

Agricultural Production, Agricultural Land and Rural Poverty in Madagascar

Jean Claude Randrianarisoa (FOFIFA)
Bart Minten (Cornell University)¹

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Abstract

Rural areas dependent on agricultural income, are often among the poorest in developing countries. However, little distinction is generally made within the agricultural sector. This lack of distinction hinders targeting of agricultural investments towards poorer farmers. This paper illustrates, using a production function analysis with flexible marginal returns, how agricultural production activities and returns to agricultural production factors differ by poverty level in the case of Madagascar. The results show that access to primary education is relatively more beneficial for poorer agricultural households while additional secondary education has no effect on agricultural productivity. Returns to agricultural inputs are significantly higher for poorer agricultural households. Land inequality increases as land sales markets benefit the richer households and as the rich engage more in extensification while rental markets improve agricultural efficiency and may thus benefit poor and rich alike. Land titling has little effect on improved agricultural productivity. More formal land titling is therefore not sufficient to change the bad performance of agriculture of the last decades.

1. Introduction

The objective of this analysis is to study the link between agricultural production and rural poverty and to quantify the determinants of agricultural productivity in Madagascar. This topic is of interest for several reasons. First, the majority of the population in Madagascar are rural households for which a large part of their incomes originates from agricultural production. Agricultural performance and growth is then crucial in any poverty reduction strategy. Second, a well functioning agricultural sector has multiplier effects on non-farm activities and might therefore contribute to growth in other sectors and thus in the whole economy. Third, economic reforms that started in the late 80's, and which are still going on, did not induce a substantial increase in agricultural production. It is then important to better study the constraints that still impede high crop productivity and, therefore, rural income growth. As such, the study hopes to be an analytical background paper for the rural development strategy that is currently being developed under the PRSP (Poverty Reduction Strategy Paper).

This study aims to be a quantitative economic study. One of its contributions is the explicit distinction within the agricultural sector of poor and non-poor farmers. Unfortunately, good recent nationally representative data on agriculture are lacking in Madagascar. The national agricultural census dates back to 1984, a period when agricultural reforms were still under way. None of the recent national household surveys (Enquête Permanente auprès des Ménages (EPM)) have good agricultural data. The most complete agricultural information is available in the comprehensive EPM of 1993. Therefore, we will base ourselves on the agricultural households of that dataset in this study. As there have been no major structural changes in agriculture since 1993, we believe that this dataset still provides a good overview of the current agricultural situation in Madagascar. If necessary, we refer to more recent datasets and studies, but not representative at the national level, in the descriptive analysis.

The structure of this study is as follows. We will start with a brief review of the economic reforms in Madagascar since independence. This will be followed by a descriptive analysis on the relationship between poverty and agriculture. The next section will present the characteristics of agro-ecological regions and their relation to poverty. Then the main analytical results on the quantitative importance of the different determinants of agricultural production are presented. The study finishes with conclusions and policy implications.

2. Overview of Economic Reforms in Agriculture

In this section, an historical overview of agricultural policies in Madagascar since independence is given. This overview will help us to better understand the current agricultural policy environment. Agricultural market reforms in Madagascar resemble those in many other African countries which have gone through cycles of government interventionism and retreat (see Berg, 1989; Staatz et al., 1989). After Madagascar

obtained independence from France, governments initially increased the intervention of the state in agricultural markets such that by the end of the 1970s, most trade in agricultural products and inputs was in the hands of the state. A reversal of policy took place in the 1980s with a transition from a state food marketing and distribution system to a liberalized market. This transition, however, was very gradual.

During the First Republic (1960-1972) small traders together with the parastatal Bureau de Commercialisation et du Stabilization du Riz (BCSR or Office of Rice Marketing and Stabilization), organized the marketing of rice. The BCSR fixed minimum and maximum prices, provided credit to farmers, and organized rural associations. During this era, agricultural policies were focused on increasing the rice area through large irrigation infrastructure schemes in areas such as Lac Alaotra, Marovoay, and the Delta of Mangoky. This was combined with agricultural extension efforts focused on the use of modern inputs (fertilizer, pesticides) and improved equipment for rice cultivation. Consequently, from independence to 1968, rice production increased by almost 50%. This change was the combination of increases in area as well as productivity. It seems that appropriate macro-economic policies, favorable terms of trade, and active participation of private operators largely contributed to the good performance of the agricultural sector during this period.

In 1972, the new socialistic government wanted to get rid of the private marketing sector that was perceived to be predatory. Thus, the government created a national monopolistic parastatal - the "Société d'Intérêt National des Produits Agricoles" (SINPA) - that was responsible for assembly, transformation, and marketing of agricultural products. A tax system as well as economic barriers were put in place in order to allow each Fokontany to benefit from agricultural production and to control product movements. The taxation systems penalized especially export crops. For example, from 1975 to 1983, coffee producers only received 40% of the world price and those of vanilla and cloves 25%. The consequences were a net reduction of export revenues. On the other hand, domestic food prices were subsidized and artificially kept low which led to low domestic production and a surge in rice imports.

As the government was unable to continue to pay for food subsidies, liberalization began in 1983 when the state officially abandoned its monopoly on the commerce of agricultural products. The initial liberalization measures implied that agricultural trading was open to everybody except in the two main production areas (the plains of Marovoay and Lac Alaotra) where two government agencies, FIFABE and SOMALAC, could continue their monopoly. The roles of these two state companies were redesigned only in 1989. At the beginning of the reforms, floor and ceiling prices were maintained. In June 1985 a government decree fixed the floor price of paddy rice, but completely removed the ceiling price. In reality, the government still effectively controlled domestic rice trade until 1986.

In the 1990s, the government became more concerned with the effect of price policies on producers. For example, in 1991 the government introduced an import tax of 30 per cent

on rice to protect local production. However, the government has frequently changed its taxing policy on rice. In 1996, the tariff on rice was 30%, going down to 10% in 1997 and to 5% in 1999, before increasing to 30% in 2000. On the other hand, the government occasionally granted tax exoneration for certain companies and shipments to assure a steady food supply. The exchange rate was made flexible in 1994 and led to a further increase in producer prices. Other liberal policies were put into place. The import licensing system was abolished, export taxes for cash crops were gradually eliminated, and the state disengaged of the maintenance of major irrigation areas, transferring responsibility to producer organizations. The current situation in agricultural markets can be described as one in which private traders have been given free rein to set prices and move agricultural products around the country and in which there is little state intervention.

3. On the Links between Poverty and Agricultural Production

While there have been some tangible macro-economic improvements in the last decade, around 70% of the population in Madagascar is currently still considered poor (Razafindravonona et al., 2001). Moreover, poor households live overwhelmingly in rural areas and depend mainly on agriculture for their livelihood (Dorosh et al., 1998; Minten and Zeller, 2000; UPDR, 2001). Hence, it is clear that the dismal performance of agriculture in the last decades is strongly related to poverty in rural areas (Roubaud, 1997)².

In this section, we look in detail at these linkages between poverty and agricultural production. We use a money measure of welfare and poverty, i.e. aggregate household expenditures per capita, as developed by Razafindravonona et al. (2001). The use of expenditures as a measure for poverty has been shown to have considerable advantages: they are likely to fluctuate less than income over time and they are often more truthfully reported than income. To be able to better compare expenditures across households in the country as a whole, real expenditures per capita are used. Means of agricultural production and agricultural production factors are calculated by quintile of total expenditures, corresponding to five classes of poverty, starting with the first quintile, the group of the poorest, to the fifth quintile, the group of the wealthiest. The discussion is organized around the three main agricultural production factors: land, labor, and capital.

The data used for this analysis come out of the “Enquête Permanente auprès des Ménages” (EPM) done in 1993. This was a nation-wide comprehensive survey with information, among others, on household characteristics, consumption, health, education, and time occupation as well as on agricultural production. While the dataset and the sampling frame is not designed to produce accurate statistics on specific agricultural crops in Madagascar³, we are confident that the agricultural data have enough observations and

² One should note that causality in the relationship poverty – agricultural production goes both ways. A high level of poverty results in low agricultural productivity, caused by the low use of agricultural inputs because of liquidity constraints, the quality of labor influenced due to insufficient calorie intake and poor health, etc. In the other way, low agricultural production might lead to lower income and higher poverty.

³ For example, Randimbison (1995) clearly documents the cases where discrepancies were found between the RNA 1984 and the EPM 1993.

variability to allow us to give an approximate overview of the situation and to establish causal relationships at the national level. The EPM sample consists of 4508 households. As the focus of our study is agricultural production, all households without land in cultivation are dropped. This reduced the sample to 2953 households.

Table 1 shows the real value of total agricultural production ("the total value product (TVP)"⁴), per household and per unit of land, by expenditure quintile level. Malagasy households earn on average 1.5 million FMG per year out of agricultural production, i.e. around \$230 per household⁵. While the value increases by quintile, it does not increase monotonically over quintiles. However, this seems to be driven by some outliers in the fourth quintile as the median does show a monotonical increase. The richest quintile shows, on average, agricultural income that is three times as high as for the poorest quintile. If we calculate this income per unit of land, the difference is less but the rich still have higher income per unit of land than the poor do. Hence, the poor produce less agricultural products in total and their land is relatively less productive. We will discuss reasons for this further on.

The type of crop that is grown seems to matter to welfare. Richer households are more likely to grow cash crops, such as coffee, cloves and vanilla, than poorer households (31% compared to 24%) are. These households are dominant in the East and the North East regions. Households that grow vegetables are mostly located in the Highlands, and in the geographical area surrounding large urban consumption centers. 9% of the sample was involved in this type of activity⁶. Income from fruits was reported by 26% of the households. In both cases, households that grow these higher value crops are found relatively more in the richest quintile.

Agricultural land ownership turns out in most rural poverty regressions to be a significant determinant of welfare (Dorosh et al., 1998; Razafindravonona et al., 2001). This means that land access can potentially make an important contribution to the welfare of the poor. Hence, we will look in detail with the data at hand at this variable. We will discuss consecutively the link between poverty and land ownership, agricultural land expansion, titling, and land markets.

3.1. Agricultural land

Land ownership and cultivation

⁴ The total value product is defined as the value of total agricultural production. Agricultural production is valued at regional product prices. As no data are available on input use and area by crop in the EPM of 1993, we were constrained to report all the analysis at the household level, aggregated over all crops.

⁵ Computed from an average exchange rate of \$1 = 6,500 MGF.

⁶ Recently, some traders started to export fresh vegetables (especially green beans and onions) to the regional markets of Eastern and Southern Africa and countries in the Indian Ocean. Longer term contracting often exists between export firms and these vegetable producers.

It seems that lack to land is highly correlated with lack of other productive assets (including education) which imply that the agricultural landless are the poorest group in the population (Bockel and Dabat, 2001). Unfortunately, there is little information on the landless in the EPM dataset so we limit ourselves to discussion of the households that own land. The average area owned per household is slightly higher than 1 ha, relatively small compared to other African countries. We notice a range from 84 are per capita for the poorest quintile compared to 181 are for the richest quintile, almost three times as much (Table 2). One third, on average, of this land is the more valuable irrigated lowland. The land distribution is more unequal if we take into consideration this quality difference: almost 40% of the land that the richest quintile owns is irrigated compared to only 27% for the poorest quintile.

