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PATHWAYS OF RURAL DEVELOPMENT IN MADAGASCAR: AN EMPIRICAL INVESTIGATION OF THE CRITICAL TRIANGLE OF ENVIRONMENTAL SUSTAINABILITY, ECONOMIC GROWTH, AND POVERTY ALLEVIATION

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ABSTRACT

This paper is based on community-level data from 188 villages in rural Madagascar. The survey that was conducted in 1997 made extensive use of long-term recall questions ascertaining changes during the past 10 years in rice yields, wages, population, soil fertility, and other pertinent variables of rural development. We find that—on average for all villages—the yields of irrigated rice, the major food crop, and real agricultural wages declined, while the communities expanded their upland area by nearly a quarter and experienced deteriorating fertility of their upland soils. These patterns are consistent with the wide-held belief that rural areas in Madagascar have witnessed increased poverty, economic stagnation, and a continued degradation of the natural resources.

Yet, the five agroecological regions in our sample exhibit quite different patterns of rural development, and at least one of them has experienced increases in yields and wages. From a policy perspective, it is important to better understand the driving forces of such diverse rural change. The overall decline in rural wages over the past 10 years is expected to have contributed to increased poverty, food insecurity and malnutrition in rural areas, as rural wage laborers traditionally belong to the poorest of the poor in Madagascar. In this paper, we present an econometric analysis of the determinants of and interdependencies between the three components of sustainable development: economic growth, environmental sustainability, and poverty alleviation.

We develop a two-stage, least-squares fixed-effect model that attempts to explain rice yields, rural migration and wages, endogenous placement of microfinance institutions, and the observed change in upland and soil fertility, with exogenous and policy variables, such as the communities' social capital, their exposure to weather risks and their access to commodity and financial markets and to public services. The paper concludes with a number of implications for policy and future research.

CONTENTS

TABLES

FIGURE

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1. INTRODUCTION

Most of the world's poor and food insecure depend directly or indirectly on agriculture for their livelihood. Much-needed increases in agricultural production can in principal come about through two pathways of rural development: expansion of cultivated area or increases in yields. We term the former the pathway of agricultural extensification since it does not require increases in agricultural productivity by using modern inputs, such as high-yielding seeds and mineral fertilizers. Shifting cultivation, by burning tropical forests for gaining arable land, is a prime example for the first pathway. The second is called a pathway of agricultural intensification (Boserup 1965; Pingali, Bigot, and Binswanger 1987; Ruthenberg 1980). Which factors induce rural communities to follow a certain pathway of use of land and forest resources, and how can policy assist to achieve environmentally sustainable pathways of development while at the same time improve incomes and alleviate poverty? In this paper, we seek to shed some light on this complex question, using a descriptive and econometric analysis of community-level data from Madagascar.

2. **CONCEPTUAL FRAMEWORK**

INDUCED (TECHNOLOGICAL AND INSTITUTIONAL) INNOVATION THEORY

Induced innovation theory suggests that environmental degradation can be self-correcting, as population growth, increasing resource scarcity, and environmental externalities induce new agricultural and resource management practices (Boserup 1965) and new forms of collective regulation of common property resources (Kikuchi and Hayami 1980; Ruttan and Hayami 1984). However, this early work on induced institutional innovation is overly optimistic, and tends to overlook, as pointed out by Baland and Platteau (1998), that evolution, including long-run institutional equilibria and the corresponding pathways of development, are themselves dependent on the initial stock of social capital, on the actions by the state, and on the distributive consequences of institutional change.

Ruthenberg's (1980) survey of literature on farming systems in the tropics documents many agricultural innovations that were associated with increasing population growth and market integration in different agroecological zones. He explains the observed technical changes in crop and soil management with the occurrence of increased scarcity of land and declining soil fertility. More recent literature, reviewed by Scherr and Hazell (1994), has described similar endogenous processes leading to pathways of agricultural intensification.

THE CRITICAL TRIANGLE OF RURAL DEVELOPMENT: THE CASE OF MADAGASCAR

Vosti and Reardon (1997) conceptualize a critical triangle that links three development objectives: economic growth, poverty alleviation, and environmental sustainability. These authors emphasize the importance of simultaneous consideration of all three development objectives, plus possible links between and trade-offs among them.

