JICA Research Institute

JICA-RI Working Paper

An Empirical Analysis of Expanding Rice Production in Sub-Sahara Africa

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No. 86

December 2014

JICA Research Institute

JICA Research Institute

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Abstract

We analyze a rice farmer panel data set that was collected in 2007/08 and 2011 in Mozambique. We found that in a rainfed area, farmers expanded their cultivated area as local paddy prices increased in parallel with international rice price trends. However, the average yield decreased as the farmers were approaching to marginal land of their land frontier. To improve yield for further production increases, the production mode must shift from extensification to intensification through the introduction of land-saving technologies, such as irrigation development. A lesson learnt from the Chokwe Irrigation Scheme, the largest scheme of the country, is useful for this aim. A key lesson is that assuring water access is crucially important because timely water application directly increases output and also increases the returns to chemical fertilizer use. In Chokwe, a recent increase in the real price of modern inputs, such as fertilizer and tractors, saw farmers substitute family labor for modern inputs, that is, a return to traditional farming. To recapture the momentum of modernization, our analyses suggest that training and market access are important. Those farmers who received a training program did not give up using animal traction. Additionally, those who had access to rice buyers, kept using chemical fertilizer.

Keywords: rice farming, Mozambique, irrigation, modern inputs, rice production training

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1. Introduction

Rice consumption in Mozambique has increased rapidly from 86 thousand tons in 1990 to 519 thousand tons in 2010, at an annual growth rate of 8.6% (USDA 2011). The growth rate of rice consumption has been faster than the three other major cereals: maize (5.5%), wheat (7.4%), and sorghum (4.7%) (USDA 2011).Initially, local rice production stagnated, resulting in a rapid increase in rice imports. Although it has started rising since 2008, local rice production is still one third of consumption. Faced with an increase in rice prices on the world market, it is crucially important for the country to design effective strategies to accelerate the ongoing trend of rice sector development. For example, under the initiative of the Coalition for African Rice Development (CARD), the country has drafted a national development strategy report emphasizing the modernization of the sector (CARD 2011).

However, it is not yet clear what strategies will push through the modernization. A first step toward a strategy for development is a clear understanding of the constraints of the current production mode. A major reason for difficulties in this task is the lack of detailed and representative data on rice. The International Rice Research Institute (IRRI) conducted a household survey in irrigated and rainfed areas in 2007/08 and 2011 to construct a panel data set on rice farmers. Although national level general surveys of farmers had been carried out, this was the first data set designed specifically for rice.

Utilizing this data set, we begin by exploring what occurred in the rice sector between the two periods in the irrigated and rainfed areas. We then aim to identify what the constraints to an increase in rice production are. In the irrigated area, modern varieties and chemical fertilizer are moderately used, achieving the paddy yield of about 2 tons per hectare. Hence, we try to identify the constraints that were placed on modernization, which has to some extent already taken place. Meanwhile, the rainfed areas that have followed a traditional style with no application of modern inputs, have achieved a paddy yield of around one ton per hectare. Boerup

(1965) argues that the modernization of agriculture starts once farmers reach the frontier of arable land and when the relative cost of extensification becomes more expensive than that of intensification. In line with this, our analysis of the rainfed areas focuses on the examination of the extensification process.

2. Rice in Mozambique

As a result of an increase in urbanization and the convenience of preparing rice meals, Mozambique, like other African countries, has seen a shift in consumer preference for rice (Hossain 2006). Demand for rice in Mozambique has, therefore, been rapidly increasing . In response to this increase, production grew initially at 12.1% annually between 1993 and 1998, but then stagnated until 2008. The growth of production between 1993 and 1998 was largely attributed to area expansion resulting from the resettlement of rural populations after the peace agreement in 1992, rather than to an increase in yield (Zandamela 2008). Therefore, as shown in Figure 1, the paddy yield hd been around 1 t/ha in this period. Once resettlement was completed, production growth lost its momentum in the period from the end of the 1990s to the early 2000s. Growth resumed in 2008 when the international commodity markets, including rice, suffered a price surge. However, the increase is still reliant on area expansion, keeping the paddy yield at around 1 t/ha throughout the period (Figure 1).

Rice in Mozambique is produced mostly under rainfed lowland ecology (Table 1), where the farmers follow traditional cultivation practices. Among rainfed lowland areas, Zambézia (57%) is the dominant area, followed by Cebo Delgado (14%), Nampula (10%), and Sofala (9%). Irrigated areas are concentrated in Gaza where the largest irrigation scheme in the country, the Chokwe irrigation scheme, is located. Chokwe is located about 220 km north of the capital, Maputo, in an area considered to be the most favorable in terms of its agro-ecological and economic conditions. However, due to a lack of rehabilitation investment and proper management of the system since its construction during the Portuguese colonial period, irrigation water from the scheme (which supplies water by a gravity system and is managed by the state) is limited and unreliable. Even worse, the system was severely damaged by the catastrophic Limpopo river floods in 2000, and has not yet fully recovered. As a result, only 4,000 hectares out of 26,000 hectares of planned command area are irrigated. We have therefore looked at a wide variation in access to water as well as the extent of modernization within the irrigation scheme.

3. Data

The International Rice Research Institute (IRRI) conducted three household surveys in order to collect two-period panel data both in irrigated and in rainfed areas. The first survey, in 2007, was conducted on the Chokwe irrigation scheme in Gaza (Figure 2). For this survey we randomly sampled small and medium-size farmers stratified by tertiary canal, and excluded commercial plantations with a land area larger than 8 hectares. After data cleaning 441 of the 451 sample farmers remained. Our sample included farmers who received a training form Japan International Cooperation Agency (JICA) that was implemented in two water user groups between March 2007 and March 2010. The contents of the program included the training on modern farming practices such as seed selection, seedling preparation, transplanting, fertilizer use, water management, and animal traction. Additionally, the introduction of rice-related businesses, such as a micro finance program for rice farmers and a rice milling service business, were also included.

The second survey was conducted in parallel with the National Agricultural Survey of 2008 (*Trabalho de Inquérito Agrícola* 2008 [hereafter, TIA08]) in collaboration with the Department of Statistics within the Directorate of Economics of the Ministry of Agriculture.

TIA08 is a nationally representative data set covering all provinces. We chose Zambézia and Sofala as the provinces representing a rainfed sample. Based on the TIA08 survey, 33 villages in 9 districts, out of 151 villages in 17 districts in these provinces, were identified as rice growing villages. TIA08 sampled around 8 households in each village, generating a sample of 270 farmers in 33 villages. IRRI additionally conducted a detailed rice survey of these sample farmers.

The third round of surveys, conducted in 2011, was undertaken simultaneously in both the irrigated and the rainfed areas. We added a number of detailed questions on rice, the importance of which was recognized after the analysis of the previous round of surveys. The survey team tried their best to identify the sample farmers in the previous round, and collected data from 323 farmers in Chokwe and 212 farmers in Zambézia and Sofala. The attrition rate of each site was 27% and 21% respectively.

4. Changes between 2007/08 and 2011

This section reviews the changes between two time periods in each agro-ecological site. The figures for the variables that were not asked in the 2007/08 round of the survey are missing from the tables. Table 2 shows the changes in rice production, technology, and water access conditions. We report not only the changes of the survey plots but also those of the aggregated rice plots, including non-survey plots.[1] This is particularly important for rainfed areas as they have multiple rice plots and expansion of the area is occurring.[2] A contrast is observed in the aggregated cultivated area between the irrigated and the rainfed areas: the former almost fully

[1] The survey plot is the plot recognized as the most important one by the interviewed household, for which we collected detailed input and output data.

[2] Note that the cultivated area of non-survey plots is based on farmers self-claim and we asked this type of question in different manners for double checking purposes. That being said, we received a wide range of answers as reported in the table. For the survey plot we measured the size with a GPS device.

utilized the entire lowland and thus experienced little change in the size of cultivated area from 1.12 to 1.20 ha; in contrast, the latter increased the size from 0.86 to 1.04 (using upper limit figure) and the increased level was close to the landholding size of lowland (1.4 ha).

In the irrigated area, paddy production and the yield of the survey parcel went down (from 2.19 tons to 1.9 tons for production and from 2.04 t/ha to 1.56 t/ha for yield), indicating a declining performance.[3] However, at the JICA training sites the decline was smaller than the others and the gap between the average at the JICA site and the overall average became wider (from 2.64/2.04=1.15 to 2.32/1.56=1.48). The farmers in the training sites seemed to be able to mitigate adverse effects more effectively. In the rainfed area, although rice cultivation became more active in that the cultivated area of survey parcel expanded from 0.36 to 0.43 ha, it was associated with small yield decline (from 1.00 t/ha to 0.80 t/ha) and little change in production (from 0.29 tons to 0.25 tons). The possible reasons for these features in irrigated and rainfed areas will be explored later, together with other summary statistics.