While richer households own absolutely more upland than the poor do, upland crops are *relatively* more important for the poor. Poorer households then depend relatively more on crop output from tenancy for their income as well as for their consumption. One interesting example is cassava. This crop is mainly grown and eaten by the poor. Ravelosoa et al. (1999) and Minten et al. (2000) illustrate the negative income elasticity for cassava and its characteristics as an inferior crop mainly consumed by the poor. Based on the same data that are used in this study, Ravelosoa and al. (1999) show that the income elasticity for cassava is around -0.88 , meaning that if income goes up by 1%, cassava consumption declines by 0.88%. This makes it an ideal food crop to be used for targeted interventions for the poor.

Land ownership might not be the only indicator of agricultural prosperity in rural Madagascar. For example, Freudenberg (1998) shows that ownership of cattle in Betsileo villages in Fianarantsoa was considered more important for wealth ranking than access to land. The same holds in most of Southern Madagascar. However, nationally, land ownership is a sign of wealth and is a significant determinant of welfare (Dorosh et al., 1998). By comparing agricultural land data from the national census of 1983 and the EPM of 1993, Dorosh et al. (1998) show that landownership might have become more unequal over time. Two reasons seem to explain this: existing land might be sold by the poor to the rich and agricultural expansion is mostly done by relatively richer households. Freudenberger (1999) provides a good discussion on the link of poverty and land expansion in the forest corridor of the Fianarantsoa area. She shows that it is mainly the relatively richer families that expand land holdings by moving into the forest and clearing new parcels as they try to assure future land for their offspring. The poorer population has shorter time horizons and is unable to make this type of investment (for evidence in other countries, see Wunder (2001)).

Agricultural land expansion

Due to high population growth in rural areas, demand for new agricultural land is high. Data from a survey by IFPRI/FOFIFA in three regions in Madagascar show that while rice land area grew by about 5 per cent as an average for all regions over a ten year period, the area of cultivated upland increased by about 24 per cent (Minten and Zeller, 2000). Considering that the population in the survey regions grew by about 3.5 per cent per year

over this time, or by more than 35 per cent over the previous ten years, the rate of growth in arable area is actually below that of the growth in population.

The expansion of the agricultural frontier came at the expense of forest-, bush-, and grassland. These land types are usually held as common property resources but become, under Malagasy law, private property when cultivated by successive generations of the same family. On average for all regions, the largest losses were experienced for area under primary forests. Indicating the level of primary forests as 100 for 1987, the index fell to 67 in 1997. The loss in secondary forest amounts to about 28 per cent, whereas the loss in grass- and bushland was about 20 per cent. These numbers coincide with alternative estimations based on aerial photographs.

That the agricultural frontier can still be expanded in many Malagasy villages is evident from the survey data: 59 per cent of villages report that there is additional land available for expanding upland cultivation; 50 per cent of villages for expanding irrigated land, and 35 per cent of villages for both types of land. Despite this, the average holding of upland per household has declined over time. Clearly, growth in population has outpaced growth of agricultural land in many communities and pressures for agricultural intensification have tended to increase over time.

Land titling

Traditional and modern land rights co-exist in Madagascar. Legally, all non-titled lands belong to the State while in practice, land even in inhabited areas are often already allocated through traditional rights. It is possible to move from traditional to modern legal rights but the process is slow, cumbersome, and non-transparent. Under traditional tenure, land property may be individual or collective⁷. However, traditional land tenure systems in most parts of the country mean individual property rights. In some areas, but not all, some socio-economic groups are excluded from land ownership. Evidence exists of the existence of a cast-based system where the lowest caste, often descendants of slaves, are socially isolated and effectively excluded from land ownership (Randriamarolaza (2001), Galy (1998), Evers (1996)). Their only way to have access to land is through sharecropping or land rental agreements⁸.

The modern system of land titling has generated its own conflicts and it seems that the titling process benefits the poor more than it benefits the rich. Table 2 shows that 31 percent of owned land were reported to be titled in 1993. While the absolute number seem

⁷ For example, in areas dominated by the Tanala or Betsimisaraka tribes, the head of each clan is the owner of traditional land rights. The clan's chief decides on the repartition of land between households and on land use and access to agricultural land has to follow customary rules (for a discussion on the case of the Beforona zone in the East, see Barck and Moore, 1997; Razafy and Andrianantenaina, 1999).

⁸ In contrast to the land tenure situation in some other African countries, Malagasy do not need to farm the land in order to maintain their land rights. While land tenure regulations differ between different ethnic groups, a Malagasy family can pass the right of usage (guaranteed by the community) down from generation to generation in most groups. Hence, this often leads to appropriation of land early in the formation of a village (Pryor, 1990; Keck et al., 1994).

to be overestimated and might not always reflect legal titles in the name of the owner⁹, the percentage of titled land is as high as 32% for the richest quintile compared to only 20% for the poorest. Hence, while the poor have access to less land, the land they own seem to have less secure legal rights as well.^{10,11}

Land markets

The EPM data show that while land sales markets are quite active as 3% and 10% of the households sold and bought land over the last five years respectively, most of land that households own, was inherited: 67% of the land was acquired through inheritance compared to 16% through purchases. Land sales markets seem to contribute to more unequitable land distribution. Table 2 shows, that during the five year period prior to the survey, 5% of the poorest quintile reported land sales compared to 2% of the richest quintile and 13% of the richest households bought land during that period compared to only 7% of the poorest quintile.¹² The same pattern is seen when one looks at the way land was acquired. Inherited land represents 62% of total land for the richest quintile compared to 76% for the poorest. While the poor start off with less land, they also participate less in land sales markets and they get less land free from the village, leading to an even bigger landownership gap between rich and poor.

Land is also redistributed through rental markets. There are two major land rental market systems that can be observed in Madagascar, i.e. leasing and sharecropping. While sharecropping is still illegal in Madagascar, it is widely present. Sharecropping might be relatively less equitable (1/2-1/2) or more equitable (1/3 -2/3). It seems that the decision on the exact share depends on the region and the owner's participation in input supply. Table 2 shows that around 8% of the cultivated land in Madagascar is under some form of rental

⁹ For example, in the Lac Alaotra area, titles are often still in the name of Somalac, the former parastatal.

¹⁰ There are quite some regional differences to land titling. One can assume that demand for legal titles increases once the traditional system breaks down. This comes often with increased population pressure or significant immigration. For example, the lowly densely populated Horombe and the Center West sub-regions have less than 5% of their land titled. The situation in the Horombe might partly be explained by an extensive livestock farming system. In such a case, having titled land might not to be the priority of farmers. Land titling is relatively important in the densely populated Highlands, with percentages varying from 25 to 44%.

¹¹ The modern legal system has induced changes in people's behavior. For example, the planting of trees that manifest the owner's intention to cultivate the land for a long period of time, is considered sufficient to secure property rights on the land. In an effort to better protect property rights, some projects in Madagascar tried to increase the incentive of planting trees by supporting and helping farmers to get the land titled after afforestation. However, this practice might sometimes actually increase the gap in size of landholdings between the poor and the rich. Freudenberger (1999) shows in Eastern Fianarantsoa that households cut down forests with the purpose to establish property rights.

¹² Given the cultural value of land to Malagasy, it seems to be the case that most of transactions in land markets are distress sales. Freudenberger (1998), Brown (1999), Razafindraibe (2001), and Goedefroid (1998) show for different regions of Madagascar that people sell land only in extreme cases, i.e. to pay for funerals and other ceremonies, food, or repayment of debts. This is typical for land sales in most developing countries (Platteau, 1996).

agreement. Averages over quintiles show that rental markets allow the mid quintiles to acquire relatively more land for cultivation.

While land rental markets seem to be more active in more densely populated areas, the IFPRI/FOFIFA community dataset¹³ also seems to indicate that land rental markets seem to become more active over time. Based on this dataset, it was estimated that the lowland area under rental agreements increased over a ten-year period by 4%, from 7% in 1987 to 11% in 1997. Overall, upland areas are less rented out than lowland, but this practice seems to become more in vogue: rented upland area increased over the same period from 3% to 5%.

3.2. Labor

Agricultural production in Madagascar is very labor intensive, with the exception of cases where animal traction or tractors are used (in general, still rather rare) and of regions where labor extensive techniques such as slash-and-burn agriculture ("tavy") and direct seeding are still dominant. The importance of labor use for agricultural production has been shown by various studies on labor allocation and agricultural productivity (UPDR, 2001; IFPRI/FOFIFA, 1998; Randrianarisoa, 2001; Bockel and Dabat, 2001). Rice - with the labor intensive transplantation technique and the manual harvesting method - is one of the most labor-intensive crops in Madagascar. For example, the average number of labor needed for one hectare of rice varies from 80 person-days for the Lac Alaotra zone to 400 person-days or more in the southern Highlands. The small average rice area (less than 1 hectare) by farm does not seem to justify individual investments in mechanical rice-planters or harvesters¹⁴ while rental markets for this type of equipment seem to be thin or non-existent. Other reasons for high dependency on human labor might be its comparative advantage with respect to modern imported equipments, as there seem often to be difficulties to find spare parts and as maintenance costs in humid areas might be prohibitively high.

Unfortunately, the EPM dataset contains little data on agricultural labor use or on the functioning of agricultural labor markets. However, it appears from other surveys that agricultural labor markets are quite active in Madagascar. Lapenu and Zeller (2000) mention that more than 50% of rural households in the IFPRI/FOFIFA survey earned income out of wage income at some point during the year. Moreover, they show that poor households rely relatively more on agricultural wage labor, seasonally and/or permanently: 27% of income of the poorest quartile originated from wage labor compared to 9% for the richest quartile^{15,16}.

¹³ 200 communities were surveyed in 1997 in the Fianarantsoa, Mahajanga, and the Vakinankaratra region.

¹⁴ Even in the Lac Alaotra area, the average rice field per household is around 2 – 3 hectares, i.e. still low for the use of mechanical equipment.

¹⁵ Bockel and Dabat (2001) illustrate the low agricultural wages in Madagascar. They are around \$0.5 per day in the Highlands, East Coast, and the Mid West while they are bit higher (around \$0.8 per day) in the North and North West.

Table 3 shows, based on the EPM data, that poorer rural households have bigger families, more children, more elder, and a higher dependency ratio. Households from the poorest quintile report on average 6 members compared to 4 members for the richer households. This does not mean that poorer households have much more labor at their disposal, as the adult work force is only 0.4 adults higher. Given that poorer households cultivate on average less land than richer households do and given that they have a slightly higher workforce, the poor need to rely less on hired labor than the rich. This is shown by the lower expenditures for hired labor by the poor (per unit of land four times as high for the rich than for the poor).