In recent years, Madagascar has become internationally known for its rich and unique bio-diversity that is threatened by rapid deforestation (Jarosz 1993). Since the mid-1980s, Madagascar has been a focus country of international conservation efforts when international development organizations provided loan and assistance programs that explicitly aimed to attain environmental objectives. Already in 1984, the Government of Madagascar embarked on a National Strategy for Conservation and Development that recognized the critical triangle by including environmental conservation, economic development, and human needs into the policy framework (Larson 1994). However, as pointed out by Gezon (1997), a number of important environmental projects implemented during the early 1990s sought to address the links between poverty and environmental degradation, but failed to take into account their economic sustainability.

The national survey Enquête Permanente auprès des Ménages (EPM), conducted in 1993 by the National Statistical Office (INSTAT), has a few questions that touch upon the critical triangle. Apart from some in-depth surveys in or near protected areas, no statistically representative data on a national or regional scale exist to the knowledge of the authors that contain both agroecological and socioeconomic data and that can be meaningfully exploited for causal analysis. Yet, the existence of such combined databases is a precondition for in-depth analysis of the underlying determinants of rural development, economic growth, poverty alleviation and environmental sustainability. One recent data set collected by the authors attempts to combine these topics, and is the basis for the analysis of this paper.

3. CHANGES IN RURAL DEVELOPMENT: A DESCRIPTIVE ANALYSIS

DATA SOURCE AND SAMPLING FRAME

In May 1997, the International Food Policy Research Institute (IFPRI) and the Ministry of Scientific Research (MRS) of Madagascar undertook a survey that covered 188 communities in five agroecological regions: *Fianarantsoa* Highlands, *Fianarantsoa* coastal and escarpment region, *Majunga* Lowland area, *Majunga* Highland area, and the *Vakinankaratra*, a diverse region in the central Highlands of Madagascar. While the general purpose of the survey was to document past trends in rural development and to explain how they have responded to the liberalization of agricultural commodity and rural financial markets, several sections were added to cover changes in the natural resource base.[1] The respondents to the survey were the mayor of the village and other community leaders. Common to all modules was that the respondents were asked to provide information for the situation prevailing in 1997 and 10 years ago.

In order to improve the efficiency of the random sampling procedure, two stratifying variables were used: the size of the village (above or below median of all villages in the agroecological region), and the terciles of the distance from the village to

[1] The authors thank John Pender and Sara Scherr for providing comments on the design of the questionnaire modules covering forest and land resources.

the next national road. These stratifiers are exogenous variables for short-run rural development, and influence communities' access to commodity and financial markets, information, preventative and curative health care, education, and other public services.

MAJOR TRENDS CHARACTERIZING THE CRITICAL TRIANGLE OF RURAL DEVELOPMENT

Rice is the major crop and also the staple food in Madagascar. For the nation as a whole, about half of calories consumed are from rice (Ravalosoa 1998; SECALINE 1996). Rice is mainly grown on irrigated lowland fields, or to a small extent on rainfed upland plots. In Table 1, the yield (in kilograms per hectare) of irrigated rice is shown for the agroecological regions in the sample. For all regions, average rice yields declined from 1,765 kilograms per hectare to about 1,540 kilograms per hectare between 1987 and 1997. Yet, important differences across regions exist. In the Vakinankaratra region, the yields remained the same. Major declines in rice yields can be noticed for the Majunga regions (Minten, Randrianarisoa, and Zeller 1998). Insofar as rice yields can be viewed as a performance indicator for the agricultural sector as a whole, we conclude that there was either stagnation or decline in productivity.

In the community survey, we sought to ask about the changes in poverty over the past 10 years. Poverty encompasses many dimensions, such as food insecurity, malnutrition, and illiteracy. Most of them are difficult to measure through community-level surveys. Moreover, we were interested in the change of poverty over the past 10 years, and, therefore, had to find variables that could be easily recalled by our respondents. One such variable, we believe, is the rural wage rate. In Madagascar, rural wages are often paid in rice, and measured as the number of *kapoaka*[2] paid per day. Table 1 differentiates wage rates by agroecological regions. We note that wage rates have declined over the past 10 years for all regions as a whole, but important differences among the regions exist. The wage rate improved in the Vakinankaratra region, whereas the other regions experienced modest (Fianarantsoa) or severe declines in wage rates (Majunga Plateau). Insofar as wage rates determine the ability of the poorest of the rural poor to feed their families in Madagascar, we conclude that food insecurity and rural poverty increased.