The middle part of Table 2 shows the adoption of new rice varieties and improved practices (such as bund construction, variety adoption, and a shift to transplanting) had rarely occurred in either area. In this period, these technologies were not the factors underlying the observed production changes.

The data on weather and irrigation in the irrigated area shows the farmers suffered drought and irrigation water shortage in 2007, while flood and too much water was the problem in 2011. As we will discover later, water access is the crucial determinant for rice production performance. The fact that the proportion of farmers who claimed insufficient water (14% in 2007) was lower than that of drought experience (53% in 2007) in the irrigated area indicates that to some extent, the irrigation system mitigated the impact of weather shocks on water access.

[3] We compute the yield based on farmers' recall of their harvest. Usually, they reported the harvest in terms of container they used (e.g., bags). We convert their answer to kilograms using a converter. For example, the most common container for rice is a 50 kg bag, which is converted to 38 kg of paddy rice (24% depreciation).

The same applies in the case of floods and too much water in 2011. Nevertheless, we will find out later that the scheme can make further improvements on irrigation performance. In the rainfed area, as indicated by the experiences of drought or flooding, weather shocks were more rampant than in Chokwe, which is located in a better agro-ecological zone.

Table 3 shows the changes in prices, inputs, income, and profit between the two periods. We start with a review of the irrigated area. Reflecting the trend in the international rice market, the paddy price at a local market increased over the period. More importantly, however, the wage rate of agricultural labor, the nitrogen price, and tractor rental cost increased at a faster pace, resulting in an increase in the real price of these inputs (the nominal price of the input divided by the paddy price) and the decline in the profitability of rice production. It is worth noting that, for example, on the international markets the fertilizer price increased but at a slower pace than that of rice.[4] Accordingly, a faster increase in input prices must stem from domestic factors. As we will see later, the high input prices seem to be a reason for the stagnation of modernization. An investigation of the domestic input market structure would be an important agenda for future research.

The levels of real input prices (the price divided by the paddy price) have been very high in comparison with those in Asia. For example, from the 1960s to the 2000s the real price of nitrogen in the Philippines was between 2 to 3 with a few exceptional years. The corresponding figure in Mozambique was 7.84 in 2007 and 9.04 in 2011. In this regard, the already high real price of fertilizer in 2007 rose even higher in 2011. This must be the main reason why the low NPK use at 21.00 kg/ha (recommended level of nitrogen, 50 kg/ha) was further reduced to 9.63 kg/ha in 2011. The real rental cost of tractors increased from 369 to 440 and we suspect a similar increase in prices was seen for animal and threshing machine rental. Accordingly the figures

[4] For example, FOB price of Thai rice (A1 Super grade) increased from 272 USD/ton to 466 USD/ton by 71% from 2007 to 2011, while Arabian Gulf FOB price of urea increased from 310 USD/ton to 400 USD/ton (29%) in the same period.

show the disappearance of the use of animals, tractors, and threshing machines, although animal use survived to a small extent. As a substitute for these power sources, family labor input increased remarkably. The use of hired labor however, changed little presumably due to an increase in the real wage rate. Because of this substitution strategy, the farmers reduced the paid out cost and ensured slightly higher levels of income even though they gave up the yield (see the lower part of Table 3).

An interesting feature observed in 2011 was the emergence of an informal credit arrangement for fertilizer transactions. Amongst fertilizer users the dominant mode of payment was cash at the time of purchase (78%). Meanwhile, 14% of users paid for the fertilizer after the harvest. This proportion is higher than for similar arrangements for seed (4%) or machine/animal (2%) transactions (not shown in the table). This kind of arrangement is very common in Asia where rice millers or buyers also deal in fertilizer. Thus the access to credit was not the critical bottleneck for the progress of the Green Revolution. Meanwhile, the number of millers and buyers in Africa is limited and they do not usually deal in fertilizer. It is alleged that in Africa credit constraints may not easily be solved. However, our case may indicate such arrangement can emerge. This is most likely because the production risk is lower and payment after harvest is more credible in the irrigated area.

In the rainfed area, as a net importer of rice, the rice price at local markets became higher than that in the irrigated area (6.67 in 2008 and 10.83 in 2011), reflecting the remoteness of the villages in the rainfed area. Although the nominal wage rate also increased in the rainfed area, the real wage rate became slightly lower in 2011 due to a faster increase in rice prices, implying an increase in profitability. These changes in the markets could be a significant stimulus to the production increase.

Regarding input use, rice production in the rainfed area relied mostly on family labor with little use of animals or machines and no use of fertilizer in 2008. In 2011 animals, machines and fertilizer were not used at all. Only 9-12% of the total labor input was hired labor. Under such a production mode the paid out cost account for only a small portion of total cost and the revenue becomes almost equal to the income. Therefore, regardless of very low yield, farmers still earn a substantial amount of income. Note that, taking advantage of the rice price increase, in the rainfed area the income per hectare as well as the total income increased from 5,703 MT/ha to 6,770 MT/ha or from 2,677 MT to 6,358 MT, respectively.

In Table 4, we review the conditions of output and factor markets. Even in the irrigated area the number of rice millers and buyers was low. The activeness of a labor market is approximated by the proportion of hired labor. Because landless households are not common -a remarkable difference between Mozambique and Asia - hired labor is not the major source of power.[5] With regard to the land rental market, only 2% of rice plots in the irrigated area were rented by the farmers in 2011. In the rainfed areas the figures were 12% in 2008 and 5% in 2011. In summary, both the agricultural labor and the land rental markets were very thin in Mozambique.

Lastly we show the changes in household characteristics (Table 5). Among human and physical capital endowments, the number of working age household members changed little in both areas. The average number of years of schooling increased slightly. In the rainfed area the number of cattle increased. With regard to welfare, the figures from the irrigated area show that households experienced an improvement in their asset position. Non-agricultural job opportunities did not change considerable, as indicated by the proportions of salary or cash earners.

Summarizing the features discussed above, the changes in rice production have been schematically summarized in Figure 3. The graph shows the production function of rice with

[5] For example, in the Philippines the proportion was 49% in 1966 and 71% in 1976 in Laguna, and 60% in 1967 and 43% in 1971 in Central Luzon. In Tamil Nadu, India, the proportion was 73% in 1971.

only the land size dimension of input on the horizontal axis. The change in the rainfed area is characterized as an area expansion with little progress in technology adoption (no shift in the production curve). Hence, the expected outcome is a production increase with more land but at a lower yield. The main reason for change in this direction during our survey period could be the stimulus created by the sharp increase in the local rice price. In the expansion process, some farmers would have started rice cultivation in the lowland, which had not yet been used for rice. If this was the case, some lowland parcels may not have been fully prepared for rice cultivation in the survey year, particularly where the plot was in a remote area or where the environmental conditions of the plot were very severe. Under such a transition process a newly expanded area might not be able to achieve its potential yield and may even fail to harvest. This situation could have resulted in, on average, an insignificant or a marginal increase in output (in the short-run) and may have made the low yield in the rainfed area even lower.

Meanwhile, in the irrigated area (the upper production function), as a result of the adverse effect of the real price increase at the factor markets, the use of fertilizer and power was reduced and, accordingly, land productivity declined. This situation resulted in a yield decline from 2008 to 2011. However, those farmers who could mitigate these adverse effects seemed to maintain a high yield; those farmers who were trained by JICA may fall in this category. In the following section we statistically examine these propositions.

5. Methodology

We have taken different estimation approaches between the irrigated and the rainfed areas. Table 6 shows the transition matrix of rice cultivation where the figures indicate the number of rice cultivators or non-cultivators in each survey round. The matrix of the irrigated area indicates that only 76 farmers cultivated rice in both years, while 56 did not and 52 started/resumed in 2011.

Our field observations show that farmers make decisions each year based on their expectations about water availability from irrigation and other constraints. If they decide not to cultivate rice, they either allow the land to lie fallow, or they cultivate vegetables or less-water demanding crops - usually at a small portion of the parcel. We therefore begin by estimating the determinants of rice cultivation by year. We then go on to estimate the determinants of rice production performance among the rice cultivators. The most important performance indicator in the irrigated area is yield. In addition, we estimate the determinants of the use of major inputs such as fertilizer, labor, animal power, and tractors.[6]

In the rainfed areas, most of the farmers who cultivated rice in 2008 also cultivated rice in 2011 (195 out of 211 farmers). Additionally, our descriptive tables indicate that what occurred in the area was not a structural change under technology adoption but rather an adjustment of resource use with the same technology set. Therefore, taking advantage of the panel structure we apply household fixed effect models to estimate the determinants of rice performance. To capture the extensification process, the main performance indicators in the rainfed area are: the area cultivated, the output, and the yield of the entire rice parcels including non-survey parcels. As it is related to the yield, we also estimate the size of the fallowed land area.