Female-headed households seem a little bit more represented in the poorer compared to the richest quintile. However, the difference is small. On the other hand, there do not seem to be major age differences between richer and poorer heads of households, implying that life cycle phenomena might not be important to explain welfare differences. There is no clear distinction between the poor and the rich in the number of households that report agriculture as their main profession (*ceteris paribus*, i.e. given that they cultivate land).

3.3. Capital

Not surprisingly, poor have less access to and use less capital in agricultural production activities. They rely less on oxen or agricultural equipment to improve agricultural labor productivity and they rely less on input use (mineral and organic fertilizer, pesticides, and purchased seed) to improve land productivity (Table 4). The major reasons seem to be seasonal or permanent liquidity constraints and less riskbearing capacity and thus less willingness to invest in inputs (IFPRI/FOFIFA, 1998).

The EPM show that agriculture expenditures per unit of land are low, one of the lowest in Africa. Expenditures are around 161 Fmg per are, corresponding to an application rate of less than 8 kg of NPK or Urea per hectare^{17,18}. Organic fertilizer use shows high variability between agro-ecological regions¹⁹. With the exception of some industrial crops

¹⁶ There is important seasonal migration (to major surplus agricultural areas such as the Lac Aloatra or the Marovoay areas (INSTAT, 1998); or even within Provinces) during which agricultural households rely mainly on agricultural salaries to cover the lean period.

¹⁷ This number is not the exact mineral fertilizer use in Madagascar as total agricultural expenditures are defined by the sum of expenditures on organic and inorganic fertilizer, seeds, and pesticides/insecticides.

¹⁸ The rate of chemical fertilizer use in Madagascar is one of the lowest in Africa. The average quantity used per hectare is only around 10 kg (IFPRI, 1998; Dernier and Dorosh, 1993). It does not show significant changes over the years, but presents high variability by crop and by region. Industrial crops such as sugarcane, cotton, tobacco, barley etc., account for 50 percent of fertilizer use while they only occupy less than 10 percent of total cultivated area. The other 50 percent are mostly used for rice.

¹⁹ This variability seem to be explained by technical as well as cultural constraints. For example, in some regions, there is a *fady* to carry organic fertilizer from animals. The rarity of cattle on the East Coast seems to explain the low use of organic fertilizers in that region. In the Highlands, a shortage of manure seems to be a major constraint on agricultural productivity. Therefore, one of the themes of the national extension

such as cotton, tobacco, and sugar cane, farmers barely use pesticides. In most cases, it seems that pesticides are only used when there is already advanced pest damage. The use of improved seed is also extremely low²⁰.

Overall, Table 4 shows that expenditures on modern inputs are the lowest for the poorest quintile. Because utilization rates are so low and the average is driven by few observations, big variability for the four individual inputs across quintiles shows up. Aggregated over expenditures for inputs, the richer quintile applies 20 times as much input than the poorest quintile. The total value for agricultural equipment shows the same trend: it is seven times as high for the richest compared to the poorest quintile. When we control for the area cultivated the differences are less striking. However, the rich use, per unit of land, four times and twice as much inputs and agricultural equipment respectively. Surprisingly, there is no difference in the number of draught oxen per unit of land and the difference in the value of agricultural "equipment" seems to come solely from mechanical equipment.

3.4. Access to institutions

Table 5 shows descriptive statistics of access to education, agricultural extension, and credit. 53 % of the head of households in the poorest quintile finished primary school compared to 72% in the richest quintile. The same trend is seen in secondary schooling: 6% for the poorest quintile compared to 24%. As has been shown by Razafindravonona and al. (2001), access to education seems an important determinant for a raise in expenditure levels and welfare.

Agricultural extension (measured by a community level variable) is directed relatively more to the richer areas or farmers: 38% of the richest quintile received the visit of an extension agent over the last year compared to 32% for the poorest quintile²¹. It seems that, at the time of the survey, there were little extension activities for the highly valuable crops such as vanilla, cloves, and coffee and most of the extension efforts were focused on densely populated, labor-constrained areas.

Farmer's access to credit seems an important indirect way to improve agricultural productivity in Madagascar. It has been shown in Madagascar and elsewhere that an

program ("Programme National de Vulgarisation Agricole" (PNVA)) was the production of compost at the farm level.

²⁰ Improved seeds played an important role in obtaining higher productivity during the Green Revolution in Asia (Hossain, 1988). Unfortunately, seed did not fulfill that role in Madagascar. Goletti et al. (1997) reported that the quality of improved rice seeds is not good enough in order to make a significant difference between adopters and non-adopters. Even the productivity at the seed multiplication farms did not show an evidence of superior quality. Hence, it is not surprising to see low utilization rates.

²¹ Unfortunately, the extension variable is too aggregated to allow us to use it in further regression analysis. There is also the distinction between public and private extension. Private extension (projects and NGO's) is usually much more specific than public extension. Some of this extension is focused on environmental activities, specific agricultural crops or livestock production. The community questionnaire does not allow us to distinguish between these categories. More research and better data, ideally panel data, would be needed to evaluate the effect of extension and its focus on the poor correctly.

increase in cash availability either through credit, non-farm income, or from off-season crops greatly contributes to increased input use and improved technology adoption (Moser, 2001; IFPRI/FOFIFA, 1998; Clay and al., 1998; Kelly et al., 1995). Major efforts have been done in Madagascar in recent years to improve formal credit access through the implementation of various mutual credit systems. As our data date from 1993, we can not see the effect of this. However, it can be stated with reasonable confidence that most of the smallholders in rural areas still remain outside of this formal credit system.

The EPM data show that only 29% of households have used credit. The poor rely relatively a little more on credit than the rich (30% of the households compared to 26% for the rich). However, only 1% of the poor gets credit through the formal system (compared to 6% for the richest quintile). Therefore, poorer farmers rely relatively a lot more on informal credit systems. There is evidence that interest rates are significantly higher in the informal sector (Zeller, 1993). It is interesting to note that there are no major differences across quintiles for use of the credit, except for the highest quintile where a significant part uses a large part of the credit for nonagricultural purposes.

Surprisingly, the poor live less in areas that are prone to weather problems. 19% and 31% of the poor and the rich respectively lived in a village that was hit by a cyclone in the year previous to the survey. The areas in Madagascar where most of the cyclones strike are on the East Coast which are also the areas where much of the high value export crops are grown. Due to their close distance to the big ports, these areas have an easier access to export markets. The poor also live in villages that had less problems with drought: 29% compared to 40% for the rich.

The descriptive statistics by expenditure quintiles show that the poor in rural areas have less land and assets, have less access to infrastructure and institutions, and rely relatively more on family labor for their agricultural activities. Even if they are disadvantaged in almost all areas, the return to some of the production factors in agriculture might be higher for the poor. The essence of a strategy for reducing rural poverty is to set priorities in possible interventions. The analysis that follows is intended to shed light on the effect of some of these interventions on agricultural production. This will be done using production function analysis. However, not only economic factors and choice variables but agro-ecological conditions as well influence agricultural productivity and poverty. To get at some of these links for Madagascar, we will discuss in detail the regional characteristics and how they might have an effect on poverty and agricultural production. To this we now turn.

4. Poverty and Agro-ecological Regions

There is ample empirical evidence on significant regional poverty differences in Madagascar (Razafindravonona et al., 2001; Goletti and Rich, 2001). As rural income is strongly linked with agriculture and agricultural production depends on the natural environment, poverty is strongly linked to regional characteristics. We will move away

from the usual administrative delimitation, i.e. the Province, for this study on agricultural production and will use agro-ecological boundaries. The agro-ecological delimitation used in this study is based on soil characteristics, rainfall, topography, climatic data, and cultural and anthropological considerations. Graph 1 shows the proposed delimitation.²² We base the definition of agro-ecological region mainly on the results of three documents: the last agricultural census report (MPARA, 1988) and regional studies in 1993 and 1995 (FOFIFA, 1995; AIRD, 1993).

As such, Madagascar is divided into six agro-ecological regions, which in turn are subdivided into 2 to 4 sub-regions, giving a total of 17 sub-regions for the whole of Madagascar. The specifics of the 6 agro-ecological regions are discussed in more detail below. Table 6 shows, among other things, that the average total value of production ranges from a high of 2.2M per hectare in the Highlands compared to 0.5M per hectare in the South. Hence, productivity differences range from 1 to 4 between agro-ecological regions. A discussion on the specifics of every agro-ecological region follows below. In annex 1, the importance of crops by region is looked at.

4.1. North & North East

The North & North East region is made up by the province of Antsiranana as well as two Fivondronana from the province of Toamasina, i.e. Maroantsetra and Mananara. We distinguish two sub-regions: the Eastern and the Western part. Rainfall is generally abundant but sub-regional variability is noticed. The Western part is less humid than the Eastern part. In the latter, average annual rainfall may reach up to 3,500 mm as for example in the Maroantsetra area.

The Eastern part encloses two large areas of preserved forests: the Mananara Biosphere Reserve and the Masoala National Park. Soils are generally of poor quality and are not very well suited for agricultural production. This region includes also “Sambava, Vohemar, Antalaha” or the SAVA zone, where most vanilla (90% of national production) and cloves (50% of national production) are grown. 64% of the households that were interviewed reported having income from export crops. This region is also characterized by a high number of cattle in the sub-region of Antsiranana and in the Fivondronana of Ambilobe. Rice dominates agricultural production in the Andapa plain. This plain provides 85% of total rice production in the SAVA sub-region (Minagri, 1998). The Western part is characterized by fertile volcanic and alluvial soils in the Sambirano zone and the area surrounding the Montagne d'Ambre; and less good soil in the Ankarana zone. Industrial

²² It slightly differs from the division used by the Groupement de Travail de Développement Rural (GTDR) as developed by the PADR (Plan d'Action de Développement Rural). This division takes into account some political considerations and tries to conserve the Province boundaries. In the GTDR divisions, there are 23 sub-regions.

sugarcane plantation (Nosy-be, Ambilobe), essential oil plants, and cacao plantation (Ambanja) are also found in this area.

The low use of agricultural inputs is a major reason for low agricultural productivity in this agro-ecological region. Table 6 shows that this area has a low level of agricultural expenditures of 53 Fmg per are. When one controls for purchase prices, which are one of the highest in the country, the lowest real expenditures of the country are noticed. Together with the East Coast region, this region has the lowest per are agricultural equipments (172 Fmg versus 661 Fmg at the national level).

4.2. East Coast

The East Coast is divided into three sub-regions: the Northern, the Center, and the South. It consists mainly of the coastal area of the province of Toamasina and Fianarantsoa, and the Fivondronana of Tolagnaro in the province of Toliary. Rainfall is abundant - during 200 days over the year - with an annual average ranging from 2,800 mm to 3,500 mm from the South to the North. Temperature is no constraint to agricultural production. However, the effect of cyclones, and inherent flooding, limits lowland cultivation and intensification. The region is specialized in export crops such as coffee, cloves, pepper, and different exotic fruits such as litchis and bananas. Rice cultivation is mainly done on the hillslopes using slash and burn methods. It is estimated that 48% of total cultivated area in this region is occupied by rice.

