0.030
	(0.25)	(0.54)
Share of land improved with rock bund	0.445	0.459
	(1.44)	(1.46)
Share of land improved with soil bund	0.107	0.096
	(1.05)	(0.94)
Share of land improved with mulching	0.240	0.291
	(1.34)	(1.64)
Share of land improved with terraces	-0.074	-0.031
	(1.40)	(0.56)
Share of land improved with grass lines	-0.225	-0.154
	(1.43)	(0.99)
Share of land with soil of medium good quality	-0.168***	-0.157***
	(3.57)	(3.27)
Share of land with gentle or steep slope	0.031	0.066
	(0.59)	(1.28)
Dummy: 1=death shock since 1998	0.100*	0.117*
	(1.67)	(1.89)
Dummy: 1=illness shock since 1998	-0.019	-0.011
	(0.33)	(0.20)
Dummy average rain on parcel is below normal	0.027	0.032
	(0.43)	(0.51)
Dummy average rain on parcel is much below normal	0.008	-0.010
	(0.11)	(0.14)
Dummy: 1=drought shock since 1998	0.192*	0.162
	(1.89)	(1.50)
Proportion of land irrigated	0.286**	0.385***
	(1.99)	(2.62)
Dummy for junior secondary school available in the village		0.175**
		(2.00)
Dummy for hospital available in the village		0.425**
		(2.45)
Dummy for bore hole for water available in the village		-0.204
		(1.18)
Dummy for village well available in the village		-0.282***
		(4.59)
Dummy for public water tap available in the village		0.168**
		(2.36)
Dummy for market available in the village		0.161**
		(2.54)
Dummy for bus service to nearby town available in the village		0.197**
		(2.33)
Dummy for village bank or other formal credit society or association available in village		0.075
		(0.73)
Dummy for agricultural extension agent available in the village		0.116
		(1.18)
Dummy for veterinary service available in the village		-0.156*
		(1.90)

TABLE 21A (CONTINUED): RUVUMA: STOCHASTIC FRONTIER ESTIMATION

	With dummies for villages	With village variables
Dummy for primary society available in the village		-0.267***
		(4.64)
Constant	2.701***	2.507***
	(4.61)	(4.40)
Observation	881	881

Dummies for ward estimated but not reported
Absolute value of z statistics in parentheses
[1] To recover 11 missing observations, the age of the head was replaced with the average age of the head in the sample and a dummy for the changed observations added.
* significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent
Source. Computed by authors

TABLE 21B: RUVUMA: DETERMINANTS OF TECHNICAL INEFFICIENCY OF TOTAL AGRICULTURAL PRODUCTION USING VILLAGE FIXED EFFECTS

Determinants of agriculture technical efficiency	Coefficient	z-value	P>|z|
Log head age	-18.317	-3.51	0.000
Square log head age	2.429	3.48	0.001
Dummy for corrections on age of the head [1]	-22.114	-0.05	0.958
Log head education	-.201	-1.16	0.245
Log nb adult equivalent	-.523	-1.96	0.050
Has bike	1.335	0.99	0.320
Has tap water	-.227	-0.52	0.603
Average distance parcels from household compound in km	-.039	-0.25	0.805
Average weighted distance from parcel to road	.002	0.93	0.353
Number of years out of the past 10, was total household income declined a lot below average	.010	0.40	0.688
Dummy SACCO	.053	0.24	0.810
Dummy banking account	-.879	-2.49	0.013
Dummy easy access to formal credit from bank & institutions	.365	1.24	0.214
Dummy for remittances	-.302	-1.01	0.313
Dummy for non farm business	-.541	-2.24	0.025
Share of time to non agricultural activities	-.271	-1.04	0.301
Dummy if 1 adult female completed primary education	.242	0.30	0.767
Dummy if 2 adult female completed primary education	-1.457	-2.12	0.034
Dummy if 3 adult female completed primary education	-.506	-2.68	0.007
Constant	-.378	-1.77	0.077

A negative sign of the coefficient increases farmer's efficiency; shaded variables are significant.
[1] To recover 11 missing observations, the age of the head was replaced with the average age of the head in the sample and a dummy for the changed observations added.
Source: Computed by authors

TABLE 21C: RUVUMA: DETERMINANTS OF TECHNICAL INEFFICIENCY OF TOTAL AGRICULTURAL PRODUCTION USING VILLAGE VARIABLES

Determinants of agriculture technical efficiency	Coefficient	z-value	P>|z|
Log head age	-20.22	-3.71	0.000
Square log head age	2.672	3.66	0.000
Dummy for corrections on age of the head [1]	-.523	-0.40	0.690
Log head education	-.043	-0.24	0.809
Dummy senior secondary school available in the village	-.494	-1.75	0.080
Log nb adult equivalent	-.257	-0.94	0.346
Has electricity	1.556	1.33	0.185
Has tap water	-.365	-0.72	0.471
Has bike	.1426	0.88	0.381
Average distance parcels from household compound in km	.001	0.45	0.655
Average weighted distance from parcel to road	.014	0.53	0.595
Dummy all weather road (gravel) available in the village	-.798	-3.86	0.000
Number of years out of the past 10, was total household income declined a lot below average	.173	0.80	0.421
Dummy SACCO	-1.016	-2.59	0.010
Dummy banking account	.504	1.64	0.101
Dummy easy access to formal credit from bank & institutions	-.311	-1.05	0.296
Has consulted an extension	-.651	-2.52	0.012
Dummy for remittances	-.454	-1.48	0.139
Dummy for non farm business	-.125	-0.12	0.901
Share of time to non agricultural activities	-1.218	-1.74	0.082
Dummy if 1 adult female completed primary education	-.451	-2.35	0.019
Dummy if 2 adult female completed primary education	-.319	-1.47	0.143

A negative sign of the coefficient increases farmer's efficiency; shaded variables are significant
[1] To recover 11 missing observations, the age of the head was replaced with the average age of the head in the sample and a dummy for the changed observations added.
Source: Computed by authors

There are several variables that appear to increase efficiency among farmers (those which appear in Tables 20b and c and 21b and c to be negative and significant according to the z-value). In Kilimanjaro, they include household size in terms of the number of adult equivalents in the household, the average distance of parcels from the main road, the dummy for having easy access to formal credit, the dummy for the household being involved in non-farm business, and one of the dummies designed to inform about the education of adult females in the household. In this case efficiency appears to be increased when a household has more than two females having completed primary education. In Ruvuma significant efficiency increasing variables are age of the head of the household, household size, a dummy for whether the household has a bank account, and two of the dummies concerning primary education of females in the household. It thus appears to be consistent across the two surveys that household size, availability of formal credit, and education of females seem to boost farm efficiency. Also age (which could be a proxy for experience) seems to be significant in Ruvuma, while being involved in a non-farm activity also contributes to efficiency in Kilimanjaro, both of which are reasonable results.