6. Determinants of rice cultivation in the Chokwe irrigation scheme

We apply a Probit model to estimate the equation of a binary dependent variable which becomes one for a rice cultivator and zero otherwise. The explanatory variables include: (1) credit access (the dummy of credit use in the survey year); (2) extension service (the dummy of service received in the survey year); (3) labor endowment (the number of working-age household members, the average number of schooling years, a female headed household dummy, the

[6] The use of thresher in 2007 is not estimated because only 7% of the farmers used it. Tractor use and thresher use in 2011 are not estimated because farmers used neither method at all.

proportion of salary earners); (4) land endowment (total landholdings); (5) power source endowment (the number of cattle owned); and (6) water access (downstream dummy, drought dummy, and flood dummy). In order to capture differential impacts of water access shocks in the irrigated area, we include interaction terms of the downstream dummy with the drought dummy or the flood dummy. Since access to credit and access to the extension service are possible endogenous variables, we estimate additional models by replacing these two variables with the value of assets and travel time to the nearest town - assuming they are given to the household for the short term at least.

Firstly, the results in Table 7 clearly indicate the importance of water access. In 2007 (a year of severe drought), the coefficient of the drought dummy is negative and highly significant but its interaction term with the downstream dummy is not so. Meanwhile, in 2011 when the drought was mild, only the downstream farmers who were affected by the drought (i.e., interaction term of drought and downstream) had to give up rice cultivation. This indicates that unless weather shocks are severe, an improvement in the capacity of a system and stricter water management, would reduce the number of downstream farmers who have to give up their rice cultivation.

Another interesting finding is that credit was important in 2007 but not so in 2011. This change will be discussed later in this paper. Access to extension services was influential in both years, implying the usefulness of knowledge about modern management in the irrigated area.

7. Determinants of rice production performance in the Chokwe irrigation scheme

The composition of explanatory variables is slightly different from the previous model. Firstly, we replaced household-level water condition variables (the drought dummy and the flood dummy) with the plot-level ones (the insufficient water dummy and the too-much water dummy).

Secondly, we included the dummy of those who received JICA training. Thirdly, in the second round of our survey we collected information about access to rice-related markets such as the number of accessible rice buyers, rice millers, and seed sellers. This information is included in the analysis of the 2011 data. As these variables are missing for some of the farmers, to check for robustness we also ran models without these new variables.

Tables 8 shows the estimation results in 2007. The results indicate that the farmers in the downstream area or those suffering from insufficient irrigation achieved a lower yield in the severe drought year. We would like to stress again the importance of access to water. In 2007, the use of chemical fertilizer was associated with credit use in a structural form or with the value of assets in the reduced form regression. This indicates the importance of having cash in hand in order to purchase the fertilizer. The negative influence of insufficient water on the use of chemical fertilizer indicates a complementary effect between the two. The number of working-age household members is significant to the total (i.e., the sum of family and hired) labor input function. This implies the existence of allocative inefficiency due to inactive factor markets. If household with a shortage of labor were able to hire as much labor as they wished, the household level labor endowment would not have a significant effect on labor input. The likelihood that animals will be used increases among those who own more cattle. The access to credit looks to be important for tractor use; however, the result is not robust as the asset variable in the alternative model is not significant. The JICA training dummy is significant in the structural form model in relation to total labor hours. This dummy is also significant in the reduced form yield function, indicating the yield is about 0.7 tons higher at the training sites. This is presumably due to the implementation of more labor-intensive farming at the project sites. Note however that since this is the result for the year that the project was started, we cannot yet be sure of the sustainability of this impact.

The results in 2011 are reported in Table 9. The corresponding results with the full sample excluding the newly collected variables are placed in the Appendix A1. Since the qualitative results are the same, our discussion relies on the results in Table 9. An important change from the 2007 results is that the impact of the JICA training becomes greater and more robust in 2011. First, the impact on yield became greater and the coefficients became significant both in structural and reduced forms. The model predicts that the trained groups can achieve a yield that is higher by about one ton. Second, this dummy is also significant in the animal use function, both in structural and reduced forms. This indicates that among other things the animal traction component was practically effective and was therefore remained adopted to help improve yield. Note also that our survey was conducted a year after the completion of the project, which implies the sustainability of the impact of this component.

Another interesting contrast to the 2007 results is that the use of credit and the value of assets are no longer associated with the use of chemical fertilizer. A possible reason for this is the emergence of post-harvest payment arrangements. This idea is supported by a positive and significant coefficient of the number of accessible rice buyers who may be the ones to accept such a payment arrangement. It should, however, be noted that the insignificant effect of credit may simply be due to the fact that the demand for fertilizer decreased when its price increased in 2011. Since the fertilizer is a crucial factor for yield improvement, a further investigation is worthwhile. The number of working-age household members is still highly significant in the total labor input function, indicating that the inactive labor market has remained.

8. Determinants of rice performance in the rainfed area

Table 10 presents the results of household-level fixed-effect models on the determinants of rice production performance. We make a few remarks about the differences between this and the analysis of the irrigated area data. Firstly, because our focus in the rainfed area is on the extensification process, the dependent variables measure the levels or amounts aggregated over all rice plots, rather than those of survey plot only. Secondly, we exclude the explanatory variables that are employed mainly to explain the adoption of modern technologies because this aspect has not emerged in the rainfed area. An advantage of this treatment is that our models become less likely to suffer endogenous variable problems.[7] Thirdly, in order to capture the price effect, we include the village-level paddy price. In contrast to the data from one irrigation scheme, we have wide geographical price variations in the rainfed area. The available data points for input prices and wage rates are too few because no modern input is used and most of the farmers rely solely on family labor in the rainfed area. We therefore stopped including these in our estimation models.

The results show that the cultivated area becomes larger with a greater land endowment and where the paddy price is higher. Our expectation based on Figure 3 is that these two key determinants affect the paddy output in the same manner. Although both have correct signs (i.e., positive signs), only the coefficient of landholding is statistically significant in the paddy output model. This is probably because the area expanded with the price stimulus has yet contributed much to the total output. Figure 3 predicts that yield decreases with the expansion of the area if the process is at the extensification stage. The coefficient of the landholding size and that of the price in the yield function have negative signs. The last model shows that the larger the land endowment, the greater the chance of land being put to fallow. The large landholders have room to selectively cultivate their parcels depending on the agronomic, weather, and market condition of each parcel in a particular season. If they cultivated favorable plots of land that season, yield would not largely decline. This could reduce a negative impact on paddy yield among the large landholders.

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[7] The variables excluded are average schooling years, number of cattle, credit use, extension service received, and proportion of salary earners.

9. Impact of rice sector development on household welfare

Our ultimate goal is welfare improvement and poverty reduction among Mozambican farmers. Can the acceleration of rice sector development contribute to this goal? Figures 4 and 5 present non-parametric regression curves on X-Y diagram, where Y measures welfare and X measures rice production performance.[8] The welfare is measured either by the rice income per household member in panel (a), or by the log of non-agricultural asset values per household member in panel (b). The performance indicator in the irrigated area is paddy yield and in the rainfed area it is paddy output. There is only asset data for the rainfed for 2011. All figures show a positive association globally, supporting rice as a strategically important commodity for the improvement of farmers' welfare.

10. Concluding remarks

Our analyses of a rice farmer panel data set collected in 2007/08 and 2011 identify the constraints on Mozambique's rice sector development. In reaction to the increase in paddy prices, the farmers in the rainfed area are approaching to marginal land of their land frontier, experiencing lowering yield. Most of the farmers in the rainfed area had been relying solely on family labor for their rice production with little use of modern seeds, inputs, animals, and machines. Further increases in rice production in the rainfed area should come from a shift of their production mode from extensification to intensification through the introduction of land saving technologies. One of these technologies is the irrigation development.

Lessons from the Chokwe irrigation scheme are useful for this aim. Assuring water access through proper system management is crucially important because timely water

[8] We use a locally weighted scatterplot smoothing method setting bundwidth at 0.8.

application directly increases output but also increases the returns to chemical fertilizer use. A recent increase in real prices of modern inputs such as fertilizer and tractors made the farmers substitute family labor for modern inputs, that is, the recurrence of traditional farming. Our analysis shows that the farmers who received a training program achieved a high yield with the use of animal traction. The farmers with access to rice buyers kept using chemical fertilizer. These findings suggest that training and market development are important for recapturing the momentum of modernization in the irrigated rice sector.