The region includes Toamasina, Madagascar's major port, and secondary ports such as Manakara, Mananjary, and Tolagnaro, which makes the export market relatively attractive. However, road infrastructure remains very poor, especially in the Center sub-region. There is no direct road connection from the North to the South sub-region. The only accessible way for transport is the "Pangalana" canal. The National Road (RN2) links the region to the Highlands from Toamasina to Antananarivo and the National Road 34 for the South East and Fianarantsoa. There is also the railway connecting Manakara to Fianarantsoa. However, the railway is outdated and was significantly damaged by recent cyclones. Freudenberg et al. (1999) describe the railway as essential to development and market integration in this region. Market exchange almost exclusively depends on the existence of the train, and currently, major investment efforts are made by USAID to improve the quality of the service.

Table 6 shows that land rental markets are almost non-existent with only 1% of the total area rented in 1993. Two factors might explain this low rate. First is the land right system: in most areas in this region, land is community held. Second is the relative ease for access to new land through cutting down forests for slash and burn agriculture. Farmers on the East Coast do almost not use animal traction. The number of draught oxen per household is close to zero.

Poverty and low agricultural production seems to be associated with the low use of agricultural equipments, the labor extensive agricultural system, and the incidence of

cyclones. Together with the North region, it is the main producer of export crops: 65% of the households grow export crops. This situation might lead to higher income variability because of higher price risk, due to price inelasticity of crops such as vanilla and coffee²³. This situation reduces the incentive for agricultural investments.

4.3. South & South West

The region is divided into two sub-regions: the South and the South West. Annual rainfall only averages 400 mm in the South and 600 mm in the South West. This is clearly the major constraint to agricultural production in the region. This is also the region where the dominant agricultural production system is based on tubers instead of rice. In some areas in this region, the farming system is based on extensive livestock production. During the last years, many NGOs (CARE International, Aide Action, etc.) and projects (SEECALINE, FID, FIDA, PSO, etc)²⁴ started rural development activities as this region is perceived as one of the poorest and most food insecure areas in Madagascar²⁵.

With the exception of few areas such as Amboasary and those with irrigated system, soils and climate are barely suitable for agricultural production. With a production of 6 kg of rice equivalent per are, the region has the lowest total value product compared to other agro-ecological regions (Table 6). Soils are sedimentary, rich in calcaire, or sandy in the semi-desert zone. Cassava, sweet potatoes, and maize are the most important food crops. Rice occupies only 32% of total cultivated area. Sisal production is the specialization in the irrigated Mandrare plain (an area of 20,000 hectares).

Beside the dry conditions, various other factors might be associated with poverty in this region. First is the low education level of the household head as only 34% of them finished primary school. Rural insecurity might also hinder development and poverty alleviation. Table 6 shows that 70% of the villages in the sample reported cattle theft during the previous year. 95% of the sample still report to make their livelihood from agricultural production. This is the highest percentage with the Littoral West and the Mid West region. However, livelihood in agriculture includes those farmers who are specialized in livestock production, which seems to be the case for a significant number of farmers in this region.

4.4. Littoral West

²³ The instability of the coffee price during the last five years illustrates this point very well. From 1997 to 2001, the farmgate price of coffee dropped by 700%, plummeting from 7,000 Fmg to 1,000 Fmg per kilo, mainly caused by the change in the world price (Midi Madagasikara, June 2001).

²⁴ SEECALINE is a nutrition and food security project mainly financed by the World Bank; FID (Fond d'intervention pour le développement), financed by the World Bank, invests mainly in schools and roads; FIDA (Fond International pour le Développement Agricole) intervenes in the region in rural development with the Mandrare project; PSO (Projet Sud Ouest) is a French funded project working in the South West region.

²⁵ Recently, sapphire was discovered in this region, attracting a significant number of immigrants, mostly out of the agricultural sector, to the Ilakaka town.

This region includes the Fivondronana between Antsalova in the South to Ankaizina in the North. The geography allows for many large alluvial plains, suitable for lowland cultivation. Average rainfall seems to be sufficient, ranging between 1000 to 1500 mm from the North to the South. The major agricultural constraint originates from the long dry season: from April to October. Temperature is relatively high, with an average of 26°C over the year. Mangrove forests dominate the vegetation in the littoral and in the large bays of Bombetoka and Mahajamba. The ferruginous and vertisol soils in the plateau zone hinder high agricultural production. The baibo, alluvial soils along the rivers, are the most fertile land in this region.

Rice is the most important crop and occupies 75% of the total cultivated area. This region includes the large plain of Marovoay, which is the second largest irrigated plain in the country. Its presence results in a relatively high percentage of irrigated land in the region, with 47% even just higher than in the Highlands (Table 7). In Marovoay and Ambato-Boeni, *jeby* rice, harvested in November (i.e. during the lean period for the rest of the country) is the dominant crop. *Asara* rice, harvested in May, is important in the mid altitude plains. Slash and burn practices are frequent in the Eastern part of the region.

A low 3% and 9% of the farmers produce export and vegetable crops respectively. The cash crops in this region include mostly industrial crops such as cotton, sugarcane, and tobacco. Some Fivondronana in the Northern zone are specialized in tomato and onion production and provide most of the supply for the capital. Constraints to improved agricultural productivity and higher incomes might be the lack of infrastructure such as road and market facilities as well as low levels of education.

4.5. Highlands

This is a large and diversified region. The Highlands are the most densely populated region of Madagascar, with a population density of around 150 per square kilometer. This region is well off with respect to access to institutions. It is characterized by a relatively high level of education, as 81% of the heads of households finished primary school (Table 6). They are also well served by agricultural extension: 45% of the households lived in a village where this service was available in 1993. Four sub-regions are distinguished within the Highlands: North, Center, South and the Lac Alaotra region.

The Northern subregion includes all the Fivondronana close to the Tsaratanana Mountains. This is a relatively remote area despite its underexploited agricultural potential, such as the Bealanana plains. The Center and the Southern sub-regions, starting from the Fivondronana of Ankazobe to Fianarantsoa is the most well developed region in terms of infrastructure and the presence of institutions. It is also characterized by the existence of three large urban consumption centers, i.e. Antananarivo, Antsirabe, and Fianarantsoa. The Center has a higher average rainfall (1600-1700 mm per year) compared to the South (1300-1500 mm per year). The difference of average temperatures during the humid and dry season may reach 10°C. Average altitudes vary from 1,425 m to 2,500 m above sea level.

Eroded and hilly ferralitic soils dominate the plateau while hydromorphic soils are frequent in the lowlands. The farmers in this area have a long agricultural tradition in rice cultivation. Rice occupies almost all of the lowland area. On the upland, farmers grow a large variety of crops such as maize, beans, and potatoes in the Center and cassava and sweet potatoes in the South. This is also the area where temperate crops such as wheat, barley, and temperate fruits are grown. However, upland crops do not show a high productivity except for the volcanic and alluvial soils in the Antsirabe region.

The Lac Alaotra sub-region has an altitude of around 800 – 1200 meters above sea level. It is characterized by the existence of a large plain with modern irrigation infrastructure. Three Fivondronana make up the sub-region: Ambatondrazaka, Amparafaravola, and Andilamena. This is a rice surplus area and supplies annually around 200,000 tons of paddy-rice to the urban areas of Antananarivo and Toamasina. The area has relatively good intra-zone road infrastructure. There are also many agricultural institutions present such as agricultural credit systems, agricultural research stations, extension, etc. and different administrative services such as a land property registry and courts.

The plain is characterized by hydromorphic soils, clay textured, and is very well suitable for rice production. However, initially rich in organic matter, the soil currently presents signs of nutrient deficiency. The plateau around the vast plain has ferralitic soils while the mountains are characterized by very poor and fragile soils, subject to spectacular erosion sites or “lavaka”, resulting in serious sedimentation in the lowland. One of the agricultural issues in this area is to solve the externality problem of halting hillside erosion to protect lowland rice areas.

The Highland region shows the highest TVP of 2.2 million Fmg per hectare. Land scarcity (it has, with a total of 99 ares per farm, one of the lowest per household cultivated areas in Madagascar) and soil degradation seem to be the most important constraints to higher agricultural production and, related, poverty alleviation. The average cultivated area per household masks very high variability between the Lac Alaotra zone (with larger farm size of 300 ares) and the Center and South Highland (lower farm size of 70 ares).

4.6. The Mid West

This is the least densely populated agro-ecological region, ranging from the Fivondronana of Ankazobe in the North to the Fivondronana of Ambalavao in the South. The farming systems are based on upland crops with rice cultivation being done in the narrow depression between the tanety. There is a diminishing gradient of rainfall from the North to the South, with a variation from 1,400 mm to 800 mm per year. Altitudes vary from 700 to 1,000 meters, gradually decreasing to the Western part. Soils are generally poor and acid, and prone to erosion. The Mid West depends on road transport, often in bad shape, for intra and inter-regional exchange. Rainfed rice dominates rice production. 42%

of total cultivated area is occupied by rice. Upland crops, i.e. mainly cassava and maize, are the other main food crops.

This region is the most insecure region of Madagascar. 63% of the households declare to be living in a village where theft occurred in the last year. This might be linked to the remoteness of certain zones such as Maintirano, Kandreho, etc. One consequence of the remoteness and insecurity seems to be the low access to agricultural extension services: only 18% of the households report having access to it, half the national average (Table 6). On the other hand, farmers have a relatively high level of education, with 69% household heads declaring to have finished primary school. Land rental markets are thin: only 6% of land is cultivated under a rental or sharecropping arrangement.

5. Determinants of Agricultural Production

5.1. Method and Description of Variables

In this section, the model and the variables used in empirical estimation are discussed. A more complete description of model and methods is given in Annex 2. First, the dependent variable is discussed and, consequently, an overview of the variables and their anticipated effect on agricultural production is given. These variables include land, labor use, capital, institutions, and natural shocks. Table 7 shows the descriptive statistics of the variables that are used for regression analysis.

To assess the determinants of farm production, we opt for the use of a primal production function approach. Due to data restrictions, particularly the non-existence of sub-regional data on input prices and agricultural wages in the EPM of 1993, the primal approach of production function analysis seems more appropriate than a profit function analysis. The use of Total Value Product (TVP) as a proxy for production is imposed by data availability²⁶. The use of TVP, instead of physical quantities, as dependent variable in a production function analysis might create extra problems. First, as the TVP includes unit prices and quantities, interpretation becomes more difficult. Second, the dependent variable is sensitive to errors in more variables (prices and quantities), so the error term might be larger. Third, aggregation problems as well are likely to affect the estimation, again tending to enlarge the error term. Different tests were done to select the appropriate model. The results favor the square root generalized Leontief function. The advantage of this specification is that the elasticity is flexible across the sample. In order to get at possible different returns of determinants, an evaluation of this elasticity (and the marginal product) is done at the means of every expenditure quintile.