Tables 22a, b and c exhibit the average levels of technical efficiency in Kilimanjaro, by group and by level of efficiency, Tables 23a, b and c do the same for Ruvuma. Farmers in Kilimanjaro appear on average less efficient than farmers in Ruvuma (53 to 59 percent in Kilimanjaro versus 65 percent in Ruvuma). No major difference in efficiency appears among the major groups within each region, though net food sellers appear slightly more efficient in both regions. The poor are also slightly less efficient in Ruvuma than the non-poor. As indicated in Tables 22b and c and 23b and c, more than half of the households appear to have technical efficiency scores between 50 and 75 percent, and less than 8 percent of households have technical efficiency below 25 percent.

The conclusion from this part of the analysis is that farmers in both Kilimanjaro and Ruvuma appear to farm relatively inefficiently, with poor households in Ruvuma *ceteris paribus* farming more inefficiently than the non-poor. Overall, the findings from the allocative and technical efficiency analyses indicate that limited input and capital use are a key factor in explaining low overall productivity in farm production in rural Tanzania.

TABLE 22A: KILIMANJARO: AVERAGE LEVELS OF TECHNICAL EFFICIENCY AMONG DIFFERENT GROUPS

	Technical efficiency percent) (from regressions with simple village effects)	Technical efficiency (percent) (from regressions with village variables)
All households	**59**	**53**
Poor	60	53
Non-poor	59	54
Coffee producers	60	55
Non coffee producers	59	50
Net food buyers	57	51
Net food sellers	65	62

Source. Computed by authors

TABLE 22B: KILIMANJARO: PROPORTIONS OF HOUSEHOLDS IN DIFFERENT RANGES OF TECHNICAL EFFICIENCY SCORES FROM REGRESSION WITH SIMPLE VILLAGE EFFECTS

Technical efficiency (percent)	All	Poor	Non-poor	Coffee producers	Non coffee producers	Net food buyers	Net food sellers
0-25	4.0	2.0	5.0	2.8	5.9	4.7	1.5
25-50	19.7	18.1	20.4	18.5	21.5	23.3	8.0
50-75	60.5	65.3	58.2	63.9	55.1	60.1	61.9
75-100	15.8	14.6	16.4	14.8	17.5	11.9	28.6

Source. Computed by authors

TABLE 22C: KILIMANJARO: PROPORTIONS OF HOUSEHOLDS IN DIFFERENT RANGES OF TECHNICAL EFFICIENCY SCORES FROM REGRESSIONS WITH VILLAGE VARIABLES

Technical efficiency (percent)	All	Poor	Non-poor	Coffee producers	Non coffee producers	Net food buyers	Net food sellers
0-25	8.0	6.0	9.0	5.4	12.9	9.8	2.1
25-50	29.5	32.8	27.8	27.4	33.1	34.0	15.2
50-75	54.3	53.7	54.6	59.4	44.9	51.3	63.8
75-100	8.3	7.5	8.6	7.8	9.1	4.9	18.9

Source. Computed by authors

TABLE 23A: RUVUMA: AVERAGE LEVELS OF TECHNICAL EFFICIENCY AMONG DIFFERENT GROUPS

	Technical efficiency (percent) (from regressions with simple village effects)	Technical efficiency (percent) (from regressions with village variables)
All households	**65**	**65**
Poor	*63*	*62*
Non-poor	*66*	*68*
Coffee producers	67	69
Tobacco producers	65	67
Cashew nut producers	60	54
Non cash crop producers	65	67
Net food buyers	62	62
Net food sellers	67	68

Source. Computed by authors

TABLE 23B: RUVUMA: PROPORTIONS OF HOUSEHOLDS IN DIFFERENT RANGES OF TECHNICAL EFFICIENCY SCORES FROM REGRESSIONS WITH SIMPLE VILLAGE EFFECTS

Technical efficiency (percent)	All	Poor	Non-poor	Coffee producers	Tobacco producers	Cashew nut producers	Non cash crop producers	Net food buyers	Net food sellers
0-25	2.4	2.7	2.1	0.8	0.0	4.7	2.5	3.2	1.5
25-50	13.4	15.3	10.9	9.8	16.0	21.6	11.2	15.0	11.2
50-75	57.0	59.9	53.5	61.5	54.2	51.0	57.7	60.6	52.3
75-100	27.2	22.1	33.5	27.9	29.8	4.7	28.6	21.2	35.0

Source. Computed by authors

TABLE 23C: RUVUMA: PROPORTIONS OF HOUSEHOLDS IN DIFFERENT RANGES OF TECHNICAL EFFICIENCY SCORES FROM REGRESSIONS WITH VILLAGE VARIABLES

Technical efficiency (percent)	All	Poor	Non-poor	Coffee producers	Tobacco producers	Cashew nut producers	Non cash crop producers	Net food buyers	Net food sellers
0-25	3.4	4.0	2.6	0.8	0.0	8.3	2.6	4.6	1.8
25-50	13.5	17.2	9.0	8.6	12.2	28.4	8.7	15.4	11.1
50-75	51.3	53.2	48.9	49.2	49.0	48.5	55.0	55.3	46.0
75-100	31.8	25.6	39.5	41.4	38.8	14.9	33.7	24.7	41.1

Source. Computed by authors

7 Determinants of input demand and access to seasonal credit

Given the apparent underutilization of inputs evidenced by the allocative efficiency analysis, it is useful to explore in more depth what determines the demand for inputs. To this end, we separately estimated a reduced input demand function for Kilimanjaro and for Ruvuma using a model checking for village characteristics through village fixed effects as well as a model whereby village characteristics are explicitly introduced to unbundle the village effects. As virtually all farmers used at least some inputs, the coefficients were estimated using OLS as opposed to the tobit procedure. The results are given in Tables 24a and 24b for Kilimanjaro and Ruvuma respectively.

The dependent variable is the (log of the) total value of intermediate inputs used for crop production by the household per acre. This includes purchased inputs as well as the value of own produced inputs (such as seeds and organic fertilizer) valued at median village prices. Purchased inputs constitute about 60 percent of total intermediate inputs. The regressions reported below were also done with purchased inputs as the only dependent variable, and yielded similar results. From the tables, input use appears to be negatively correlated with the land area cultivated. In other words, the smaller the landholding, the more intensively the land is cultivated. This effect is even more pronounced in Kilimanjaro (elasticity of input value to land size estimated at -0.35 to -0.47) where land scarcity is much more pronounced than in Ruvuma (input to land elasticity of -0.11 to -0.20) where land is more abundant in most districts. Input use is also higher among more educated and younger households. However, it is especially the educational attainment of the most educated woman which positively affects input use, and to a much lesser extent the educational attainment of the men. While post secondary education appears not to affect input use in Kilimanjaro, it positively affects input use in Ruvuma when it concerns the most educated male, but negatively when it concerns the most educated female. Surprisingly, in Kilimanjaro, the share of land irrigated is negatively associated with the amount of inputs used.

Regarding village characteristics, having easy access to the inputs themselves and being well connected with the rest of the economy emerge as quantitatively important determinants of input use. Households in villages with a bus service (a proxy for the village's integration in the economy) spent on average 20 percent and 53 percent more on inputs in Kilimanjaro and Ruvuma respectively. Households in villages with an agricultural input supply shop spent on average 41 and 83 percent more on inputs. The marginal effects of being connected and having easy access to inputs are substantially larger in Ruvuma compared with Kilimanjaro, consistent with the more remote nature of villages in Ruvuma as well as of the Ruvuma region itself. Finally, while these estimates are likely upward biased because they may also capture placement effects,[20] they are nonetheless sufficiently large to underscore the critical importance of connectivity and easy access to inputs in promoting input adoption.