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Table 1. Area of rice production in 2005 and agro-ecology by province

Province	Area of rice production in 2005 (000ha)	Proportion (%)	Predominant agro-ecology in major rice provinces
Niassa	5.9	2	
Cebo Delgado	38.2	14	Rainfed lowlands/Uplands
Nampula	28.1	10	Rainfed lowlands/Uplands
Zambézia	158.2	57	Rainfed lowlands
Tete	1.6	1	
Manica	3.2	1	
Sofala	24.9	9	Rainfed lowlands
Inhambane	6.0	2	Rainfed lowlands/Uplands
Gaza	11.8	4	Irrigated
Maputo	0.4	0	Rainfed lowlands
Total	278.3	100	

Source: TIA 2005 for area and proportion. Zandamela et al. (1994) referred to in Agrifood Consulting International (2005) for agro-ecology.

Table 2. Changes of rice production, technology, weather, and irrigation conditions from 2007/08 to 2011

	----- Chokwe -----		--- Zambézia & Sofala ---	
	2007	2011	2008	2011
Rice production -- aggregated over all rice plots--				
Land holding (lowland) (ha.)	1.84	1.80	1.92	1.40
Rice cultivated area (ha.)	1.12	1.20	0.50-0.86	0.60-1.04
Rice production -- survey plot --				
Rice cultivated area (ha.)	1.12	1.20	0.36	0.43
Paddy production (t)	2.19	1.90	0.29	0.25
Paddy yield (t/ha)	2.04	1.56	1.00	0.80
Paddy yield of JICA training sites (sub-sample) (t/ha)	2.67	2.32		
Rice technology and practice				
Plot with bund (%)	68	98	45	47
Plot subdivided by bund (%)		94		41
Bund height (cm)		28.80		38.75
Bund construction in survey year (%)		97		61
Major variety (name and %)	TIA312, 61%	TIA312, 74%	Nene, 16%	Mamia, 22%
Transplanting (%)	77	74	28	23
Weather and Irrigation				
Drought experienced farmers (%)	53	19	74	65
Flood experienced farmers (%)	3	58	26	12
Insufficient water experienced farmers (%)	14	9		
Too much water experienced farmers (%)	7	13		

Table 3. Changes of price, inputs, income, and profits from 2007/08 to 2011

	----- Chokwe -----		--- Zambézia & Sofala ---	
	2007	2011	2008	2011
Price				
Paddy price (MT/kg)	3.97	6.36	6.67	10.83
Wage rate (av. all ag labor works) (MT/day)	45.60	84.50	31.68	44.61
Price of nitrogen (MT/kg)	30.40	57.10		
Tractor rental cost (MT/ha)	1432	2800*		
Real wage rate (in paddy)	11.80	13.40	5.27	4.40
Real nitrogen price (in paddy)	7.84	9.04		
Real tractor rental cost (in paddy)	369	440		
Input				
Fertilizer (NPK) amount (kg/ha)	21.00	9.63	0.00	0.00
Fertilizer payment, at the time of purchase		0.78		
Fertilizer payment, after harvest		0.14		
Animal use (%)	45	1	1	0
Tractor use (%)	55	0	0	0
Thresher use (%)	7	0	1	0
Family labor input excl. bird scaring (days/ha)	50	94	159	119
Hired labor input excl. bird scaring (days/ha)	34	33	16	16
Income and profit				
Rice income per ha. (MT/ha)	3,771	3,871	5,703	6,770
Rice profit per ha.(MT/ha)	269	-2173	453	1,797
Total rice income from the survey plot (MT)	3,322	4,992	2,677	6,358

*obtained from secondary source

Table 4. Changes of output, labor, and land markets from 2007/08 to 2011

	----- Chokwe -----		--- Zambézia & Sofala ---	
	2007	2011	2008	2011
Output market				
Rice miller (number)		0.22		0.05
Rice buyer (number)		0.44		0.17
Labor market				
Proportion of hired labor (%)	33	22	9	12
Exchange labor for crop establishment* (%)			9	
Hired labor for crop establishment* (%)			26	
Exchange labor for harvesting* (%)			14	
Hired labor for harvesting* (%)			26	
Land transaction				
How land obtained (%)				
from traditional/formal authority		56	6	8
from relative		5	22	17
rent-in or borrow		12	10	8
Occupied		2	22	24
Purchased		0	14	20
inherited		23	26	24
Others		0	0	0
Prop of rented-in plot of all rice plots (%)		2	12	5

*data from the village level questionnaire

Table 5. Changes of household characteristics from 2007/08 to 2011

	----- Chokwe -----		--- Zambézia & Sofala ---	
	2007	2011	2008	2011
Household Characteristics				
No. of working age members	4.1	3.7	2.2	2.5
Female-headed HH (%)	34	38	23	23
Head's schooling years	2.90	2.69	3.07	3.06
Average schooling years	4.03	4.44	3.02	3.32
Credit experience in survey year (% of farmers)	6	7	2	3
Extension service, received in survey year (% of farmers)	39	17	8	17
Value of asset (MT)	35,977	61,914		6,544
Cattle number	3.14	3.54	0.07	0.21
Proportion of salary earner in a family (%)	16	9	9	6
Proportion of cash earner in a family (%)	23	21	24	17

*secondary data

Table 6. Rice cultivator transition matrix

Chokwe

		2011		
		Cultivator	Non-cultivator	
2007	Cultivator	76	56	132
	Non-cultivator	52	139	191
		128	195	323

Zambézia and Sofala

		2011		
		Y	N	
2008	Cultivator	195	15	210
	Non-cultivator	1	0	1
		196	15	211

Table 7. Probit analysis of rice cultivation in 2007 and 2011, Chokwe Irrigation Scheme

	Dep. var.: Rice cultivation=1			
	---------------- 2007 ---------------		-------------- 2011 --------------	
Credit use in survey year	1.409***		0.257	
	(2.817)		(0.804)	
Extension service received	0.437***		0.456**	
	(2.722)		(2.206)	
Value of assets		-4.82e-07		-4.86e-07
		(-0.413)		(-0.630)
Travel time to the nearest town		-0.00747**		-0.00240
		(-2.316)		(-0.938)
No of working age HH members	-0.00338	-0.0174	-0.0212	-0.0319
	(-0.0939)	(-0.474)	(-0.552)	(-0.819)
Ave. schooling years	-0.00507	0.00401	0.0404	0.0352
	(-0.130)	(0.0948)	(1.222)	(1.010)
Female-headed HH dummy	-0.0126	0.0327	0.0622	0.0649
	(-0.0759)	(0.193)	(0.375)	(0.396)
HH head age	-0.00658	-0.00569	-0.00329	-0.00270
	(-1.262)	(-1.021)	(-0.960)	(-0.789)
Total land holdings	0.101**	0.148***	0.155***	0.170***
	(2.449)	(3.700)	(3.813)	(4.218)
No of cattle, owned	-0.0194*	-0.0164	0.000870	0.00607
	(-1.670)	(-1.182)	(0.120)	(0.709)
Prop of salary earners	-1.213**	-1.376**	-0.178	-0.0562
	(-2.059)	(-2.305)	(-0.286)	(-0.0905)
Downstream dummy	-0.481	-0.647**	-0.105	-0.122
	(-1.555)	(-2.067)	(-0.310)	(-0.363)
Drought experience dummy	-0.458***	-0.533***	0.0113	0.0550
	(-2.606)	(-3.068)	(0.0515)	(0.254)
Drought*downstream	0.124	0.348	-0.950*	-0.961*
	(0.297)	(0.807)	(-1.776)	(-1.813)
Flood experience dummy	-0.104	-0.192	0.277	0.302*
	(-0.243)	(-0.456)	(1.629)	(1.780)
Flood*downstream [a]			0.534	0.556
			(1.257)	(1.314)
Constant	0.235	0.650	-0.790***	-0.641**
	(0.601)	(1.576)	(-2.781)	(-2.155)
Observations	323	303	323	321

a) not included in 2007 regression due to the drop of two observations by the perfect prediction by this variable.
z-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 8. Determinants of paddy yield, fertilizer quantity, labor inputs, animal use, and tractor use in 2007, Chokwe Irrigation Scheme