Land

²⁶ Ideally, separate production function would have been done on rice and other upland crops but in this study, we are constrained to use TVP for the whole farm as land area and input expenditures were only collected at the household level.

Four variables related to land and land quality are used in the regression analysis: cultivated land by the household, the percentage of titled land, the area under rental agreement, and irrigated area. It is expected that the more land and the higher the quality of the land, the higher agricultural production. The literature is ambiguous on the effect of land tenure on productivity. The common wisdom is that temporary or insecure property rights might have a negative effect on agricultural productivity, as there is less incentive for investments by the temporary or insecure owner. However, empirical results on land titling are mixed. Studies for different countries in Central Africa show neutral effects of legal land rights on agricultural productivity (Place and Hazell, 1993; Platteau, 1996). Other studies have documented that insecure rights lead to less input use, investments, and, therefore, lower productivity (Anim, 1999; Lutz et al, 1994; Reardon and al., 1999; Feder and Feeny, 1991). We expect the argument for secure property rights to lead to a positive coefficient for titling and a negative effect for the rental land variable. On the other hand, there is a potential second, positive, effect of rental markets. Credit constrained owners might rent out to tenants who have better access to liquidity, labor and inputs²⁷.

Labor

Unfortunately, we have no exact data on labor use in agricultural production. Household size and sex and age of the head of the household are used as proxies for labor input. These variables are clearly incomplete as we capture clearly only a part of the quantity and quality of labor supply. We expect that a positive effect of the household size on agricultural production, *ceteris paribus*, is an indication of imperfect labor markets. One dummy variable is included which measures if the farmer reports farming as his major profession. 80 % of the sample reports to have agriculture as their main profession. The effect of this variable is ambiguous. On the one hand, we would expect this variable to be positive as the farmer might devote more time to agricultural activities. On the other hand, non-farm income of the households might positively affect agricultural productivity as by reducing the liquidity constraint at the beginning of agricultural season, these households might acquire more agricultural inputs, equipment, or hired labor.

Capital

Capital in the agricultural production process is measured by the value of agricultural equipment in the household, the number of draught oxen, and agricultural input expenditures. All are expected to have a positive influence on agricultural production. Agricultural input expenditures are defined as monetary expenditures on chemical fertilizers, organic fertilizer, seeds, and pesticides/insecticides. The total value of agricultural equipments is used as a proxy for the level of fixed capital for the household. It includes the values of motorized and animal traction equipment and small manual tools such as rotary-hoes. The value for agricultural equipment and input expenditures is calculated in terms of the price of rice-equivalent to reduce the biases from price differences over the regions.

²⁷ Anecdotal evidence suggests that this might be the main driving force in the large irrigated plains.

Institutions

Access to education, credit, agricultural extension, or health services are among the most important other variables that might affect agricultural production. Various studies have shown access to education to be an important determinant of agricultural productivity (see f.ex. Appleton and Balihuta, 1996; Jolliffe, 1998). Better education might affect the ability to use information and translate it into better management, leading to a more efficient use of agricultural production factors. In this analysis, primary and secondary education of the household head is distinguished²⁸. Descriptive statistics show that 65% of the household heads did finish primary school while 14% finished secondary school or higher. Almost none of the head of the households in the sample did follow a professional training in agriculture so this variable could not be used in the regression.

Insecurity is considered by some policy-makers to be a cause of low agricultural productivity in rural area. However, very few papers have documented such assertions²⁹. In some regions, cattle theft constitutes a major constraint to agriculture and livestock production. Efforts made by the government seem not to be enough to eradicate the plague. For example, from the 3000 case of theft of cattle that were reported in 1999, the retrieval rate was around 49% (Raharinjanahary, 2001). Cattle theft may influence agricultural production in different ways: first, it diverts labor away from agricultural activities as potentially productive time is spent on property protection and theft prevention; second, it might reduce the number of draught oxen available at the farm level, influencing labor use as well as organic fertilizer availability; third, it might result in lower access to market and in high prices of inputs; fourth, it constitutes a barrier to migration from overpopulated less fertile areas to areas of high agricultural potential. Rural insecurity is proxied by the incidence of theft of cattle at the community level.

Natural shocks

Two types of natural shocks are measured and included in the regression: cyclones and droughts in the agricultural year prior to the harvest.³⁰ The cyclone proxy provides the number of times the eye of a cyclone passed through the fivondronana by season. The drought proxy is the number of dekads (10-day periods) in the previous year in which precipitation was less than 75 percent of the norm for that particular dekad. A direct effect of these shocks might be the loss in agricultural production due to flooding or drought³¹.

²⁸ Estimates of economic benefits of education are important as the education budget represents around 2.5 percent of the country's GDP, equivalent to 30 percent of the government annual budget, but still judged insufficient. Based on the national household surveys of 1993, 1997, and 1999, Glick et al. (2001) suggested an increase in the government contribution for primary school as these services are mostly used by the poor.

²⁹ IFPRI/FOFIFA (1998) showed that in some areas, the number of input traders that were victim of theft during the previous year could be as high as 15%.

³⁰ The environment data was graciously provided by CNS (CARE SIRCat Project). We caution that there is no information on the severity of the cyclone.

³¹ In the IFPRI/FOFIFA survey it was found that 80 per cent of the planted rice area faced production problems in one particular year (1997), such as those related to water (rain too late, inundation, drought), crop

Shocks might also be beneficial to non-affected farmers near these shocks as they might benefit of the higher agricultural prices. The effect for poor and rich farmers might be different if richer farmers cultivate relatively more on lowlands that might be more prone to flooding after a cyclone. Because of their higher risk aversiveness, poorer households might show lower productivity as they might invest less in areas that are often hit by cyclones.

5.2. Results and Interpretation

5.2.1. Land

Land area

Land variables affect agricultural production in different ways: the area cultivated, the quality of the land, and property rights security. Increases in land area correspond to an increase in TVP. The low overall elasticity - significantly lower than one - indicates an inverse relationship between farm size and agricultural productivity. It means that increases in cultivated area result in a decrease in production efficiency.

This finding confirms previous findings of Randrianarisoa (2001) and Barrett (1996). The magnitude of the elasticity varies for different quintiles, ranging from 0.46 to 0.33 for the poorest compared to the richest quintile respectively, indicating the higher relative importance for the poor.

The existence of the inverse relationship between farm size and agricultural productivity has been shown in previous research in Madagascar (Randrianarisoa, 2001; Barrett, 1996) as well as in other countries (Barrett, 1996; Bhalla, 1988; Rao and Chotigrat, 1981; Deolalikar, 1981; Feder, 1985). Various researchers have tried to explain this difference. Bhalla (1988) demonstrated in India that a difference in land quality was the main cause of the difference. However, in other settings, this explanation was shown not to be sufficient.

A second argument is based on a differential opportunity cost of labor. Small farms are facing lower opportunity costs of labor, allocate relatively more labor to their limited plot area and thus achieve higher land productivity. If small farms were indeed shown more efficient than large farms, it would be economically rational to increase the land area of small farms. It seems that in the current situation in Madagascar market imperfections exist that do not allow land and labor markets to reduce the efficiency gap between big and small farms.³²

Property rights

diseases, or losses due to insects and animals. The area in upland crops was similarly affected by covariant risks (IFPRI/FOFIFA, 1998).

³² In estimating returns to land, Razafindravonona et al. (2001) find that returns to landholdings decreased over time, from 1993 to 1999, for those households with less than 0.4 hectares per capita. They conclude that extensification of land use by these small holders in the presence of demographic pressures is leading to use of less productive and more fragile land.

Land titling shows an insignificant effect on TVP. There is also little difference over the expenditure quintiles. As we can only imperfectly control for land quality and as it is reasonable to assume that titling happens on better quality parcels, these results indicate that the possession of legal property rights on agricultural land does not improve efficiency at the national level and that informal land rights do not lead to lower agricultural production, *ceteris paribus*³³. Land rental arrangement might have two opposite effects on productivity, creating more insecurity to the cultivator or leading to reallocation of the land to more efficient tenants. The results of the regression indicate that the latter effect is more important as land under rental agreements slightly increase productivity. Every extra are of land under such an agreement leads to the extra production of 2.5 kg rice equivalent. This supports the analysis of the descriptive section that seemed to indicate that land was rented out to a middle group of farmers who could cultivate it more efficiently (see also Dorosh et al., 1998). Access to this rental land seems especially important for the poorer households as they seem to be able to use this land more efficiently than the rich as shown by their higher coefficient.

Irrigated land

Studies on agricultural production show a significant but low magnitude of direct irrigation effects in Madagascar (Minten et al., 1998; Randrianarisoa, 2001). The current study presents similar findings. At the national level, a doubling of the area under irrigation would result in a 3.4% increase in TVP³⁴. However, the analysis of the direct effect of irrigation infrastructure at the household level is fraught with difficulties as the effect of irrigation is a complex process that does not only depend on the physical characteristics of specific parcels (irrigation, drainage, location etc.) but also on the socio-organization surrounding the perimeter or the group of irrigated parcels. An irrigation scheme with water conflict among users results in non-homogenous production across the parcels. The organization of water distribution affects thus this coefficient. Lastly, the estimated coefficient measures only the direct effect of irrigation. The biggest effect of irrigation might be its indirect effect: through better water control, households might be less dependent on weather and be prepared to invest more in inputs and labor.

5.2.2. Labor

Household size

Household size is used as a measure for family labor. If labor markets would function perfectly, household size as such would not be expected to have an influence on

³³ Separate regressions were run on factor demand variables as titling might lead to higher agricultural input or labor use (that we already control for). However, formal titling did not show a significant effect on factor use.

³⁴ Regional regressions were run to test for regional differences. The Highlands show the highest direct effect (10 – 12%). For the North and the East Coast, its effect is not very important because of the quasi-permanent rainy season. Water control would be focused on the improvement of the drainage system. For the Mid West, the irrigation effect is also small because agricultural production is dominated by upland crops.

agricultural output as labor could be rented in or out to be used most effectively. Household size shows an elasticity of 12%, indicating that larger households tend to be more productive than small households are. The rationale for this relationship might be that larger households could easier find necessary labor to complete critical tasks during periods of peak demand. The marginal value product shows that the coefficient is significantly larger for richer quintiles compared to poorer quintiles: an increase of the household size with one unit would lead to 26 kg extra rice equivalent production for the poorer households, *ceteris paribus*, compared to five time as much for the richest households. This higher return to extra labor explains why richer households do rely more on hired labor as shown in Table 4 and why poorer households rent out their labor for agricultural wage labor^{35,36}.

Gender

Female-headed households are shown to have 13% less TVP than the male headed households³⁷. The cost of not living with a man seems especially high for the poorer households as they show a TVP that is 19% lower compared to a male headed household. The main reasons for this lower performance might be the lack of access to credit due to collateral issues linked to the inheritance system mostly adopted in Madagascar (although women can inherit land, they are often disadvantaged (Brown, 1999)). There is also the constraint of a shortage of family labor, resulting in increased dependency on hired labor. As we are not able to completely control for labor input, this might contribute to the explanation for the gap. Women might also have more non-agricultural activities than men (especially child rearing), resulting in lower returns to agricultural production.