[20] "Placement effects" refers to the fact that if placement of, for instance, an input supply shop were not random but intentional to target a fertile area where there was already high demand for fertilizer, it is not certain that the estimated coefficient is actually picking up only the effect of the fertilizer supply. It could pick up both the effect of the supply and the effect of there being high demand for fertilizer in the village and hence a shop meeting that demand. In other words, providing another area with a supply point may not necessarily yield the same increase in inputs. Care is needed in interpreting the coefficient as it might overestimate the effect, unless all characteristics in the environment are accounted for. This is sometimes a quantitatively important issue, which cannot be simply disregarded.

TABLE 24A: KILIMANJARO: DETERMINANTS OF INTERMEDIATE INPUTS

Dependent variable lLog value of total intermediate inputs utilized for crop production per acre	(1) With dummies for villages	(2) With village variables
Log acres of land cultivated	-0.3465***	-0.4706***
	(4.31)	(5.47)
Log value agricultural capital per acre	0.0580**	0.0739***
	(2.49)	(2.75)
Log value of non agric. capital per acre	-0.0064	0.0115
	(0.30)	(0.50)
Number of small animals	0.0055	0.0059
	(1.63)	(1.48)
Number of medium sized animals	0.0163***	0.0082
	(3.16)	(1.53)
Number of large animals	0.0051	0.0089
	(0.82)	(1.43)
Value of durables	0.0171	0.0226
	(1.18)	(1.29)
Value of dwelling	0.1057**	0.0427
	(2.29)	(1.38)
Log age of the head	-0.4270***	-0.4327**
	(2.60)	(2.28)
Head belongs to Pare ethnic group	0.1477	-0.3012***
	(1.01)	(2.72)
Years of education of most educated male	0.0313*	0.0454**
	(1.70)	(2.19)
Years of education of most educated female	0.0562***	0.0824***
	(2.69)	(3.67)
Dummy most educated male has post secondary education	-0.0899	-0.1486
	(0.56)	(0.83)
Dummy most educated female has post secondary education	-0.0727	-0.3002
	(0.41)	(1.55)
Log household size	0.0513	-0.1316
	(0.51)	(1.24)
Dependency ratio	0.1420	-0.2010
	(0.43)	(0.52)
Share of land with soil of good quality	0.0984	0.1557*
	(1.21)	(1.74)
Share of land improved with mulching	0.1362	0.0818
	(0.98)	(0.54)
Share of land improved with terraces	0.0491	-0.1192
	(0.37)	(0.87)
Proportion of land irrigated	-0.2227*	0.0200
	(1.82)	(0.16)
Dummy. easy to get seasonal credit for inputs on the farm	0.1984**	0.2518***
	(2.32)	(2.62)
Dummy: non farm business	0.0359	-0.0615
	(0.47)	(0.73)
Share of non wage non farm income to total household income	0.4086***	0.4647***
	(2.95)	(3.05)
Share wage to total household income	-0.0479	0.0673
	(0.39)	(0.63)
Dummy if household has consulted an extension officer	0.1445*	0.1256
	(1.81)	(1.35)
Dummy market available in the village		0.2246**
		(1.98)
Dummy electricity available in the village		-0.0254
		(0.23)
Dummy availability of bus services to nearby village		0.2064**
		(2.35)
Dummy agricultural extension agent available in the village		-0.1552*
		(1.69)
Dummy agricultural input supply shop available in village		0.4112***
		(3.58)
Constant	3.3848***	3.9274***
	(4.83)	(5.39)
Observations	948	818
R-squared	0.37	0.24

First column: Dummies for ward estimated but not reported
Robust t statistics in parentheses
* significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent
Source. Computed by authors

TABLE 24B: RUVUMA: DETERMINANTS OF INTERMEDIATE INPUTS

Dependent variable log value of total intermediate inputs utilized for crop production per acre	(1) With dummies for villages	(2) With village variables
Log acres of land cultivated	-0.1082*	-0.1960***
	(1.69)	(3.23)
Log value agricultural capital per acre	0.0227	0.0129
	(0.74)	(0.47)
Log value non agricultural capital per acre	0.0142	0.0107
	(0.53)	(0.42)
Number of small animals	0.0118***	0.0140***
	(5.59)	(6.34)
Number of medium animals	0.0263***	0.0286***
	(3.45)	(4.19)
Number of large animals	0.0047	-0.0152
	(0.20)	(0.57)
Value of durables	0.0003***	0.0003***
	(3.54)	(3.61)
Value of dwelling	-0.0001	0.0012***
	(0.33)	(6.62)
Log age of the head	-0.2746**	-0.2150*
	(2.06)	(1.79)
Dummy for ethnicity: Matengo	-0.5767***	-0.8580***
	(2.70)	(6.57)
Dummy for ethnicity: Ngoni	-0.0597	-0.2270
	(0.34)	(1.60)
Dummy for ethnicity: Yao	-0.2653	-0.6597***
	(1.61)	(5.14)
Dummy for ethnicity: other	-0.2633	-0.5738***
	(1.44)	(4.21)
Years of education of most educated male	-0.0035	0.0097
	(0.22)	(0.64)
Years of education of most educated female	0.0474***	0.0428***
	(3.15)	(3.08)
Dummy most educated male has post secondary education	0.3181**	0.2421*
	(2.30)	(1.88)
Dummy most educated female has post secondary education	-0.3409**	-0.3322**
	(2.35)	(2.09)
Log household size	-0.0177	-0.0364
	(0.23)	(0.51)
Dependency ratio	0.1601	0.2943
	(0.42)	(0.91)
Share of land with soil of good quality	0.1225*	0.1014
	(1.93)	(1.61)
Share of land improved with mulching	0.1149	0.0132
	(0.55)	(0.06)
Share of land improved with terraces	0.0870	0.0414
	(1.14)	(0.59)
Proportion of land irrigated	-0.0385	0.1218
	(0.21)	(0.64)
Easy to get seasonal credit for inputs on the farm	0.1448*	0.2039***
	(1.85)	(2.72)
Dummy non farm business	0.4213*	0.4092
	(1.68)	(1.25)
Share of non wage non farm income to total household income	0.2316	0.2460*
	(1.22)	(1.88)
Share wage to total household income	0.2113	0.2730*
	(1.09)	(1.95)
Dummy if household has consulted an extension officer	0.2876***	0.3372***
	(3.83)	(4.42)
Dummy for market available in the village		-0.0263
		(0.36)
Dummy for bus service to nearby town available in the village		0.5310***
		(6.10)
Dummy for agricultural extension agent available in the village		0.0249
		(0.34)
Dummy for sales point for agricultural inputs (fertilizer, seeds) available in village		0.8313***
		(3.77)
Dummy for primary society available in the village		-0.0083
		(0.12)
Constant	3.1892***	2.1060***
	(5.88)	(4.48)
Observations	891	891
R-squared	0.49	0.41

Firstr column: Dummies for ward estimated but not reported
Robust t statistics in parentheses
* significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent
Source. Computed by authors

The total value of inputs used was also positively associated with regular interaction with extension services. Households who had consulted an extension agent in the past year were also found to spend more on inputs. Nonetheless, caution is again warranted in interpreting the size of the coefficients as placement effects cannot be excluded.