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
VARIABLES	Paddy yield	Paddy yield	NPK amount	NPK amount	Total labor hrs	Total labor hrs	Animal use dummy	Animal use dummy	Tractor use dummy	Tractor use dummy
Credit use in survey year	-0.333		11.34*		28.86		-0.0697		0.241*	
	(-1.038)		(1.776)		(1.136)		(-0.517)		(1.878)	
Extension service, received	0.0602		-2.396		-20.96		-0.0226		0.0627	
	(0.268)		(-0.535)		(-1.176)		(-0.239)		(0.695)	
Value of assets		1.42e-06		0.000103***		0.000195		-6.52e-07		2.36e-07
		(0.805)		(3.067)		(1.358)		(-0.884)		(0.329)
Travel time to the nearest town		-0.00173		-0.000635		-0.440		-0.00182		-0.000590
		(-0.326)		(-0.00625)		(-1.019)		(-0.819)		(-0.272)
No of working age HH members	0.0388	0.0356	-1.250	-1.524	20.67***	21.35***	-0.00424	0.0103	0.0411*	0.0290
	(0.703)	(0.605)	(-1.138)	(-1.354)	(4.729)	(4.459)	(-0.183)	(0.420)	(1.857)	(1.208)
Ave. schooling years	0.108*	0.103	1.590	0.811	2.408	-2.097	-0.0495**	-0.0514*	0.0505**	0.0540**
	(1.849)	(1.574)	(1.363)	(0.651)	(0.519)	(-0.395)	(-2.013)	(-1.882)	(2.152)	(2.032)
Female-headed dummy	-0.0901	-0.0109	-2.312	0.660	-21.55	-15.28	-0.0832	-0.0536	0.00577	-0.0224
	(-0.388)	(-0.0453)	(-0.499)	(0.144)	(-1.171)	(-0.781)	(-0.853)	(-0.532)	(0.0619)	(-0.229)
HH Head age	-0.000849	0.00346	0.284*	0.427**	-0.882	-0.808	0.000322	0.000319	0.000247	0.00120
	(-0.105)	(0.385)	(1.758)	(2.478)	(-1.372)	(-1.102)	(0.0945)	(0.0845)	(0.0759)	(0.326)
Total land holdings	-0.00169	-0.0266	2.452**	3.050***	-2.881	-2.752	-0.0254	-0.0268	0.00892	0.0206
	(-0.0327)	(-0.526)	(2.376)	(3.156)	(-0.702)	(-0.670)	(-1.168)	(-1.267)	(0.429)	(1.002)
No of cattle owned	0.0324	0.0350*	-0.0152	-0.225	-1.924	-2.762*	0.0153*	0.0141*	0.000762	0.00112
	(1.626)	(1.774)	(-0.0384)	(-0.596)	(-1.218)	(-1.719)	(1.831)	(1.702)	(0.0953)	(0.140)
Prop of salary earners	-0.734	-0.477	2.952	-15.60	-30.67	-39.79	0.358	0.402	0.00643	-0.0847
	(-0.877)	(-0.540)	(0.177)	(-0.923)	(-0.462)	(-0.554)	(1.019)	(1.087)	(0.0191)	(-0.235)
Downstream dummy	-0.718*	-0.678*	-10.79	-10.21	41.35	43.15	0.184	0.230	-0.248*	-0.349**
	(-1.975)	(-1.804)	(-1.489)	(-1.420)	(1.435)	(1.411)	(1.204)	(1.460)	(-1.698)	(-2.277)
Insufficient irrigation	-0.830**	-0.844**	-16.93**	-12.33*	-4.885	2.658	0.121	0.117	0.0947	0.109
	(-2.510)	(-2.531)	(-2.569)	(-1.933)	(-0.186)	(0.0980)	(0.868)	(0.838)	(0.714)	(0.803)
Insufficient*downstream	0.345	0.214	-8.204	-8.533	-30.02	-28.18	-0.202	-0.276	0.520	0.645
	(0.354)	(0.220)	(-0.422)	(-0.459)	(-0.388)	(-0.356)	(-0.492)	(-0.678)	(1.328)	(1.627)
Too much irrigation water	-0.209	-0.0870	1.353	7.009	-36.18	-21.07	0.110	0.168	-0.296	-0.423**
	(-0.455)	(-0.182)	(0.148)	(0.765)	(-0.992)	(-0.541)	(0.571)	(0.840)	(-1.601)	(-2.165)

Too much*downstream	-1.062	-1.364	-6.097	-17.28	-31.07	-47.53	0.390	0.254	0.00462	0.160
	(-0.774)	(-0.974)	(-0.223)	(-0.645)	(-0.286)	(-0.417)	(0.676)	(0.434)	(0.00838)	(0.280)
JICA training WUG dummy	0.453	0.657*	-2.798	-3.762	46.36*	44.51	0.0993	0.00646	-0.190	-0.123
	(1.352)	(1.839)	(-0.419)	(-0.550)	(1.747)	(1.530)	(0.705)	(0.0432)	(-1.412)	(-0.847)
Constant	1.703***	1.495**	1.910	-5.957	61.77	73.63	0.633***	0.639***	0.123	0.172
	(3.280)	(2.577)	(0.185)	(-0.537)	(1.501)	(1.560)	(2.899)	(2.628)	(0.592)	(0.726)
Observations	132	125	132	125	132	125	132	125	132	125
R-squared	0.201	0.238	0.196	0.279	0.213	0.232	0.122	0.150	0.198	0.192

t-statistics in parentheses,
*** p<0.01, ** p<0.05, * p<0.1

Table 9. Determinants of paddy yield, fertilizer quantity, labor input, and animal use in 2011, Chokwe Irrigation Scheme (sub-sample)

VARIABLES	(1) Paddy yield	(2) Paddy yield	(3) NPK amount	(4) NPK amount	(5) Total labor hrs	(6) Total labor hrs	(7) Animal use dummy	(8) Animal use dummy
Credit use in survey year	0.660		-3.631		83.79*		0.0845***	
	(1.490)		(-0.569)		(1.954)		(3.126)	
Extension service, received	0.000372		1.142		5.768		0.00449	
	(0.00115)		(0.244)		(0.184)		(0.227)	
Value of assets		2.49e-06		-1.42e-05		-0.000119		-2.87e-09
		(1.211)		(-0.481)		(-0.589)		(-0.0217)
Travel time to the nearest town		-0.00276		-0.0444		-0.619		6.24e-05
		(-0.469)		(-0.529)		(-1.081)		(0.166)
No of working age HH members	0.0393	0.00683	-1.152	-0.918	24.42***	21.72***	-0.00281	-0.00574
	(0.487)	(0.0818)	(-0.991)	(-0.764)	(3.125)	(2.651)	(-0.571)	(-1.066)
Ave. schooling years	0.0652	0.0697	0.837	0.990	-10.05*	-7.571	-0.000509	-0.000191
	(1.047)	(1.038)	(0.933)	(1.023)	(-1.667)	(-1.149)	(-0.134)	(-0.0442)
Female-headed dummy	-0.436*	-0.430*	-7.562**	-7.472**	-14.42	-19.30	-0.00950	-0.0133
	(-1.874)	(-1.808)	(-2.271)	(-2.201)	(-0.644)	(-0.834)	(-0.673)	(-0.878)
HH Head age	0.000529	0.00170	0.0703	0.0720	-0.596	-0.443	0.000113	0.000204
	(0.0855)	(0.274)	(0.789)	(0.807)	(-0.996)	(-0.728)	(0.299)	(0.511)
Total land holdings	-0.000352	0.00279	1.698*	1.575*	-22.11***	-19.96***	-0.00178	0.000451
	(-0.00558)	(0.0442)	(1.881)	(1.747)	(-3.642)	(-3.249)	(-0.465)	(0.112)
No of cattle owned	0.00821	-0.00736	-0.104	-0.0389	-0.214	0.00104	0.00107	0.000812
	(0.488)	(-0.374)	(-0.430)	(-0.137)	(-0.131)	(0.000539)	(1.044)	(0.640)
Prop of salary earners	1.273	1.352	-18.76	-18.32	191.5*	216.3*	0.245***	0.250***
	(1.133)	(1.154)	(-1.158)	(-1.086)	(1.759)	(1.882)	(3.569)	(3.317)
Downstream dummy	-0.311	-0.351	-8.738	-9.743*	60.73	49.15	-0.00633	-0.00976
	(-0.798)	(-0.892)	(-1.554)	(-1.718)	(1.607)	(1.272)	(-0.266)	(-0.384)
Insufficient irrigation	-0.0472	-0.0848	-7.864	-8.295	101.1**	84.09*	-0.00133	-0.0109
	(-0.103)	(-0.183)	(-1.190)	(-1.247)	(2.275)	(1.855)	(-0.0474)	(-0.367)
Too much irrigation water	-0.287	-0.252	-5.533	-6.150	-66.61	-75.05*	-0.0188	-0.0253
	(-0.609)	(-0.536)	(-0.836)	(-0.929)	(-1.496)	(-1.665)	(-0.668)	(-0.853)
Too much*downstream	-0.500	-0.222	7.645	8.657	-13.32	-0.311	0.0186	0.0219
	(-0.472)	(-0.206)	(0.503)	(0.560)	(-0.130)	(-0.00296)	(0.289)	(0.317)
JICA training WUG dummy	1.132***	0.913**	-2.118	-2.723	26.23	10.87	0.0631**	0.0590**
	(2.850)	(2.209)	(-0.370)	(-0.458)	(0.682)	(0.268)	(2.603)	(2.216)
Rice experience years	0.00440	0.00470	-0.0442	-0.0208	0.898	0.748	0.00113	0.000983