5.2.3. Capital

Modern Inputs

Regression results show a positive elasticity of 5% for expenditures on modern agricultural inputs. This seems small but might be explained by the low base. When the coefficient is converted to a marginal value product, we see that a 1 Fmg investment in modern inputs lead to an increased output of 3.2 Fmg. Hence, we see high profitability even given the high price of modern inputs in Madagascar³⁸. These averages seem sufficient to cover the opportunity costs of own or borrowed capital, even at high interest rates.

³⁵ In this analysis, we assumed that men and women should be counted as identical. In fact, there are gender specific tasks and it is difficult to rank tasks that require more or less energy. For example, rice transplantations are generally done by women and all tasks related with plowing are done by men. Sometimes, technological innovations lead to a perturbation of the socio-cultural organization for the family. For example, the use of rotary-hoes for rice-weeding moves the female task of manual weeding to the men.

³⁶ Return to agricultural labor seems to differ widely in Madagascar given the widely different wages that are paid. Recent studies in Madagascar show that for small farm sizes, the marginal return to labor becomes very close to zero (UPDR, 2001; Randrianarisoa, 2001). It seems to be the case that the allocation of extra labor on small plots result in an increase in land productivity but a decrease in labor productivity.

³⁷ Similar results were found in other studies in Madagascar, most notably Zeller (1995), and Dorosh et al. (1998).

³⁸ IFPRI/FOFIFA showed that prices of modern inputs were on average 50% higher than in East Asian countries. This was explained by high transport costs to and within Madagascar and by thin markets.

However, while this shows absolute average profitability, high production and price risk in agriculture requires a premium in pay-off rates. Given the production risk in Madagascar due to climatic conditions and due to the current state of irrigation infrastructure, which could potentially reduce this production risk in the case of rice, and the high price risk³⁹, this leads to a low rate of use of modern inputs⁴⁰. The benefit of modern input use is as high as 6:1 for the poor compared to 3:1 for the rich. The poor would benefit enormously from an increased use of modern inputs. However, given that the poor do not use modern inputs, it seems that severe liquidity constraints in the lean period might oblige them to forego this profitable investment.

Agricultural Equipments

The regression results show a significant effect at the national level of agricultural equipment (elasticity of 7%). The value of the marginal value product is 1.1, indicating a 10% return. Again, the poor show a higher return to agricultural equipment than the rich do. For the rich, the marginal value falls even below one indicating that they might be underutilizing this equipment.

Draught Oxen

Draught oxen might contribute to increased agricultural production through an increase in labor productivity (allowing for faster and better tilling, for planting on time, or for manure transportation) and through the production of organic fertilizer⁴¹. Draught oxen might also possibly serve as collateral to obtain credit. The overall effect is positive with an elasticity of almost 2% and a high marginal value product of 80 kg of additional rice equivalent for an additional animal. The high positive effect indicates significant imperfections in the market for draught animals. There is no clear trend across quintiles for the marginal value of draught oxen indicating a short supply of oxen across the board.

5.2.4. Productivity shifters

Education

Primary education shows the highest effect on agricultural production. A dummy measuring if the household head has finished primary education or not shows positive and

³⁹ Producer prices for paddy in the Lac Alaotra region were in 2001 half the prices of last year. While this type of variation seems to be exceptional for rice, it is common for export crops such as vanilla and coffee.

⁴⁰ For example, Dorosh et al. (1993) showed that the marginal value product of chemical fertilizer on rice in Madagascar highland was 4.6 kg of rice, but concluded that the return was not large enough to bring farmers to use more inorganic fertilizer on their rice field. In East Asia, at the beginning of the Green Revolution, a ratio return to fertilizer over the price of fertilizer of 9 was reported.

⁴¹ For example, Freudenberger (1998) shows in the Fianarantsoa province that access to organic fertilizer is a major constraint on agricultural productivity and that households that do not own cattle have significantly lower yields.

significant results at the 1 percent level. A household head with primary education is expected to get 7.5% more TVP compared to a household where the head did not finish primary education⁴². Additional secondary and higher education seem not to have a strong effect and even a negative effect on agricultural productivity. Various reasons might explain this. One might be the low return from agricultural labor compared to other activities and another that agricultural production might be a “safety first” option for some households, leading them to neglect agricultural production and to seek off-farm employment once secondary studies have been finished. The primary education coefficient is evaluated at 11% for the poorest quintile compared to 6% for the richest quintile. Hence, it seems that the poor benefit disproportional by the presence of primary education as the pay-off for them is, relatively, almost twice as much than for the richest quintile. This seems to confirm previous analysis which suggested increased investment for primary education as a pro-poor policy (Glick and Razakamanantsoa, 2001; Razafindravonona et al., 2001).

Rural Safety

While the coefficient of rural safety turns out to be negative, it is rather small. However, we suspect that the coefficient might be significant in some particular regions where cattle holdings are small (and thus each head counts for agricultural productivity) and insecurity is rampant. This coefficient measures also only the direct effect, i.e. the direct loss of agricultural produce through theft. It might be that the indirect effect through area, labor and input use is much more important. We did not test for this effect.

Natural Shocks

The results show that the passage of a cyclone in the year prior to the survey reduces the TVP by 7%. Agricultural production of the poorest quintile seems to suffer relatively more than for the richest quintile as the former show a impact of 11% compared to 6% for the latter. This might be due to the higher risk bearing capacity of richer households. They might be able to diversify their agricultural production and its location more or they might be able to invest in new planting. The effect of drought was not a very important determinant of agricultural production in 1993 and in the case there was one, it seems to have affected poor and rich households equally.

Regional dummies

The regression results confirm the regional disparity, after controlling for other factors. It is shown that the Mid West agro-ecological region shows the highest TVP while the lowest is noticed in the South, ceteris paribus. This reflects the physical characteristics of these regions.

⁴² We have tried to look at the effect of professional training, but almost no households in the sample have benefited from professional training in agriculture. We are therefore unable to quantify the effect of this kind of education on agricultural productivity.

6. Conclusions

6.1. Conclusions and policy implications

This report analyzes the link between agricultural production and poverty. To this effect, we rely on primary data analysis of the agricultural data of the national household survey. The major implications of this quantitative analysis for the agricultural sector, given the technologies that are currently available to the Malagasy farmers, are summarized below.

Education is an important determinant of agricultural productivity. The results of the regression analysis indicate that households where the household head finished at least primary education show 8 % higher agricultural production compared to households where the head did not finish primary school. Additional secondary education does not show a significant effect on agricultural production. Moreover, results indicate that the poorest quintile benefits disproportional compared to the richest quintile of primary education: 11% compared to 6% respectively.

Diversification in high value crops contributes to increased welfare. Farmers who grow export crops, vegetables or fruits are represented more in the richest quintile than in the poorest quintile. Poorer households depend relatively more on upland crops for their agricultural income than the richer households do. One "less valuable" upland crop that should be mentioned is cassava. It has been shown in other studies (Ravelosoa et al., 1999; Minten et al., 2000) that cassava has the characteristics of an inferior crop, mainly grown and eaten by the poor. Hence, any success in improved productivity and consequent lower prices for this crop would be of direct benefit to the poorer part of the population.

The presence of legal agricultural land titles is shown to have small benefits for productivity at the national level. While an improvement of secure property rights that can be established in a cheap way might benefit agricultural productivity and efficiency in some regional settings, increasing attention should be paid to include the poor in this titling process. It is shown that the rich hold relatively more secure titles to land than do the poor and some studies have shown that the rich might even get titles to the detriment of the poor (Healy and Ratsimbarison, 1999).

Rental agreements are shown to have a positive effect on efficiency and on equity. These results suggest that more secure rental contracts might be beneficial for poverty alleviation and for the agricultural sector. Two types of incentives seem to drive rental or sharecropping contracts. On the one hand, rich households rent out to smaller farms as they can not efficiently cultivate the extra land they possess. On the other hand, poorer households that do not have the means to cultivate the land might prefer renting out land to richer households. It seems that in both cases rental agreements are used to the benefit of the poorer households. Therefore, the Malagasy law that still prohibits sharecropping arrangements seems obsolete. Given that land sales markets are thin and will be very

difficult to activate in the Malagasy context in the short run, a better pro-poor policy would be to ensure a more secure contractual environment for rental agreements.

On average, poorer households show low labor productivity while returns to a unit of extra land for them are large. Hence, it would make economic sense to assure better access to land for the poor. This can be achieved through more active land markets as well as increased mobility within the country as there are still fertile and productive areas in Madagascar that are little used due to insecurity or lack of infrastructure. Labor markets seem to function imperfectly in Madagascar as shown by the large impact of the family composition on agricultural productivity, especially for the poorer households. Given that results seem to indicate that the poor depend heavily on agricultural wage labor, they would probably be the biggest beneficiaries to increased mobility. This mobility could potentially be increased through a reduction in rural insecurity and through the development of better rural infrastructure. While we could not test for the effect of rural road infrastructure directly, it is widely assumed that it is a major constraint for improved agricultural productivity. Labor intensive construction of rural infrastructure might benefit the poorer part of the population through increased employment opportunities with the additional benefit of creating better functioning input and output markets, leading to higher agricultural productivity.

Modern input use shows to have high pay-offs, especially for the poor⁴³. This suggests that an improvement in the functioning of credit market might be an important way to solve the problem of insufficiency of cash at the beginning of the agricultural season. However, it seems that targeting of credit to the poor is difficult due to lack of collateral. Hence, they rely disproportional on informal credit systems that charge significantly higher interest rates (Zeller, 1993; Joseph, 2000). A second policy option is to encourage non-farm or off-season activity for improved agricultural production. A third way to improve input use is through stimulation and better enforceability of vertical contract agreements. This might shift the price and production risk towards firms, which have a higher risk bearing capacity. Such success stories in Madagascar in the agricultural sector exist for barley and tobacco.

6.2. Limits of the study

Some important variables for agricultural production could not be handled in this analysis. First, agricultural extension services might contribute to higher agricultural productivity as it might improve the information on as well as access to new technologies. However, evaluating the effect of agricultural extension with the data at hand is difficult because of the heterogeneity of extension services, lack of information on agricultural extension in the dataset, and the problem of endogeneity. Second, the effect of road infrastructure on agricultural production was also not considered. It is evident that better

⁴³ However, "modern" does not necessarily mean that it is better. In their study of the rice seed markets, Goletti et al. (1998) mention that current improved rice varieties are not well adapted to field conditions. While rice seeds show high yields in on-station trials, yields drop precipitously on seed multiplier farms and show no higher yields than traditional varieties.

transport infrastructure leads to higher output and lower input prices and creates therefore incentives for higher agricultural production. However, evaluating the effect of access to roads is difficult as roads are clearly endogenous variables and as one would need to consider the whole road network, not only the presence of a road in the village. It seems that this effect can only be measured through panel data. Lastly, health services might affect agricultural production. However, its effect is difficult to assess with our data due to endogeneity issues as poor health results in low production but causality runs also the other way as low production, low consumption and low income affects the health situation of the household.