Finally, easy access to credit has a large positive effect on input use, underscoring the importance of credit constraints in adopting modern inputs. The value of input use among households who reported having easy access to seasonal credit for inputs was 20 and 14 percent higher in Kilimanjaro and Ruvuma respectively. Similarly, households with sources of off-farm income (either non-wage non-farm income in Kilimanjaro or non-farm business income in Ruvuma) as well as small liquid assets (small and medium animals) - both proxies of liquidity constraints - or big assets which could be used as collateral, tend to spend more on inputs.

Given the critical importance of access to credit in input use, we also further explored the correlates of having access to credit. In particular, we ran a probit regression with as dependent variable a dummy equal to 1 if the head of the household reports that it is easy to obtain seasonal credit for intermediate inputs, and to zero otherwise. Note that this does not concern only formal credit, but credit from any source. Tables 25a for Kilimanjaro and 25b for Ruvuma give the results, which suggest that the amount of cultivated land affects the ease of obtaining credit for seasonal inputs positively in Kilimanjaro but not in Ruvuma. This may be related to the differential scarcity and hence the differential value of land in both regions, as land may function as a collateral. Households who belong to a SACCO or who have a bank account are about 10 percent more likely to obtain a seasonal credit for input purchases. While it is *a priori* not fully clear how the causality runs, the importance of fostering savings among households and the development of appropriate institutional arrangements to do so, as a means to increase their access to inputs, deserves to be further explored.

A good case in point is the fact that being a tobacco farmer is strongly associated with having easy access to credit — tobacco farmers in Ruvuma are 33 percent more likely to have access to seasonal credit. This follows from their contractual arrangements with the tobacco companies who provide inputs on credit and agronomic advice in exchange for a guaranteed supply of quality produce. Such contractual arrangements disappeared in the coffee sector after markets were opened up to private traders and contractual enforcement became more difficult. Nonetheless, this finding supports the notion that interlinked factor markets operating through contracts or membership of credit cooperatives are beneficial for producers in credit constrained rural economies.

Interestingly, households in Ruvuma in villages with a sales point for agricultural inputs were also much more likely to have easy access to credit. As it is, however, not immediately clear how contract enforcement would operate under such conditions, this finding deserves further investigation. Finally, while irrigation did not directly increase the use of inputs in Kilimanjaro, it appears to affect the use of inputs indirectly by facilitating the household's access to credit.

TABLE 25A: KILIMANJARO: DETERMINANTS OF EASY ACCESS TO SEASONAL CREDITS

Dependent variable is dummy equal to 1 if household reports easy access to seasonal credit	(1) With dummies for villages	(2) With village variables
Log acres of land cultivated	0.063***	0.062**
	(2.73)	(2.36)
Value of durables	-0.002	-0.002
	(0.53)	(0.62)
Value of dwelling	0.010	0.014
	(0.77)	(0.96)
Log household size	-0.054*	-0.054
	(1.71)	(1.51)
Log age of the head	0.013	0.021
	(0.30)	(0.45)
Head belongs to Pare ethnic group	0.031	0.012
	(0.67)	(0.24)
Years of education of most educated male	-0.003	-0.003
	(0.55)	(0.49)
Years of education of most educated female	-0.001	-0.001
	(0.20)	(0.19)
Dummy most educated male with post secondary education	-0.005	-0.004
	(0.09)	(0.07)
Dummy most educated female with post secondary education	-0.010	-0.017
	(0.18)	(0.27)
Dummy: 1=have bank account	0.108***	0.118**
	(2.68)	(2.45)
Dummy: 1=belong to SACCO	0.107***	0.099**
	(2.65)	(2.29)
Proportion of land irrigated	0.076**	0.124***
	(2.13)	(2.92)
Dummy non farm business	0.034	0.050
	(1.26)	(1.62)
Share of non wage non farm income to total household income	0.007	-0.024
	(0.15)	(0.46)
Share wage to total household income	0.015	0.029
	(0.43)	(0.77)
Share of household who have consulted an extension officer	0.019	0.019
	(0.75)	(0.66)
Dummy market available in the village		0.053
		(0.64)
Dummy electricity available in the village		0.101
		(1.33)
Dummy availability of bus services to nearby village		0.040
		(0.58)
Dummy agricultural extension agent available in the village		-0.031
		(0.37)
Dummy agricultural input supply shop available		0.022
		(0.27)
Observations	942	815

First column: Dummies for ward estimated but not reported
Robust z statistics in parentheses
* significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent
Source. Computed by authors

TABLE 25B: RUVUMA: DETERMINANTS OF EASY ACCESS TO SEASONAL CREDITS

Dependent variable is dummy equal to 1 if household reports easy access to seasonal credit	(1) With dummies for villages	(2) With village variables
Log acres of land cultivated	-0.002	-0.009
	(0.06)	(0.28)
Value of durables	-0.0003	-0.0002
	(0.83)	(0.95)
Value of dwelling	-0.0004	-0.0003
	(1.26)	(0.52)
Dummy tobacco production	0.320***	0.333***
	(2.76)	(3.06)
Log household size	0.052	0.035
	(1.50)	(1.04)
Log age of the head	-0.025	-0.006
	(0.42)	(0.12)
Dummy for ethnicity: Matengo	0.137	0.094
	(1.42)	(1.32)
Dummy for ethnicity: Ngoni	-0.061	-0.019
	(0.79)	(0.24)
Dummy for ethnicity: Yao	-0.013	0.015
	(0.15)	(0.20)
Dummy for ethnicity: Other	0.026	0.021
	(0.30)	(0.27)
Years of education of most educated male	0.011	0.010
	(1.40)	(1.30)
Years of education of most educated female	-0.001	0.000
	(0.18)	(0.04)
Dummy most educated male has post secondary education	0.009	0.018
	(0.15)	(0.30)
Dummy most educated female has post secondary education	0.061	0.054
	(0.79)	(0.74)
Dummy: 1=have bank account	0.073	0.053
	(1.25)	(0.97)
Dummy: 1=belong to SACCO	0.105**	0.118**
	(2.05)	(2.38)
Proportion of land irrigated	0.046	0.042
	(0.48)	(0.48)
Share of non wage non farm income to total household income	0.060	0.023
	(0.87)	(0.36)
Share wage to total household income	0.066	0.068
	(1.00)	(1.09)
Share of household who have consulted an extension officer	0.067*	0.050
	(1.66)	(1.27)
Dummy for market available in the village		-0.026
		(0.77)
Dummy for bus service to nearby town available in the village		-0.032
		(0.72)
Dummy for agricultural extension agent available in the village		-0.020
		(0.58)
Dummy for sales point for agricultural inputs (fertilizer, seeds) available in village		0.371***
		(2.99)
Dummy for primary society available in the village		0.018
		(0.54)
Observations	836	884

First column: Dummies for ward estimated but not reported
Robust z statistics in parentheses
* significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent
Source. Computed by authors

8 How can agricultural productivity be increased?

The descriptive and empirical results outlined above suggest that farmers produce well below the production frontier using too much labour and too little inputs and capital to maximize their profits, and that increasing their technical and allocative efficiency would substantially reduce rural poverty. The key policy challenge is thus how to increase agricultural productivity in a profit maximizing manner. There are broadly two ways through which agricultural productivity can be improved, which are not mutually exclusive. The first involves the development and adoption of better production technologies (to cause an outward shift in the production frontier) to optimize the allocation of endowments. The second involves a more efficient and more optimal use of existing technologies (i.e. a move towards and along the existing production frontier). The former process tends to be slower as it involves adaptive research into better production methods, as well as education of farmers in their use. The latter also involves agricultural extension and better education of the farmers. In addition, it requires that some of the factor market constraints that currently prevent a more intensive use of existing techniques are adequately relaxed.