The change in soil fertility is the third indicator shown in Table 1, reflecting the environmental objective of the critical triangle. Community leaders were asked how the fertility of the upland *(tanety)* in their community has changed. The variable "soil fertility" ranges from 3, if soil fertility improved over the past 10 years; 2, if no change; 1, if soils degraded somewhat; and 0, if soils became severely degraded. We find that soil fertility significantly decreased, on average, for all regions, with major degradation observed in the Fianarantsoa Highlands (HT), the Vakinankaratra and the coastal and escarpment area of the Faritany of Fianarantsoa. The rice yield, wage rate, and soil fertility variables serve in our analysis as indicators of the trends in agricultural growth, in poverty, and in

[2] This common measure is the tin can used by Nestle Company for its condensed milk, which holds 285 grams of white rice.

environmental degradation, respectively. Overall, the data reveal quite disturbing trends. Only one of the five regions improved in two of the three criteria over the 10-year period.

THE EXPANSION OF THE AGRICULTURAL FRONTIER IN RURAL MADAGASCAR

The yields of rice have stagnated or declined in Madagascar during the past 10 years. This is not evidence that an intensification strategy had been chosen by the rural households and communities. Table 2 supports this notion. While rice land area grew by about 5.3 percent as an average for all regions, the area of cultivated upland (*tanety*) increased by about 24.0 percent. Considering that the population in the survey regions grew by about 3.5 percent per year over this time, or by more than 35 percent over the past 10 years, the rate of growth in arable area is actually below that of the growth in population.[3]

The expansion of the agricultural frontier came at the expense of forestland, bushland, and grassland. These land types are usually held as common property resources but become, under Malagasy customary law, private property when cultivated successively

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[3] The natural population growth rate of 3.5 percent, which was measured in the community-level survey through recall questions on the number of people residing 10 years ago and now in the village, correcting for the number of people in-migrating and out-migrating, is considerably higher than the one estimated at 2.9 percent for the country for the period of 1980 to 1989. We note that our growth rate is based on quite simple, and therefore, imprecise questions on population size of village 10 years ago and now. Growth rates, obtained from census data at two points in time, are admittedly much more exact. Second, the rate reported here is not weighted by the initial size of the village (in comparison with other villages) so that high population growth rates observed in small villages biases our estimate upwards. When we weigh the population growth rate by the size of each village in the sample, the weighted population growth rate for all survey regions as an aggregate is measured at 3.0 percent. In other words, when correcting for the faster population growth in smaller villages, our estimates coincide very well with the national ones.

by the same family.[4] On average for all regions, the largest losses were experienced for area under primary forests (Table 2). Indicating the level of primary forests as 100 for 1987, the index fell to 67.4 in 1997. The loss in secondary forest amounts to about 28 percent, whereas the loss in grassland and bushland (*kijana*) was about 20 percent. If this rate of deforestation continues, the survey regions could be without primary forests in two to three decades.[5]

That the agricultural frontier can still be expanded in many Malagasy villages is evident from the survey data. On average for all regions, 59 percent of villages report that there is additional land available for expanding upland cultivation. Fifty percent of villages have such possibilities for expanding irrigated land (*tanimbary*), and 35 percent of villages dispose over possibilities to expand both types of land. Despite this, the average holding of upland per household declined from 1.74 hectares in 1987 to 1.28 hectares in 1997. Clearly, growth in population has outpaced growth of agricultural land in many communities, and pressures for agricultural intensification have tended to increase over time.

THE THREE MAJOR PATHWAYS OF RURAL DEVELOPMENT IN MADAGASCAR

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[4] On land law in Madagascar, see Keck, Sharma, and Feder (1994), Rakotomanga (1976), and Rakotonirainy (1984).

[5] This result coincides with an estimate by the Economist Intelligence Unit in 1990, cited from Keck, Sharma, and Feder (1994).