Finally, data limitations were the driving force for the choice of the approach used in this analysis. The major limitations of this approach can be summarized as follows. First, as production factors were not separated by crop or plot, we were obliged to aggregate over all crops. Separate analysis of lowland and upland or by crop would give better estimation on the benefits of, particularly, irrigation, agricultural expenditures, and extension services. Second, as these are cross-sectional data, endogeneity problems seem to exist. Panel data or good instruments would be needed to achieve better estimates of the different determinants. Third, having data on input and output prices and wage rates would allow to establish the link agricultural supply and market prices, and would allow for profit analysis in which case there might be less endogeneity problems.

Given that a new household survey, with an extensive agricultural section, is to be implemented by the end of this year, crop specific analysis might be possible, which would allow for better priority setting in the agricultural sector.

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Annex 1: Regional Crop Production

In this section, the importance of specific crops by agro-ecological region is looked at. The statistics that are presented come from the Ministry of Agriculture as they hold the most recent data (Service de Statistique Agricole, MINAGRI, 1999). First, rice is omnipresent, with the exception of the South and South West where its importance comes after maize and tubers. The Highlands, which includes the Lac Alaotra region, a major surplus area and the rice basket in Madagascar, and many zones of rice production such as Antananarivo, Fianarantsoa and Vakinankaratra, accounted for 39% of total rice production in 1998. The North West, including the Marovoay plains, comes second, accounting for 11% of national production.

The East Coast is characterized by a high relative importance of cassava, representing respectively 41% and 17% of national production. This is especially due to the high production of cassava in the South East sub-region. Cassava is the most important substitute for rice during the lean season in this region. Depending on the rainfall and the temperature, cassava's cycle may be as short as 7 months or as long as 20 months. Its advantage is that farmers can store the tubers in the soil and can repeatedly harvest over a longer period. All the cassava is not used towards human consumption. In the Mid West for example, most production is used as animal feed (hog and cattle).

Export crops such as coffee, vanilla, and cloves are typical of the East Coast and the North East region. These regions supply more than 95% of national production of these crops. In contrast to the rest of the world, coffee is grown in coastal areas instead of highlands. This dates back to the colonial period⁴⁴. One weakness of Madagascar's coffee is the poor quality, which reduces the price it fetches on the international market. Part of the lower price is due to variety as more than 80% of Malagasy production is the *canephora* variety while the variety *robusta* has a higher price in the world market. Agricultural research has developed the *arabusta* clone in the 90's but dissemination is still restricted to the Center East.

In the Highlands, cash crops consist of beans and other industrial crops such as barley, wheat, and tobacco. Strong vertical coordination, where buyers supply inputs and guarantee a fixed price after harvest, is frequent in the industrial crop sub-sector. This leads to high agricultural productivity apparently because most of the production and price risk is borne by the buyer. It seems that the development of this kind of market organization is restricted by two major constraints. First is the often small and geographically limited size of the market. For example, barley is only used by the brewery in Antsirabe. Second is the difficulty for the firm or farmers to enforce contracts. This is the case in the wheat and/or bean subsector where farmers and/or firms do sometimes not respect their engagements, often resulting in non-resolved conflicts. Given the poor state of justice and therefore, the difficulty for enforcement of contractual arrangements in Madagascar, this results in

⁴⁴ During the 1980's, a project was done with the explicit purpose to implement coffee plantation in the highland. However, the results were unsatisfactory, and currently, very few plants survive.

significant contract uncertainty for contractors and limits the arrangements to agents that have developed trust among each other (Fafchamps and Minten, 2001).

Crops for industrial processing are mainly sugar, cotton, and tobacco. Besides scattered sugarcane production by small farmers in the Highlands, most sugarcane production is concentrated near the sugar processing industries: SIRAMA in the North, North West, and East (in Brickaville) and SIRANALA in the Center West. Cotton production is mostly located in the Western part of the country. The sugarcane and cotton subsectors are the sole sub-sectors still under the State control through SIRAMA and HASYMA parastatals respectively. The tobacco sector was liberalized a few years ago but marketing remains subject to government restrictions.

Annex 2: Methods and model

We postulate a model where the quantity produced is a function of cultivated area, input use, labor, household characteristics, natural shocks, and community and regional characteristics. This type of model can be simplified as follows:

$$Y = F(x, z; \beta)$$

where Y is agricultural production, x is a vector of variable factors, z a vector of fixed and quasi-fixed factors and β is an error term. The use of Total Value Product (TVP) as a proxy for production is imposed by data availability⁴⁵. TVP is obtained by multiplying the quantity produced by the shadow prices of the outputs:

$$TVP_i = \sum_{c=1}^n p_{zc} q_{ic}$$

where c is a specific crop;

n is the number of crops cultivated;

i is the household identification;

and z is the village identification.

The use of TVP, instead of physical quantities, as dependent variable in a production function analysis might create extra problems. First, as the TVP includes unit prices and quantities, interpretation becomes more difficult. Second, the dependent variable is sensitive to errors in more variables (prices and quantities), so the error term might be larger. Third, aggregation problems as well are likely to affect the estimation, again tending to enlarge the error term. It is assumed that input choices on fertilizer, manure, and other chemical inputs are made at the beginning of the season, and are therefore exogenous to actual harvest levels.

Various functional forms in production analysis have been proposed. The applicability of three types of models was tested: the translog, the quadratic and the square root generalized Leontief forms⁴⁶. To choose between the three models, the Mackinnon - White - Davidson (MWD) test⁴⁷ for non-nested functional forms was used. The results favor the square root generalized Leontief function. Like other flexible forms, the square root GL exhibits diminishing marginal returns to factors of production. Its marginal productivity does have an unrestricted sign, allowing it to represent all stages in the production process. GL is linear in parameters, so it can be estimated with a linear regression method. However, a drawback of this form is that we cannot normalize the

⁴⁵ Ideally, separate production function would have been done on rice and other upland crops but in this study, we are constrained to use TVP for the whole farm as land area and input expenditures were only collected at the household level.

⁴⁶ While the Cobb Douglas form is computationally easier, it is limited by the existence of zero values and by the impossibility to have pairwise interaction effects between independent variables. This linear form also implies strong a priori assumptions on the production behavior (Sadoulet and deJanvry, 1996).

⁴⁷ The MWD test consists in identifying the “best among the tested” functional form for the data. It is used for non-nested models that have different dependent variables measurement units (See Gujarati, 1995).

variables to have zero means⁴⁸. We then will work with non-normalized variables, therefore we might not have exact second order approximation everywhere.

The final empirical model is of the form:

$$\sqrt{y} = \alpha_0 + \sum_{i=1}^n \alpha_i \sqrt{x_i} + \sum_{k=1}^m \delta_k z_k + \sum_{i=1}^n \sum_{i=1}^n \varphi_{ii} (\sqrt{x_i})^2 + \sum_{i=1}^n \sum_{j=1}^{n-1} \beta_{ij} \sqrt{x_i} \sqrt{x_j} + \mu_i$$

where y is TVP measured in rice equivalent;

x is a vector of inputs

z is a vector representing the farm characteristics, the community characteristics, and some natural conditions;

α , β , δ , φ are parameters to be estimated;

μ is the error term;

n is the number of x variables

m is the number of z variables

The elasticity on TVP of different factor choices can be computed from the first derivative of this specification:

$$\varepsilon_{y,xi} = \frac{dy}{dx_i} \frac{x_i}{y} = \left(2 \sum_{i=1}^n \sum_{i=1}^n \varphi_{ii} \sqrt{x_i} + \sum_{i=1}^n \alpha_i + \sum_{i=1}^n \sum_{j=1}^{n-1} \beta_{ij} \sqrt{x_j} \right)$$

⁴⁸ Negative values are not allowed by the square root function of the GL model.

Table 1 – Agricultural Income by Expenditure Quintile

<i>Variables</i>	<i>Unit</i>	<i>National</i>	<i>Quintile 1</i>	<i>Quintile 2</i>	<i>Quintile 3</i>	<i>Quintile 4</i>	<i>Quintile 5</i>
Per capita real expenditure	FMG	341,359	101,588	176,740	246,163	347,623	889,916
Per household Expenditure	FMG	1,654,012	668,177	1,091,072	1,334,646	1,618,496	3,772,229
Total Value	FMG	1,458,374	746,880	930,677	1,106,352	2,731,085	1,879,439
Product	FMG/are	10,821	8,916	7,962	8,111	16,746	10,388
Grow cash crops	% of hhs	26	24	24	25	26	31
Grow vegetables	% of hhs	9	5	5	10	12	13
Grow fruits	% of hhs	26	21	25	26	28	34
Diversification	% of hhs	41	36	36	40	44	49

Source: computed by authors from EPM 1993

Table 2 – Agricultural Land by Expenditure Quintile

<i>Variables</i>	<i>Unit</i>	<i>National</i>	<i>Quintile 1</i>	<i>Quintile 2</i>	<i>Quintile 3</i>	<i>Quintile 4</i>	<i>Quintile 5</i>
<hr/>							
Land cultivators							
Farm size	Are	135	84	117	136	163	181
Farm size per capita	Are	34	15	21	31	41	63
Irrigated land	Are	48	23	39	49	63	68
Rental land	% of area	8	5	10	9	8	8
<hr/>							
Landowners or cultivators							
Bought land over the last five years	% of hhs	10	7	10	11	10	13
Sold land over the last five years	% of hhs	3	5	4	3	3	2
<hr/>							
Landowners							
Inherited land	Are	83	53	65	90	112	104
Purchased land	Are	20	10	21	14	24	31
Land gotten for free from village	Are	20	7	16	19	29	32
Land without title	Are	85	56	79	83	97	113

Source: computed by authors from EPM 1993

Table 3 – Labor by Expenditure Quintile

<i>Variables</i>	<i>Unit</i>	<i>National</i>	<i>Quintile 1</i>	<i>Quintile 2</i>	<i>Quintile 3</i>	<i>Quintile 4</i>	<i>Quintile 5</i>
Family members	Number	5.06	6.15	5.68	5.10	4.42	3.77
Adult labor (15-60 year)	Number	2.46	2.64	2.62	2.43	2.30	2.25
Teenager (7-14 year)	Number	1.08	1.49	1.27	1.13	.85	.57
Elder (> 60 year)	Number	.19	.16	.19	.23	.20	.15
Sex head of household	Female = 1	.17	.17	.15	.18	.19	.14
Age head of household	Year	42.7	42.8	42.1	43.3	43.3	42.0
Main activity head of hh	Agriculture = 1	.80	.79	.82	.77	.81	.80
Total hired labor	FMG	41,691	7,251	17,860	21,829	57,775	77,370
	FMG/are	152	52	80	114	215	227