Concerning the choice of the appropriate technology, it was seen that agricultural production is basically labour and land intensive, with little capital utilized. However, the labour to land ratios are quite different in Kilimanjaro and Ruvuma with Kilimanjaro exhibiting more labour intensive technology (170 days per acre versus 116 in Ruvuma, see Table 9). These figures are consistent with labour being relatively cheaper than land in Kilimanjaro (the ratio of the market price of labour to the price of land from Table 19 is 1.5/84 = 0.017 in Kilimanjaro versus 1.1/37 = 0.029 in Ruvuma). This implies that pursuing land saving technologies or labour intensive technologies such as the increased use of modern inputs is appropriate in Kilimanjaro.

The situation appears somewhat more complex in Ruvuma. Land is used relatively more abundantly than labour in the production process, which is consistent with the higher relative price ratio of labour to land compared with Kilimanjaro. The ratio of the marginal value of labour in agriculture to its marginal value in the market is even lower in Ruvuma than in Kilimanjaro suggesting even more unproductive/excess use of labour in Ruvuma than in Kilimanjaro. This points to the important need to increase labour productivity in Ruvuma either through increasing access to off-farm employment or through increased labour productivity in agriculture. Land appears not to be underutilized at the margin (rather the opposite), suggesting that technologies permitting farmers to cultivate more land (e.g. through mechanized agriculture) may not be appropriate to increase their labour productivity. The extreme underutilization of modern inputs, which on the other hand require more labour inputs, suggests that labour could be used more effectively in the agricultural production process through the application of more modern inputs.

The technical and allocative efficiency analysis revealed that the increased use of intermediate inputs and agricultural capital is an important entry point in increasing agricultural productivity in the case study regions. This raises the question; why do households not apply more inputs, or agricultural capital, if they have such high potential payoff? To further investigate whether investment in agriculture is indeed still remunerative at the margin and if access to capital/credit is an important factor in preventing many households from doing so, households were asked how they would utilize a windfall of extra income (equal to 50 percent of their current income). If households were free to adjust their income portfolio among various activities they would choose those that are most remunerative at the margin, given their riskiness. As a result, if the expansion of certain remunerative activities in their current income portfolio was constrained by access to capital, they would utilize any extra income to invest in that activity. Tables 26a and b report how households would allocate an extra amount of income equal to about 50 percent of current income.

In Kilimanjaro about 50 percent of all households would use the extra income to expand their agricultural production activities, whether food, cash crop or livestock production. In Ruvuma, 41 percent of households would spend the extra income to expand their agricultural activities. The responses do not differ significantly between poor and non-poor households. The second most important item of spending of extra money is investment in non-farm enterprise and improving housing. Noteworthy is the relatively high share (11 percent) of households in Kilimanjaro who report improving their children's education as their priority, while virtually nobody in Ruvuma reported this as a priority.

TABLE 26A: KILIMANJARO: DESIRED USE OF AN INCREASE BY 50 PERCENT OF ANNUAL INCOME

Most important desired use of extra money from income activities (percent of all households in given class)	All	Poor	Non-poor	Coffee producers	Non coffee producers	Net food buyers	Net food sellers
Increase agricultural food production	23.61	19.43	25.79	20.97	27.72	24.53	20.54
Increase coffee production	8.91	6.03	10.33	14.62	0.00	8.32	10.87
Increase production of non-food cash crops beside coffee	4.70	5.95	4.09	1.90	9.07	3.82	7.63
Increase livestock production	10.39	10.69	10.51	11.77	8.24	10.41	10.32
Increase farm processing activity	0.68	0.33	0.86	0.61	0.81	0.75	0.46
Increase storage capacity or other farm buildings	0.09	0.27	0.00	0.14	0.00	0.11	0.00
Invest in non-farm enterprise	15.41	16.41	14.78	13.41	18.53	15.38	15.50
Improve house	13.56	15.93	12.39	12.11	15.83	14.54	10.31
Buy bicycle, motorcycle	0.25	0.00	0.38	0.00	0.64	0.33	0.00
Buy food or other consumer goods	5.04	5.85	4.64	5.47	4.36	5.20	4.50
Pay children's education	11.29	14.43	9.75	13.87	7.26	10.62	13.52
Buy household appliances	0.63	1.56	0.18	0.54	0.78	0.59	0.79
Put in savings account	2.51	0.81	3.35	2.21	2.99	2.52	2.50

Source. Computed by authors

TABLE 26B: RUVUMA: DESIRED USE OF AN INCREASE BY 50 PERCENT OF ANNUAL INCOME

Most important desired use of extra money from income activities (percent of all households in given class)	All	Coffee producers	Tobacco producers	Cashew nut producers	Non cash crop producers	Poor	Non poor	Net food buyers	Net food sellers
Increase agricultural food production	22.8	12.4	25.8	17.1	24.3	21.6	21.6	19.4	27.3
Increase coffee production	6.9	20.5	0	2.5	7.6	6.4	6.4	6.2	7.8
Increase production of non-food cash crops beside coffee	3.1	1.6	0	3.6	2.3	3.7	3.7	2.1	4.4
Increase livestock production	8.0	15.2	3.8	3.6	9.6	6.6	6.6	8.7	7.0
Increase farm processing activity	0.1	0	0	0	0	0.2	0.2		0.3
Increase storage capacity or other farm buildings	0.1	0.4	0	0	0	0.2	0.2	0.2	
Invest in non-farm enterprise	16.8	18.3	7.2	13.2	19.1	15.0	15.0	19.0	14.0
Improve house	20.2	13.2	36.1	21.3	17.0	22.8	22.8	20.3	20.1
Buy bicycle, motorcycle	0.9	0.8	0	0	1.6	0.3	0.3	0.7	1.1
Buy food or other consumer goods	3.6	6.4	0	3.2	3.4	3.8	3.8	3.6	3.6
Pay children's education	3.8	2.4	9.0	4.0	3.1	4.5	4.5	3.4	4.4
Buy household appliances	2.2	1.6	3.8	5.2	2.3	2.2	2.2	2.9	1.4
Put in savings account	3.6	5.2	0	1.5	5.3	2.3	2.3	4.3	2.7
Increase tobacco production	0.7	0	8.6	0.8	0.6	0.8	0.8	0.6	0.8
Increase cashew nut production	5.6	0	0	21.4	2.9	7.8	7.8	5.9	5.4

Source. Computed by authors

The above results suggest that agricultural production is indeed perceived as a profitable activity by most households, in which they would invest extra cash. Nevertheless, the descriptive statistics have shown that the value of agricultural capital is very small, and from the analysis of allocative efficiency that there is significant underutilization of intermediate inputs as well as physical capital. The use of inputs obviously depends on a host of other factors beyond their profitability. From Section 7 it was shown that households with younger heads and more educated women tend to use more inputs, pointing to the importance of entrepreneurialism and education. Regular interaction with extension services and better physical access to the inputs themselves (e.g. through input supply shops) as well as markets in general (e.g. to sell produce) also tended to foster the use of inputs. Finally, the ease of access to credit also emerged as an important factor in determining the amounts of inputs used.