	(0.379)	(0.397)	(-0.264)	(-0.122)	(0.800)	(0.645)	(1.594)	(1.292)
No of accessible rice buyers	0.562***	0.599***	9.048***	8.967***	-5.159	-4.599	-0.0109	-0.0104
	(2.810)	(2.958)	(3.147)	(3.078)	(-0.267)	(-0.232)	(-0.897)	(-0.797)
No of accessible rice millers	0.691**	0.804**	-2.829	-2.596	25.21	26.08	-0.0226	-0.0208
	(2.141)	(2.374)	(-0.612)	(-0.537)	(0.811)	(0.792)	(-1.153)	(-0.960)
No of accessible seed sellers	0.127	0.0647	3.378	4.043	21.88	29.71	0.00986	0.0132
	(0.367)	(0.179)	(0.688)	(0.791)	(0.663)	(0.853)	(0.474)	(0.575)
Constant	0.579	0.699	6.775	7.347	118.1**	145.2**	-0.0268	-0.0154
	(1.137)	(1.230)	(0.925)	(0.903)	(2.397)	(2.619)	(-0.862)	(-0.423)
Observations	123	121	124	122	124	122	124	122
R-squared	0.305	0.309	0.230	0.233	0.280	0.259	0.254	0.175

Insufficient*downstream is not included due to perfect collinearity with the other variable.

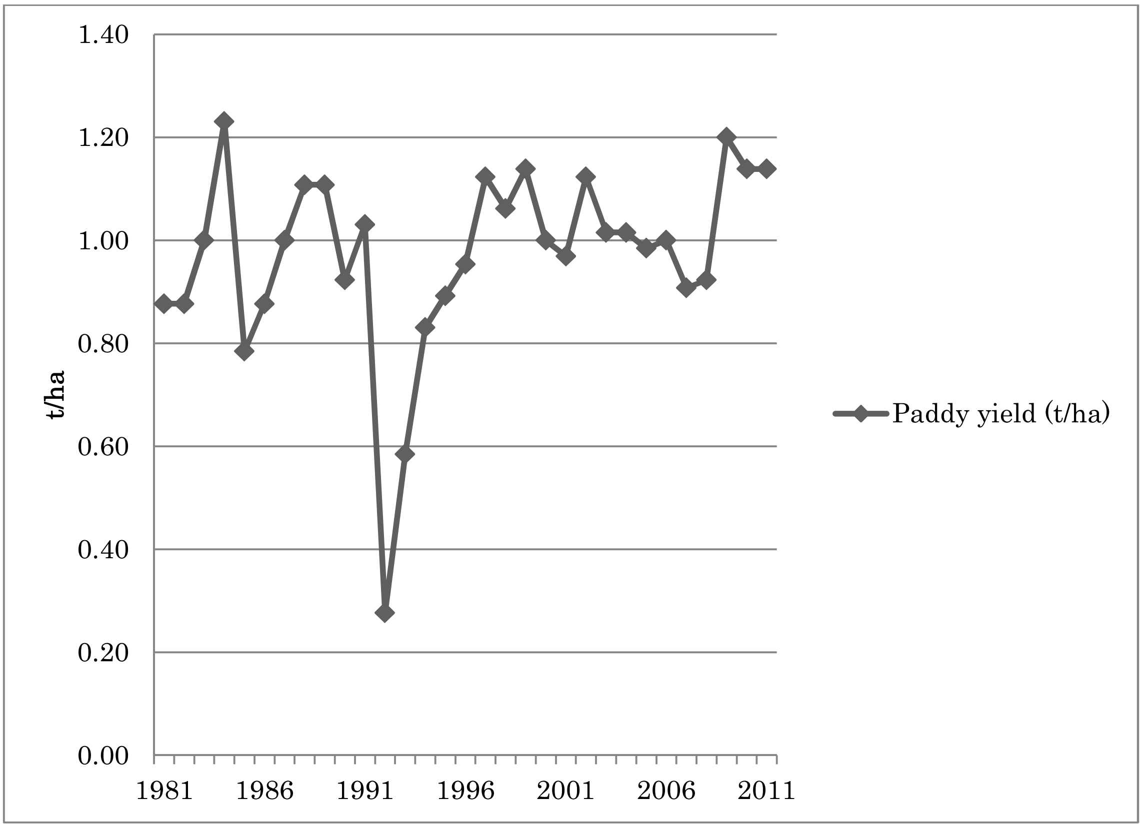
t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 10. Determinants of rice cultivated area, output, and yield in 2008 and 2011, Zambézia and Sofala (HH Fixed-Effect Model)

VARIABLES	Cultivated area	Paddy output	Paddy yield	Fallowed lowland size
Land holding (lowland)	0.132***	0.0265**	-0.0680**	0.0312***
	(7.448)	(2.126)	(-2.583)	(3.441)
No. of working household members	0.0456	-0.0153	-0.108	0.0290
	(0.872)	(-0.414)	(-1.380)	(1.078)
Village paddy price	0.0180*	0.00160	-0.0559***	-0.00609
	(1.597)	(0.201)	(-3.334)	(-1.055)
Drought experience dummy	-0.00484	-0.122	-0.444***	0.0357
	(-0.0433)	(-1.542)	(-2.663)	(0.622)
Flood experience dummy	-0.116	0.191**	0.281	0.0266
	(-0.937)	(2.193)	(1.527)	(0.419)
Constant	0.0991	0.484***	2.131***	-0.0278
	(0.496)	(3.434)	(7.164)	(-0.271)
Observations	390	390	390	390
R-squared	0.232	0.070	0.142	0.074
Number of hhid	195	195	195	195

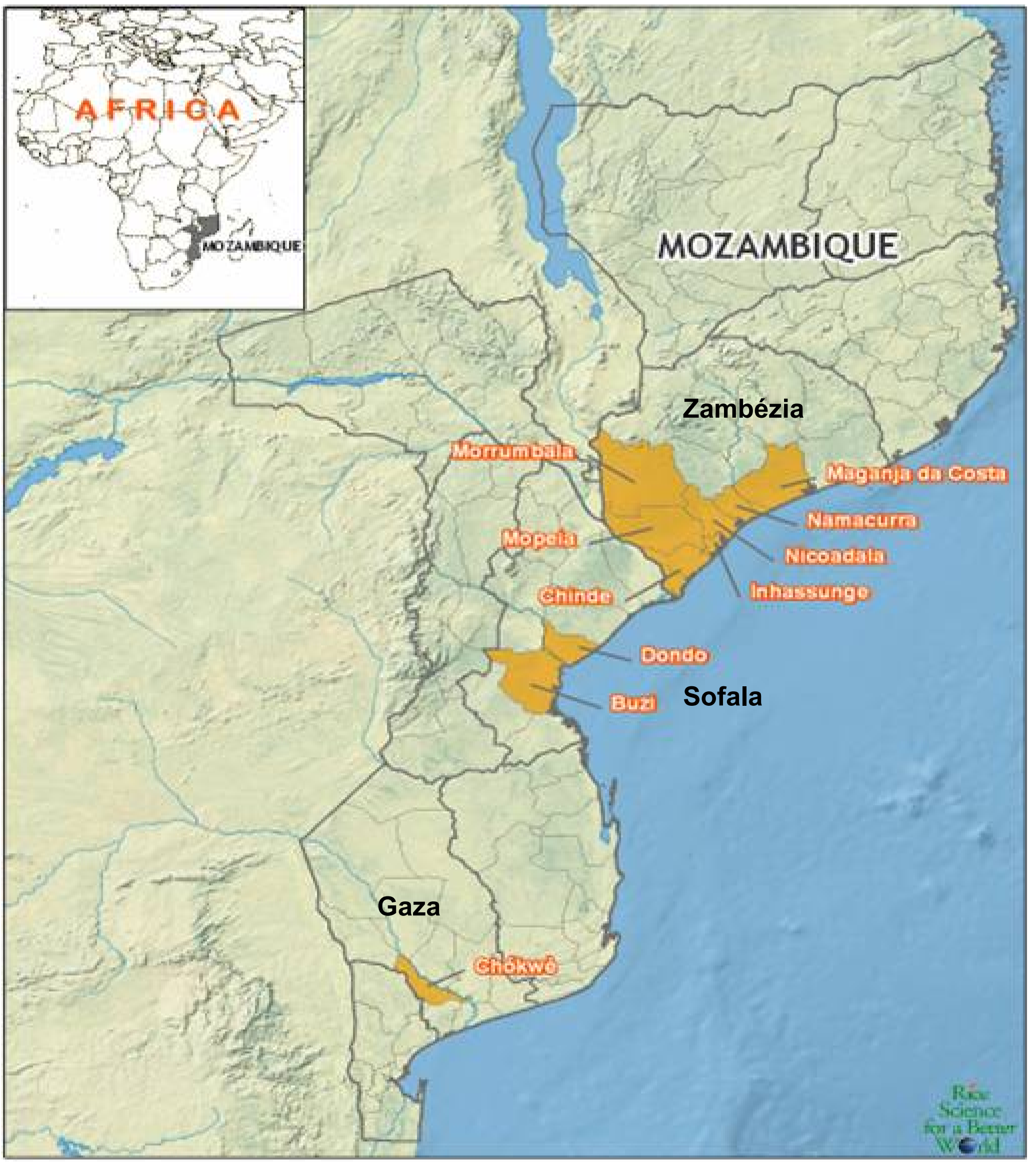
t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 1. Paddy yield in Mozambique from 1981 to 2011