Source: computed by authors from EPM 1993

Table 4 – Input Use by Expenditure Quintile

<i>Variables</i>	<i>Unit</i>	<i>National</i>	<i>Quintile 1</i>	<i>Quintile 2</i>	<i>Quintile 3</i>	<i>Quintile 4</i>	<i>Quintile 5</i>
Mineral	FMG	13,665	1,100	4,812	5,672	6,450	39,837
fertilizer	FMG/are	37.75	11.55	29.15	46.09	24.50	63.62
Organic	FMG	1,824	66	1,062	230	249	6,065
fertilizer	FMG/are	7.18	2.12	5.86	3.29	3.84	17.07
Purchased seed	FMG	6,885	3,797	2,242	2,267	16,822	6,052
	FMG/are	26.61	35.24	21.40	15.66	37.71	17.07
Pesticides	FMG	8,476	144	3,790	1,839	3,206	26,518
	FMG/are	15.90	1.77	12.16	9.05	11.02	36.12
Modern input	FMG	60,346	7,741	16,518	15,921	63,809	151,460
expenditures	FMG/are	161	60	86	96	216	265
Value agr.	FMG	186,861	42,583	92,524	100,313	283,974	306,793
equipment	FMG/are	660	297	373	419	1,342	593
Draught oxen	Number/hh	.50	.28	.47	.49	.54	.74
	Number/are	.004	.003	.004	.004	.003	.004

Source: computed by authors from EPM 1993

Table 5 – Institutions by Expenditure Quintile

<i>Variables</i>	<i>Unit</i>	<i>National</i>	<i>Quintile 1</i>	<i>Quintile 2</i>	<i>Quintile 3</i>	<i>Quintile 4</i>	<i>Quintile 5</i>
Primary education	If finished = 1	.65	.53	.66	.70	.67	.72
Secondary education	If finished = 1	.14	.06	.09	.15	.16	.24
Head of hh education level	Year	3.1	2.0	2.8	3.4	3.4	4.1
Maximum education level	Year	4.6	3.5	4.5	4.9	4.9	5.5
Exposed to agr. extension*	Yes = 1	.34	.32	.31	.34	.35	.38
Used credit	Yes = 1	.29	.30	.35	.28	.28	.26
Type of credit	Formal = 1	.04	.01	.04	.04	.08	.06
Credit use	Agriculture = 1	.79	.80	.81	.80	.85	.69
Cattle theft*	Important = 1	.43	.40	.44	.44	.46	.40
Cyclone**	Yes = 1	.26	.19	.27	.25	.29	.31
Drought**	Yes = 1	.39	.29	.39	.41	.46	.40

* Variable collected at the village level

** Variables collected at the Fivondronana level from CNS (CARE SIRCat Project).

Source: computed by authors from EPM 1993

Table 6 – Agricultural Variables by Agro-ecological Region

<i>Variables</i>	<i>Unit</i>	<i>North</i>	<i>Oriental Coast</i>	<i>South</i>	<i>Littoral West</i>	<i>Highland</i>	<i>Middle West</i>
<i>Income & Activity</i>							
Per capita real expenditure	FMG	416,943	345,534	219,056	508,800	304,655	332,844
Per household expenditure	FMG	1,920,383	1,610,589	995,432	2,563,282	1,567,064	1,566,860
Total Value Product	FMG	1,129,337	993,813	496,749	1,383,719	2,169,633	1,599,714
Grow cash crops	% of hhs	65	62	1	3	6	8
Grow vegetables	% of hhs	4	8	7	9	13	6
Grow fruits	% of hhs	60	53	11	8	13	6
Crop diversification	% of hhs	77	78	16	19	24	16
<i>Land</i>							
Cultivated land	are	203	99	155	177	99	180
Irrigated land	% cultivated	31	25	30	46	50	24
Titled land	% cultivated	21	26	17	18	33	24
Rented – Sharecropping	% cultivated	11	2	9	9	13	3
<i>Labor</i>							
Family members	Number	4.70	5.06	4.85	4.91	5.27	5.13
Sex head of household	Female = 1	.27	.14	.20	.19	.14	.13
Age head of household	Years	43.5	41.8	44.4	42.8	42.7	42.0
Main activity head of hh	Agriculture = 1	.74	.54	.95	.95	.86	.94
Total hired labor	FMG/are	39	154	48	110	275	201

Table 6 – Continued

<i>Variables</i>	<i>Unit</i>	<i>North</i>	<i>Oriental Coast</i>	<i>South</i>	<i>Littoral West</i>	<i>Highland</i>	<i>Middle West</i>
<i>Input expenditures</i>							
Mineral Fertilizer	FMG/are	3.05	7.64	7.05	2.46	76.36	99.90
Organic fertilizer	FMG/are	4.56	0.01	0.00	3.20	15.84	12.85
Purchased seed	FMG/are	9.64	23.73	11.76	13.13	57.68	23.12
Pesticides	FMG/are	6.71	.53	34.51	2.59	20.02	32.68
Total agr. equipment	FMG/are	172	70	132	313	2,003	455
Draught oxen	Number/hh	.67	.00	.49	.94	.57	.71
<i>Institutions</i>							
Primary education	If finished = 1	.65	.59	.32	.56	.82	.68
Secondary education	If finished = 1	.15	.10	.11	.16	.17	.12
Household head education level	Year	2.9	2.6	1.6	2.8	4.1	3.0
Maximum education level	Year	4.7	3.9	2.5	4.2	6.1	4.2
Credit use	Yes = 1	.32	.33	.35	.17	.29	.25
Exposed to agr. extension*	Yes = 1	.40	.23	.28	.27	.48	.20
Cattle theft*	Yes = 1	.35	.10	.60	.62	.51	.63
Cyclone*	Yes = 1	.17	.33	.03	.58	.21	.31
Drought*	Yes = 1	.36	.15	.42	.12	.76	.03

Source: computed by authors from EPM 1993

Table 7 – Descriptive Statistics of Variables Used in the Regression Analysis

<i>Variables</i>	<i>Unit</i>	<i>Mean</i>	<i>Standard Deviation</i>	<i>Median</i>
Dependent variable= Total Value Product N=2953	Kg of rice equivalent	1,864	15,721	768.5
<i>Land</i>				
Cultivated land	Are	134.7	202.7	70.0
Irrigation	Are	47.5	127.8	n.a
Titled	Are	32.8	126.8	n.a
Rented / sharecropping	Are	11.0	44.4	n.a
<i>Labor</i>				
Family labor	Number	3.3	1.9	n.a
<i>Capital</i>				
Agricultural expenditures	Kg of rice equivalent	28.6	271.8	.62
Agricultural equipment	Kg of rice equivalent	123.7	2,055.3	6.57
Draught oxen	Number	.50	1.52	n.a
<i>Institutions</i>				
Primary education	Dummy: finished = 1	.65	.48	n.a
Secondary education	Dummy: finished = 1	.14	.34	n.a
Sex of household head	Dummy: female = 1	.17	.37	n.a
Main activity of household head	Dummy: agriculture = 1	.80	.40	n.a
Diversification	Dummy: yes = 1	.41	.49	n.a
Cattle theft	Dummy: important = 1	.43	.49	n.a
Cyclone	Dummy: yes = 1	.26	.44	n.a
Drought	Dummy: yes = 1	.39	.76	n.a
Age of household head	Year	42.7	15.2	40.0

Source: computed by authors from EPM 1993

Table 8 – Production Function Estimates, Nationally and by Quintile

<i>Dependent variables =TVP</i>	<i>Unit</i>	<i>National</i>	<i>Quintile 1</i>	<i>Quintile 2</i>	<i>Quintile 3</i>	<i>Quintile 4</i>	<i>Quintile 5</i>
<i>Input variables</i>							
Cultivated land	Kg rice/are	5.5 (.38)	4.7 (.46)	4.0 (.41)	4.2 (.39)	7.0 (.35)	5.5 (.33)
Agricultural expenditures	FMG/FMG	3.2 (.06)	5.9 (.04)	4.4 (.05)	3.9 (.05)	3.7 (.06)	2.6 (.07)
Family labor	Kg rice/unit	65.0 (.12)	26.3 (.12)	35.2 (.12)	46.8 (.12)	102.0 (.11)	125.9 (.12)
Agricultural equipment	FMG/FMG	1.1 (.07)	2.2 (.08)	1.6 (.08)	1.4 (.07)	.9 (.08)	.9 (.06)
Draught oxen	Kg rice/unit	79.9 (.02)	89.1 (.03)	53.9 (.02)	60.3 (.02)	105.9 (.02)	71.0 (.01)
<i>Land characteristics</i>							
Irrigation	Kg rice/are irrigated	1.3 (.03)	1.2 (.03)	1.0 (.03)	1.0 (.03)	1.8 (.04)	1.4 (.04)
Title	Kg rice/are titled	.3 (.005)	.4 (.008)	.2 (.004)	.2 (.004)	.5 (.005)	.2 (.003)
Rent and sharecrop	Kg rice/are rented	2.5 (.01)	4.0 (.02)	1.7 (.02)	1.8 (.01)	3.3 (.01)	1.8 (.01)
<i>TVP shifters</i>							
Age of household head	Kg rice/year	-1.3 (-.0%)	-.8 (-.0%)	-.8 (-.0%)	-1.0 (-.0%)	-1.9 (-.0%)	-1.7 (-.0%)
Primary education	Kg rice from 0 to 1	143 (7.5%)	88 (10.6%)	91 (8.4%)	103 (7.3%)	205 (6.8%)	186 (5.8%)
Secondary education	Kg rice from 0 to 1	-49 (-2.5%)	-30 (-3.6%)	-31 (-2.9%)	-35 (-2.5%)	-70 (-2.3%)	-64 (-2.0%)
Sex of household head	Kg rice from 0 to 1	-252 (-13.2%)	-156 (-18.7%)	-161 (-14.8%)	-183 (-12.9%)	-363 (-12.0%)	-329 (-10.3%)
Main activity of household head	Kg rice from 0 to 1	417 (21.9%)	258 (30.9%)	266 (24.5%)	303 (21.4%)	600 (19.9%)	545 (17.0%)
Crops diversification	Kg rice from 0 to 1	411 (21.5%)	254 (30.5%)	262 (24.1%)	298 (21.1%)	591 (19.6%)	537 (16.8%)
Cattle theft *	Kg rice from 0 to 1	-10 (-.5%)	-6 (-.7%)	-6 (-.5%)	-7 (-.5%)	-14 (-.4%)	-13 (-.4%)
Cyclone *	Kg rice from 0 to 1	-142 (-7.4%)	-88 (-10.6%)	-91 (-8.4%)	-103 (-7.3%)	-205 (-6.8%)	-186 (-5.8%)
Drought *	Kg rice from 0 to 1	-19 (-1.0%)	-11 (-1.4%)	-12 (-1.1%)	-14 (-.9%)	-27 (-.9%)	-24 (-.7%)

Values in parenthesis are elasticity of the variable with respect to the TVP or % change in TVP for a switching value of binary variables.

Source: computed by authors from EPM 1993