As the policy implications may differ depending on the reasons behind the perceived difficulties in getting access to credit, it is useful to elaborate further on the latter empirical result. An important factor determining the provision of credit from the provider's perspective are the costs related to the enforcement of the contract. As most poor rural households do not have sufficient collateral *ex ante* (e.g. land or other assets which could be liquidated), they must rely on the crops themselves as collateral. Enforcement of repayment then becomes easier when the farmers are engaged in contract farming in oligopolistic settings such as in the case of tobacco growing. Given the multiplicity of selling points for food crops, enforcement of contracts between input sellers and food crop producers is usually more difficult.

Nevertheless, households may not only need credit because they have insufficient resources/endowments of their own on average, but rather because they face liquidity constraints. Households may on average earn sufficient cash to cover the purchase of inputs, but their inability to save over even a short period of time may prevent them from expanding the use of fertilizer when their cash earnings and spending patterns are not synchronized. The importance of liquidity constraints and farmers' inability to save (even over short time periods) in determining their adoption of modern inputs was most recently empirically demonstrated by Duflo, Kremer and Robinson (2006) among farmers in Kenya through randomized experiments. This underscores the importance of developing appropriate savings institutions in helping households adopt inputs and help them overcome credit constraints. Generation of off-farm employment opportunities (preferably during slack labour periods) can further augment the effectiveness of such savings or spending commitment devices in overcoming the perceived credit constraints.

Finally, even with sufficient cash (or liquid assets such as food storage), during the time of input purchase decisions households may still need additional access to credit due to the need to hold on to their savings as a buffer in case of shocks (also known as the precautionary savings motive). This holds true especially if using cash or selling a unit of stored product (e.g. maize) during the planting season increases the risk of food shortage later on despite higher *expected* yields from increased application of inputs. If this is the case, providing more working capital may well be used to augment the consumption smoothing capacity of the household rather than to increase the application of inputs. The quantitative importance of a household's *ex post* consumption smoothing capacity in determining its *ex ante* input adoption decisions (controlling for their *ex ante* access to credit) was empirically demonstrated by Dercon and Christiaensen (2005) in Ethiopia. To test this insight in the present context, the regressions on intermediate inputs were rerun with the addition among the independent variables of a vulnerability index, estimated by reference to covariate and idiosyncratic risks faced by households (Sarris and Karfakis, 2006). The index measures the probability that a household's consumption will fall below poverty in the next period. Hence, more vulnerable households will exhibit higher values of the index. According to the discussion above, more vulnerable households should be expected to utilize smaller amounts of intermediate inputs per acre, as they would need to have adequate own funds in case of an external shock. Tables 27a and b for Kilimanjaro and Ruvuma respectively repeat the regressions of Tables 24a and b with the village fixed effects (regressions with village variables gave similar results) with the simple addition of the vulnerability index, and compare the results with those of the earlier tables.

The coefficient on the vulnerability index is negative and strongly significant in both Kilimanjaro and Ruvuma. Almost all the other variables that are significant in the earlier regression are significant here, with the notable exception of the variable denoting easy access to credit in Kilimanjaro, although not in Ruvuma, where it continues to be significant and of the same magnitude. This suggests that vulnerability and easy access to credit are negatively correlated, and indeed a simple regression of the vulnerability index on the ease of access to a seasonal credit dummy produces a negative and significant coefficient in Kilimanjaro and a negative but not significant coefficient in Ruvuma. Thus, it appears that vulnerability is an additional explanatory variable in Ruvuma, but this is only partially so in Kilimanjaro. In Kilimanjaro the explanation that is consistent with this result is that the lack of access to seasonal credit by vulnerable households makes them use extra cash to deal with vulnerability arising from food insecurity, health and family emergencies, etc. This demand for liquidity for consumption smoothing purposes tends to make it harder for them to devote resources to increasing agricultural productivity via larger amounts of intermediate inputs. In Ruvuma, the same explanation holds, but it appears also that demand for liquidity for consumption smoothing works in addition to the lack of access to seasonal credit in reducing the amounts of intermediate inputs used.

In other words, while evidence shows that use of production inputs is highly profitable and could improve agricultural productivity considerably, it appears that there are two complementary policies that may facilitate increased use of such inputs, and hence improve agricultural productivity. The first entails facilitating the provision of cash by the household itself by providing better consumption safety nets, and hence releasing cash to be used for productive purposes. The second entails providing more direct external seasonal finance. If the marginal use of cash is largest in consumption smoothing or risk coping activities rather than agricultural production, then a policy of providing the household with a more complete safety net may be more conducive to releasing a household’s own cash resources to be used for agricultural production. On the other hand if the marginal use of cash is largest in buying inputs for agricultural production, then the best policy may be to provide seasonal finance directly or indirectly in some way. The data and analysis here, as well as from showing that the marginal value of intermediate inputs and hence seasonal capital for agricultural production, is very high, indicates that both policies would be conducive to improving agricultural production, though they do not allow the one with the highest return to be pinpointed.