Source: USDA PS&D Online downloaded from http://worldfood.apionet.or.jp/index-e.html

Figure2. Location of survey districts



Source: IRRI Social Science Division

Figure 3. The change of rice production in irrigated area and rainfed area

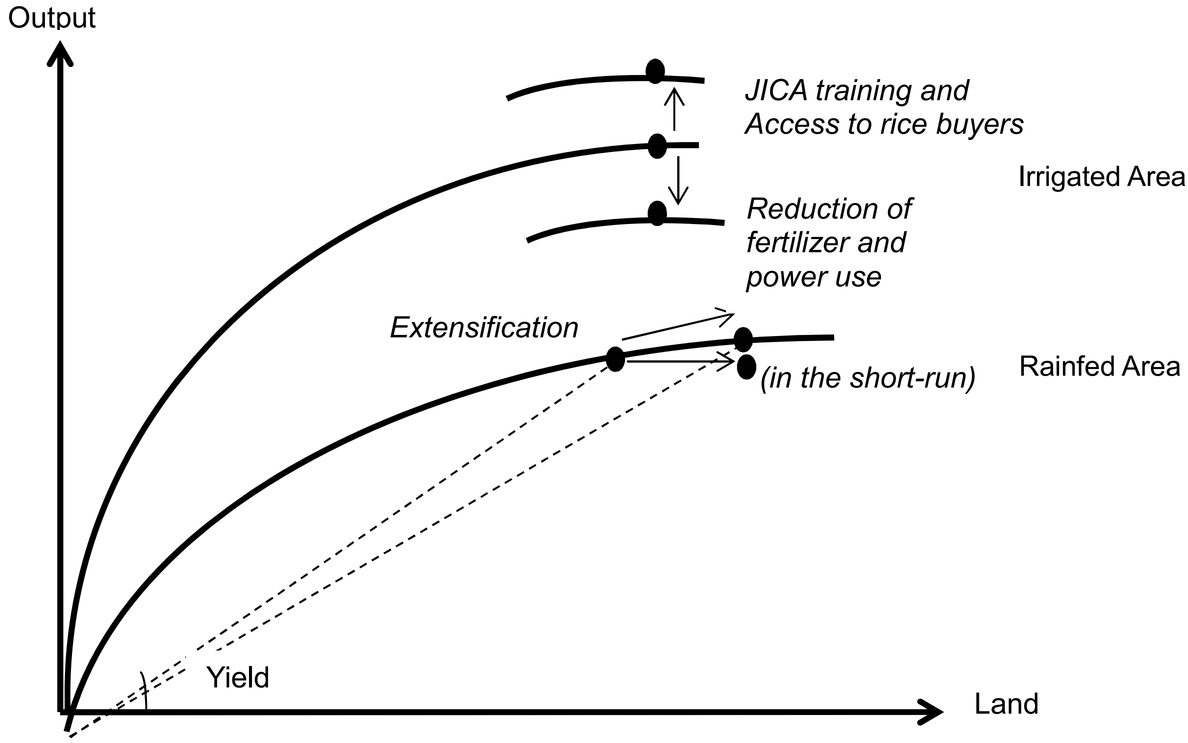
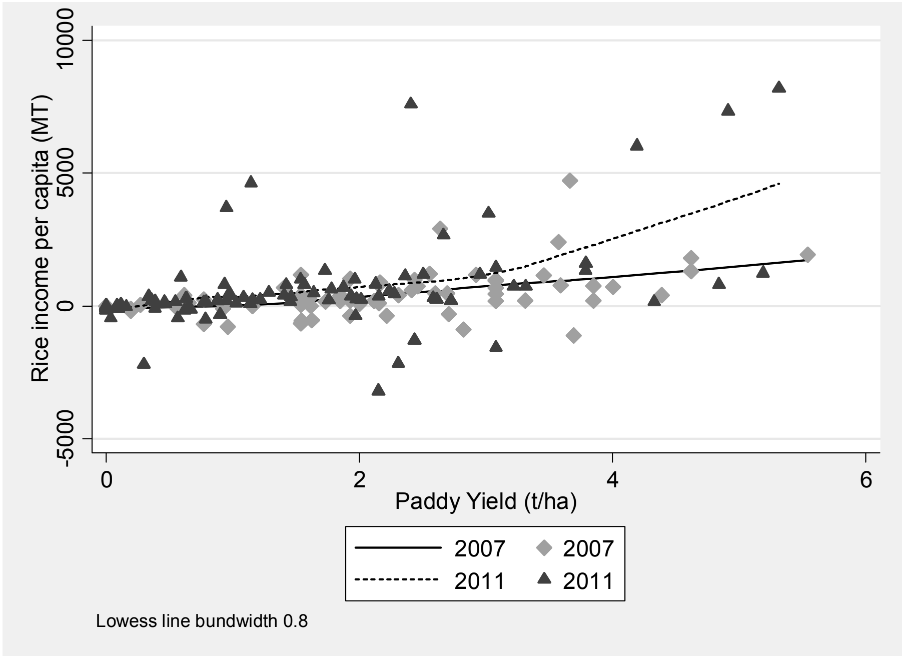
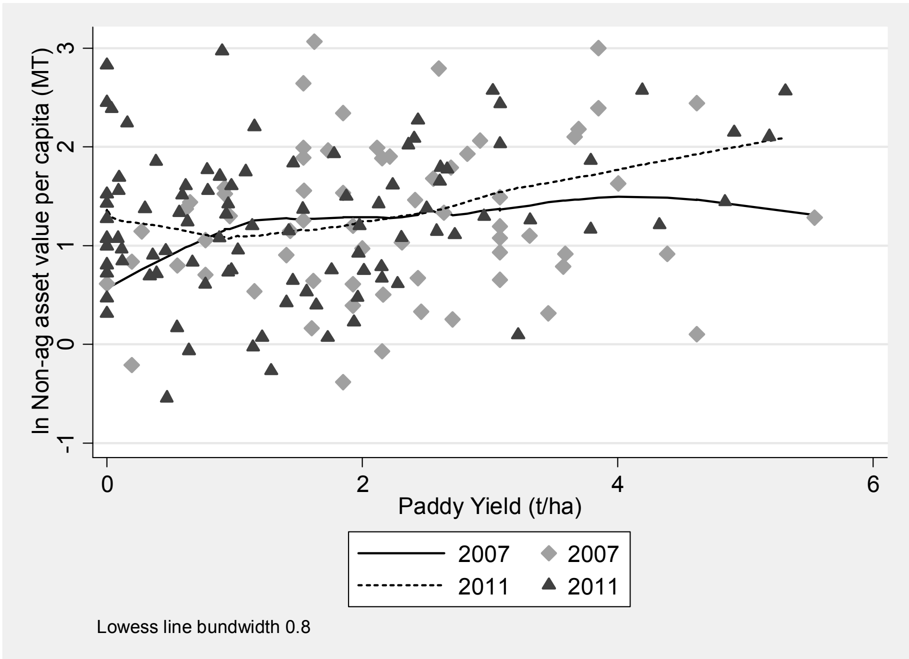