TABLE 27A: KILIMANJARO: DETERMINANTS OF INTERMEDIATE INPUTS

Dependent variable log value of total intermediate inputs utilized for crop production per acre	With dummies for villages	With dummies for villages
Vulnerability index		-1.1590***
		(4.89)
Log acres of land cultivated	-0.3465***	-0.4665***
	(4.31)	(5.86)
Log value agricultural capital er acre	0.0580**	0.0461**
	(2.49)	(2.00)
Log value of non agricultural capital per acre	-0.0064	-0.0124
	(0.30)	(0.60)
Number of small animals	0.0055	0.0051*
	(1.63)	(1.73)
Number of medium animals	0.0163***	0.0129***
	(3.16)	(2.60)
Number of large animals	0.0051	0.0067
	(0.82)	(1.13)
Value of durables	0.0171	0.0145
	(1.18)	(1.17)
Value of dwelling	0.1057**	0.1151**
	(2.29)	(2.49)
Log age of the head	-0.4270***	-0.3704**
	(2.60)	(2.26)
Head belongs to Pare ethnic group	0.1477	0.0387
	(1.01)	(0.26)
Years of education of most educated male	0.0313*	0.0277
	(1.70)	(1.52)
Years of education of most educated female	0.0562***	0.0453**
	(2.69)	(2.20)
Dummy most educated male with post secondary education	-0.0899	-0.1178
	(0.56)	(0.74)
Dummy most educated female with post secondary education	-0.0727	-0.0853
	(0.41)	(0.48)
Log household size	0.0513	0.3587***
	(0.51)	(3.04)
Dependency ratio	0.1420	0.0812
	(0.43)	(0.25)
Share of land with soil of good quality	0.0984	0.0967
	(1.21)	(1.21)
Share of land improved with mulching	0.1362	0.1357
	(0.98)	(0.99)
Share of land improved with terraces	0.0491	0.0380
	(0.37)	(0.28)
Proportion of land irrigated	-0.2227*	-0.2362**
	(1.82)	(1.98)
Easy to get seasonal credit for inputs on the farm	0.1984**	0.1069
	(2.32)	(1.27)
Dummy non farm business	0.0359	-0.0548
	(0.47)	(0.72)
Share of non wage non farm income to total household income	0.4086***	0.3545**
	(2.95)	(2.45)
Share wage to total household income	-0.0479	-0.0874
	(0.39)	(0.63)
Share of household who have consulted an extension officer	0.1445*	0.1297*
	(1.81)	(1.66)
Constant	3.3848***	3.3932***
	(4.83)	(4.88)
Observations	948	948
R-squared	0.37	0.39

Robust t statistics in parentheses
* significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent
First column: dummies for villages estimated but not reported
Source. Computed by authors

TABLE 27B: RUVUMA: DETERMINANTS OF INTERMEDIATE INPUTS

Dependent variable log value of total intermediate inputs utilized for crop production per acre	With dummies for villages	With dummies for villages
Vulnerability index		-1.2161***
		(8.28)
Log acres of land cultivated	-0.1082*	-0.1474**
	(1.69)	(2.33)
Log value agricultural capital per acre	0.0227	0.0054
	(0.74)	(0.18)
Log value non agricultural capital per acre	0.0142	0.0078
	(0.53)	(0.30)
Number of small animals	0.0118***	0.0092***
	(5.59)	(3.95)
Number of medium animals	0.0263***	0.0193**
	(3.45)	(2.37)
Number of large animals	0.0047	-0.0149
	(0.20)	(0.60)
Value of durables	0.2635***	0.2060***
	(3.54)	(3.32)
Value of dwelling	0.0000	0.0000
	(.)	(.)
Log age of the head	-0.2746**	-0.1046
	(2.06)	(0.80)
Dummy for ethnicity: Matengo	-0.5767***	-0.5360***
	(2.70)	(2.61)
Dummy for ethnicity: Ngoni	-0.0597	-0.0055
	(0.34)	(0.03)
Dummy for ethnicity: Yao	-0.2653	-0.2630
	(1.61)	(1.62)
Dummy for ethnicity: Other	-0.2633	-0.2659
	(1.44)	(1.52)
Years of education of most educated male	-0.0035	-0.0135
	(0.22)	(0.87)
Years of education of most educated female	0.0474***	0.0370**
	(3.15)	(2.55)
Dummy most educated male has post secondary education	0.3181**	0.2535*
	(2.30)	(1.86)
Dummy most educated female has post secondary education	-0.3409**	-0.2522*
	(2.35)	(1.89)
Log household size	-0.0177	0.2595***
	(0.23)	(3.31)
Dependency ratio	0.1601	0.0676
	(0.42)	(0.18)
Share of land with soil of good quality	0.1225*	0.0587
	(1.93)	(0.94)
Share of land improved with mulching	0.1149	0.1680
	(0.55)	(0.75)
Share of land improved with terraces	0.0870	0.0682
	(1.14)	(0.93)
Proportion of land irrigated	-0.0385	-0.0296
	(0.21)	(0.15)
Easy to get seasonal credit for inputs on the farm	0.1448*	0.1475*
	(1.85)	(1.94)
Dummy non farm business	0.4213*	0.2923
	(1.68)	(1.18)
Share of non wage non farm income to total household income	0.2316	0.0133
	(1.22)	(0.07)
Share wage to total household income	0.2113	0.0507
	(1.09)	(0.28)
Share of household who have consulted an extension officer	0.2876***	0.1996***
	(3.83)	(2.74)
Constant	3.1663***	3.1259***
	(5.95)	(6.03)
Observations	891	891
R-squared	0.49	0.54

Robust t statistics in parentheses
Significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent
First column: dummies for villages estimated but not reported.
Source: Compued by authors.

9 Summary and conclusions

The results presented in this paper provide a socio-economic description of smallholders and their livelihood strategies in Tanzania and indicate several entry points for reducing their poverty.

First, overall asset ownership among rural households in Tanzania is quite low. This holds not only in terms of human capital, but also in terms of physical capital, as well as access to a variety of infrastructure variables. Education levels are very low, and so is access to basic rural infrastructural services such as electricity and tap water.

Second, while there are substantial differences in average incomes among different groups of households, farmers differ less in the amount of productive assets they possess.

Third, the main differentiating factor among rural households in both Kilimanjaro and Ruvuma is agricultural productivity. These results suggest that a pro-poor rural development strategy in Kilimanjaro may need to be anchored around improvements in agricultural productivity.

Fourth, the analysis of allocative efficiency concluded that family labour is substantially overutilized, suggesting considerable excess labour in farm households. On the other hand, farm households appear to utilize substantially smaller amounts of intermediate inputs than would be commensurate with their estimated marginal productivities. Further investigation shows that the demand for inputs is especially high among younger households with educated female household members. Households who are better connected with the wider economy through bus services and closer to input supply points are also much more likely to use modern inputs, and this emerges as a major constraint in Ruvuma. Finally, households with easy access to credit spent on average between 15 and 20 percent more on inputs. Access to credit is in turn associated with 1) the contractual arrangements under which farming takes place (e.g. tobacco versus coffee farmers) and 2) being a member of a savings and credit organization, underscoring the need to better understand how the development of improved saving mechanisms could help boost the use of modern inputs.

The financial constraint discussion is supported by the portfolio preferences of farm household heads. It is notable that the highest preference among the farm households when asked where they would like to invest excess savings is to increase agricultural production. Clearly farm households perceive unrealized investment opportunities in farming.

The use of intermediate inputs was also found to be negatively related to a household's vulnerability, implying that consumption smoothing and precautionary savings are significant determinants of low input use and hence farm productivity. This indicates that interventions on the consumption safety net side could have important production and income increasing effects.

In sum, the empirical results highlighted in this paper lead to the following policy conclusions. First, there remains much scope for improving agricultural productivity among farmers. In particular, considerable progress in agricultural productivity and poverty reduction can be made by working within the confines of existing technologies. The importance of two areas of policy intervention stands out. The first involves policies and institutions that facilitate easier access by farmers to seasonal credit for intermediate inputs. Such policies may include wider use of credit cooperatives, promotion of other membership type organizations like cooperatives that can facilitate access to credit by farmers, and promotion of contractual types of arrangements that can be combined with easier access to productive inputs. The second area of policy intervention involves more efficient rural consumption safety nets. While these may be advocated on humanitarian and emergency relief grounds, evidence came to light that such policies, by helping households release resources that may be locked into reserves for risk coping activities, can also assist them to find their own resources for productive activities.

Second, there is considerable room for improvements in allocative efficiency by better access to off-farm activities, so that farmers utilize labour more efficiently. An alternative may be easier access to credit for expansion of land cultivation in areas with land expansion potential like Ruvuma, so as to utilize more efficiently excess family labour.

Third, major gains to agricultural productivity are to be expected from better village connectivity, especially in relatively isolated regions such as Ruvuma, underscoring the role of rural infrastructure and the provision of rural transport services.

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Appendix 1: Construction of expenditure and poverty measures

Households were first according to their total expenditures (cash and non-cash). From the survey the value of cash and non-cash expenditures per household as well as per capita and per equivalent adult were computed. The value of non-cash expenditures was based on the value of home consumption of own produced food products, and the value of gifts received in kind. For the value of home produced food products, two types of valuation were made. One was based on reported quantities of consumption out of own production from the expenditure module of the questionnaire using average consumer prices. The other valuation was based on production used for home consumption from the production module of the questionnaire, and valued at the average (for the village or ward) producer prices.

While the two methods produced similar values on average (for Kilimanjaro for instance, the average yearly per equivalent adult home consumption with the consumption questionnaire was 63 400 Tsh while the average using the production method was 59 300 Tsh), the standard deviations of both methods were large (for Kilimanjaro 53 400 Tsh for the first method and 117 700 Tsh for the second). A simple linear OLS regression of the (log of) producer based home consumption on the log of consumer based home consumption gave coefficients lower than one (for Kilimanjaro equal to 0.784 and highly significant). This is expected because consumer prices are usually higher than producer prices, though the R^2 amounted to only 0.232. As consumption out of home production is quite high in Tanzania, the proper valuation of home consumption is important for the classification of households as poor or nom-poor. Most analyses utilize the consumption based method, and this is why it was chosen for this study. However, surveys such as the HBS use a survey method based on recording of actual transactions rather than recall, which was employed here in the expenditure module. It is not clear whether in the case of recall the consumption based method is superior to the production based one.

We classify households as poor if their per adult equivalent total expenditure (cash and non-cash, excluding some items[21]) is lower than the basic needs rural poverty line adapted from the 2000/01 HBS. In particular, the rural 2000/01 HBS poverty line was inflated to the year and month of the survey by the Tanzanian National Consumer Price index, further multiplied by the average per capita GDP growth rate, and subsequently also multiplied by an additional factor. This last factor, known as the ratio of "underestimation" of the consumption in the HBS survey, is equal to the ratio of average per capita total expenditure, as estimated from the surveys in the present study, and the same average from the 2000/01 HBS, inflated by the Tanzanian National Consumer Price Index between the time of the HBS and the time of this survey, times the average per capita GDP growth rate. This procedure was used because simply inflating the basic needs poverty line from the HBS and comparing it with the estimated consumption figures from this survey produced poverty incidence estimates that were much below those reported in the HBS (less than one third of the HBS reported poverty incidence). This led to questions about the comparability of the two surveys (potentially related to the timing of the surveys and the methodology used in estimating consumption figures). The procedure used in

[21] The HBS definition of the poverty line excluded expenditures on medical care, education, water and postage, and expenditures on rarely purchased large durable items to make the data comparable to earlier surveys done in periods where most of the above items were provided free of charge. Consequently, these items were also excluded. Irrespectively, such expenditures amounted to less than 4 percent of rural household expenditures in the HBS, and they only accounted for a small share of total expenditures in our survey as well.

this study, which has no impact on the subsequent analysis other than in the descriptive tables, gave a poverty incidence for Kilimanjaro of 33 percent, while for Ruvuma the corresponding poverty incidence was 57.7 percent. These are higher than the incidences reported in the 2000/01 HBS (31 percent for Kilimanjaro and 41 percent for Ruvuma).

It must be noted that the correspondence between the poverty estimates using on the production-based home consumption figures and those using on the consumption based home consumption figures is imperfect. Less than 40 percent of households classified as poor with one method are also classified as poor with the other method. The method of estimation and valuation of home consumption is thus crucial for classifying households as poor, especially when home consumption is a large share of total consumption, which is the case for many of the rural poor in Tanzania. While there is no obvious reason to choose one method over the other, it must be underscored that the choice does not have much influence on the econometric analysis below, although it would influence the average household characteristics reported in this section.

Appendix 2: Empirical estimation of the stochastic production frontier

Since the pioneering model of Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977), the stochastic frontier has attracted a great deal of attention in the literature, and a variety of techniques have been used. Here a model of estimation of a stochastic frontier production function using a Cobb-Douglas functional form (Coelli and Battese, 1996) on a sample of N farms in which an additional random error v_i is added to the non-negative random variable, u_i, is used to provide the following specification:

$$\ln(y_i) = \beta \ln(x_i) + v_i - u_i \qquad i = 1,2,...N \qquad (1)$$

where $\ln(y_i)$ is the logarithm of the output for the i-th farm.

ln(x_i) is a (K+1)- column vector, whose first element is "1" and the remaining elements are the logarithms of the K-input quantities (or values) used by the i-th farm;

$\beta = (\beta_0, \beta_1, ..., \beta_K)$ is a (K+1)-row vector of unknown parameters to be estimated,

v_i is the random error and it accounts for measurement error and other random factors on the value of output variable, together with the combined effects of unspecified input variables in the production function. v_i is assumed to be a two-sided error term representing the statistical noise and is assumed to be normally distributed with mean 0 and variance $\sigma_v{}^2$ and

u_i is a one-sided non-negative random variable, representing technical inefficiency in production of farms. It is assumed to be i.i.d. u_i can, therefore, be expressed as the shortfall in output y from its maximum value given by the stochastic frontier $f(x_i;\beta) + v_i$. Although this one-sided term can follow different types of distributions such as half-normal, exponential, and gamma (Aigner, Lovell, and Schmidt 1977; Green 1980; Meeusen and Van den Broeck 1977), along with the typical literature on stochastic frontier approach it is assumed that *u* follows a half-normal distribution with unknown mean and variance. $(u \sim N[m_i, \sigma_u^2])$.

The technical inefficiency effect, u_i, could be replaced by a linear function of explanatory variables reflecting farm characteristics and shock variable (e.g., Battese and Coelli, 1995). The technical inefficiency effects are assumed to be independent and non-negative truncations (at zero) of normal distributions with unknown mean and variance. Specifically,

$$\mathrm{u_i} = \delta_o + \sum_{j=1}^{J} \delta_j z_{ji} + \omega_i \,, \qquad (2)$$

where z_{ji} are farm specific explanatory variables associated with technical inefficiency; δ_0 and δ_j (*j=1,…J*) are parameters to be estimated; and ω_i is an independently and identically distributed random variable with $N(0,\sigma_u^2)$ and truncated at $-\left(\delta_0 + \sum \delta_j z_{ji}\right)$ from below. The latter implies that

$u_i \sim N(\delta_0 + \sum \delta_j z_{ji}, \sigma_u^2)$ truncated at zero from below. After substituting (1) into (2) the resulting model is estimated by a single-equation estimation procedure using the maximum likelihood method.