Figure 4. Relationship of paddy yield with (a) rice income per capita or (b) non-agricultural asset values per capita in Chokwe

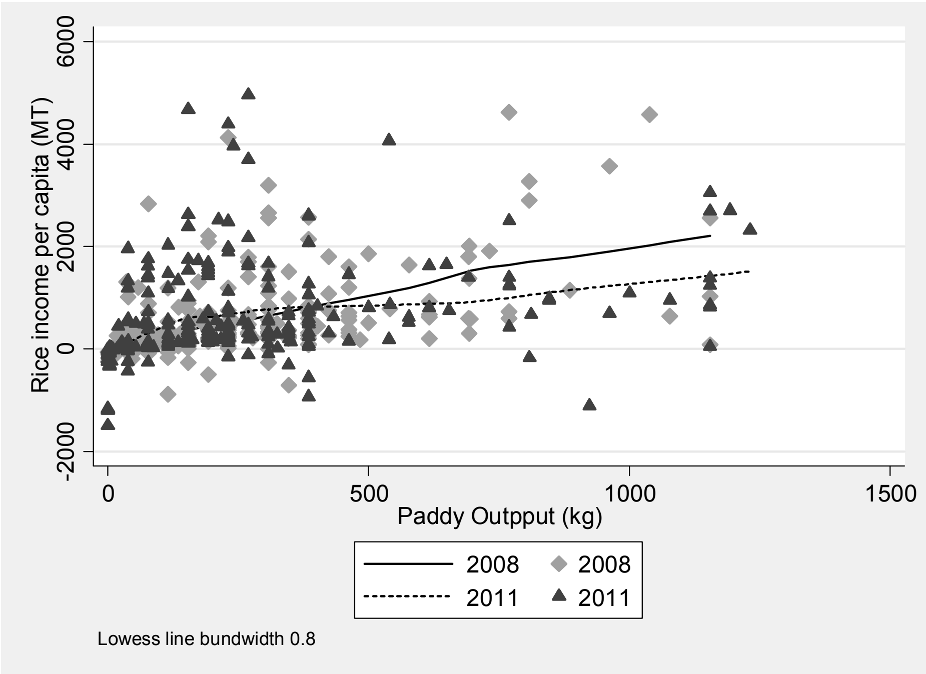


(a) Paddy yield and rice income per capita



(b) Paddy yield and non-agricultural asset values per capita

Figure 5. Relationship of paddy output with (a) rice income per capita or (b) non-agricultural asset values per capita in Zambézia and Sofala



(a) Paddy output and rice income per capita

(b) Paddy output and non-agricultural asset per capita

Table A1. Determinants of paddy yield, fertilizer quantity, labor input, and animal use in 2011, Chokwe Irrigation Scheme

VARIABLES	(1) Paddy yield	(2) Paddy yield	(3) NPK amount	(4) NPK amount	(5) Total labor hrs	(6) Total labor hrs	(7) Animal use dummy	(8) Animal use dummy
Credit use in survey year	0.760		-1.800		86.97**		0.0781***	
	(1.621)		(-0.280)		(2.106)		(2.997)	
Extension service, received	0.0861		0.223		7.595		0.00898	
	(0.256)		(0.0485)		(0.257)		(0.482)	
Value of assets		2.64e-06		-1.36e-05		-9.57e-05		2.71e-08
		(1.265)		(-0.477)		(-0.515)		(0.224)
Travel time to the nearest town		-0.00448		-0.0110		-0.648		-6.07e-06
		(-0.746)		(-0.135)		(-1.217)		(-0.0274)
No of working age HH members	-0.0152	-0.0659	-1.367	-1.112	24.94***	21.45***	-0.00321	-0.00630
	(-0.181)	(-0.763)	(-1.185)	(-0.942)	(3.369)	(2.791)	(-0.690)	(-1.256)
Ave. schooling years	0.0630	0.0585	0.687	0.975	-10.77*	-8.687	-0.00137	-0.00124
	(0.972)	(0.829)	(0.772)	(1.011)	(-1.886)	(-1.385)	(-0.381)	(-0.303)
Female-headed dummy	-0.285	-0.287	-8.466**	-8.507**	-9.587	-14.02	-0.0111	-0.0141
	(-1.190)	(-1.176)	(-2.585)	(-2.561)	(-0.456)	(-0.649)	(-0.842)	(-1.001)
HH Head age	0.00334	0.00493	0.0903	0.0895	-0.690	-0.527	0.000158	0.000255
	(0.523)	(0.771)	(1.028)	(1.023)	(-1.224)	(-0.927)	(0.452)	(0.688)
Total land holdings	0.00211	0.0191	2.119**	2.035**	-20.74***	-18.03***	-0.00149	0.000866
	(0.0323)	(0.293)	(2.373)	(2.295)	(-3.620)	(-3.127)	(-0.412)	(0.230)
No of cattle owned	0.0162	0.000613	0.0347	0.0908	-0.260	-0.0463	0.000663	0.000293
	(0.930)	(0.0302)	(0.145)	(0.327)	(-0.169)	(-0.0257)	(0.684)	(0.249)
Prop of salary earners	1.456	1.844	-21.52	-23.14	181.1*	213.2*	0.221***	0.233***
	(1.249)	(1.521)	(-1.345)	(-1.395)	(1.764)	(1.975)	(3.415)	(3.370)
Downstream dummy	-0.243	-0.282	-8.028	-8.502	70.59*	60.12	-0.00266	-0.00605
	(-0.592)	(-0.683)	(-1.425)	(-1.502)	(1.953)	(1.633)	(-0.117)	(-0.251)
Insufficient irrigation	-0.385	-0.455	-5.793	-6.305	86.83**	69.84*	-0.000928	-0.00944
	(-0.831)	(-0.974)	(-0.912)	(-0.987)	(2.130)	(1.681)	(-0.0361)	(-0.348)
Too much irrigation water	-0.411	-0.391	-4.511	-4.835	-60.52	-67.01	-0.0151	-0.0198
	(-0.872)	(-0.830)	(-0.721)	(-0.778)	(-1.507)	(-1.657)	(-0.598)	(-0.751)
Too much*downstream	-0.450	-0.228	1.919	1.980	-39.66	-29.33	0.0206	0.0251
	(-0.451)	(-0.229)	(0.141)	(0.146)	(-0.455)	(-0.332)	(0.376)	(0.436)
JICA training WUG dummy	0.849**	0.677*	-2.397	-2.684	32.27	17.36	0.0585***	0.0533**
	(2.201)	(1.699)	(-0.453)	(-0.493)	(0.950)	(0.490)	(2.732)	(2.316)
Constant	0.990**	1.222**	9.289	8.652	137.6***	166.8***	-0.0129	-0.000961
	(1.988)	(2.194)	(1.360)	(1.139)	(3.141)	(3.377)	(-0.467)	(-0.0311)
Observations	128	126	129	127	129	127	130	128
R-squared	0.141	0.140	0.131	0.135	0.265	0.243	0.217	0.144

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Abstract (in Japanese)

要約

本論文は、２００７/０８年と２０１１年にモザンビークで収集されたコメ生産農家のパネルデータを分析した。天水地域においては、農家が国際コメ価格の上昇に反応し、コメ耕作地を拡大した。しかし、同時に平均収量は低下しており、このことは、農家が土地生産性の低い土地フロンティアに近づいていることを示唆している。生産性を高め、さらなるコメ増産を達成するためには、生産の形態を外延的拡大から土地集約化の方向へと変えていかなければならない。そのための有力な技術の一つが灌漑開発である。

同国最大の灌漑施設であるショクエ灌漑スキームの経験からは、各農家の水へのアクセスの保障が極めて重要であることが分かった。なぜなら、それだけでも収量は上がるが、化学肥料のリターンを高めてさらなる収量の増加が可能となるからである。また、トレーニングやマーケットへのアクセスも大切である。

近年､化学肥料やトラクターの価格が上昇したことにより､同地域でのコメの生産は､それらの使用を控え､主に家族労働に依存するかつての形態に戻ってしまった｡しかし､分析からは、トレーニングを受けた農家は役畜を使用し続け、コメの仲買人へのアクセスの良い農家は化学肥料を使い続ける確率が高いことが分かった。

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