We conclude from this analysis that about half of the villages in the survey regions will still be able to choose the extensification pathway for the near and distant future. These more land-abundant communities may maintain their living standards with their low-input agriculture for some time, while continuing to expand arable area and degrade soils. Yet, while such extensive expansion of agricultural production may meet subsistence needs in the short run, the continued degradation of forests, watersheds, and soils has implications for future agricultural productivity, health, and nutrition (von Braun 1997). Current subsistence and food security are then likely to be at the expense of future generations. The households are most certainly aware of these trade-offs; yet, extreme poverty can lead to high time preference rates. For example, Lapenu et al. (1998) show that households in a significant number of sample villages needed more time to collect firewood now compared to 10 years ago. In these villages with increasing firewood shortages, the need for reforestation was perceived more frequently than in villages with below-average time needed to collect firewood.

The remaining half of the villages does not have the possibility of further land expansion anymore. In order to maintain or improve their living standards, households in these land-constrained villages can in principal pursue two other generic development pathways: (1) agricultural intensification, and related increased trade and diversification into off-farm enterprises, or (2) migration. The main, and certainly most promising and viable strategy in the long run, is to intensify agriculture, and to make it more productive and environmentally sustainable.[6] The third strategic response to land scarcity is to migrate, i.e., to leave the village seasonally or forever. Its consequences for poverty alleviation and the environment can be quite different from an agricultural intensification strategy, as is shown later.

TRENDS IN ACCESS TO FINANCIAL AND COMMODITY MARKETS AND TO PUBLIC SERVICES

A number of factors that are considered to have exogenously evolved during the period 1987-1997 are expected to have influenced the phenomena that villages differ in their development paths. These factors include access to financial and to agricultural input and output markets, and access to public services.

Access to Microfinance Institutions

As in most low-income countries in Sub-Saharan Africa, the formal banking sector has barely penetrated rural Madagascar. Until 1986, the state-owned Banque pour le Développement Rural (BTM) was the main institution providing loans to farmers. Apart from the requirement of tedious paperwork and collateral that poor households neither can

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[6] Higher rural incomes could possibly be achieved by growth in the rural nonfarm sector. While this paper focuses on agricultural income growth, the promotion of nonfarm enterprises (for example, for food processing and marketing and for provision of rural services) can be an important strategy for overall rural growth. However, the success of this strategy depends to a large extent on the relative magnitude of forward and backward linkages of the (dominant) farm sector with the nonfarm sector. Islam (1997) finds that the growth multiplier was estimated between 1.35 to 1.90, i.e., $1 of additional farm income increases nonfarm rural income by $0.35 to $0.90. On farm-nonfarm growth linkages, see, for example, Hazell and Röell (1983) and Hazell and Haggblade (1993).

understand nor provide, the one-way travel time of the average smallholder to the nearest bank branch is 4.75 hours. In other words, it takes an entire day to apply for a loan. The travel times to banks, post offices, and postal savings bank also increased during the past 10 years (Table 3). In the early 1990s, a number of village bank programs and credit and savings cooperative societies were introduced and subsequently expanded to better reach rural smallholders, especially in the Vakinankaratra, the Fianarantsoa Highlands, at Lake Alaotra and in Marovaoy (Fraslin 1997). The survey obtained information on the existence and size of member-owned financial institutions in the village that allowed defining a variable that measures the density of village-level participation in financial institutions. This information was only obtained for 1997, but it is safe to assume that none of the villages had access to similar organizations in 1987 because they were all formed after that year. Eleven percent of households participate in member-based financial institutions in 1997.

Access to Agricultural Input and Output Markets

Survey data not presented here for lack of space show that access to markets for seed rice and farm equipment improved, while access to mineral fertilizer, pesticides, herbicides, vegetable seeds, and veterinary inputs worsened over the survey period. Particularly noteworthy is the large decline in access to fertilizer markets. On the other hand, the access to agricultural output markets improved somewhat, in particular for rice.

Community Access to Public Services

We asked about the travel time from the village to over 15 public services that are provided by central or local government. The travel time in the rainy season—using the commonly used modes of transport in the village—ranges between two and four hours. Travel time to access a public phone booth is highest among all public services. It takes an average of two hours to travel to either the nearest primary and secondary school, or the nearest health post or hospital. Compared to 1987, the average travel times for all regions taken as a whole in 1997 are either the same or slightly higher.

4. A CAUSAL DIAGRAM OF THE CRITICAL TRIANGLE

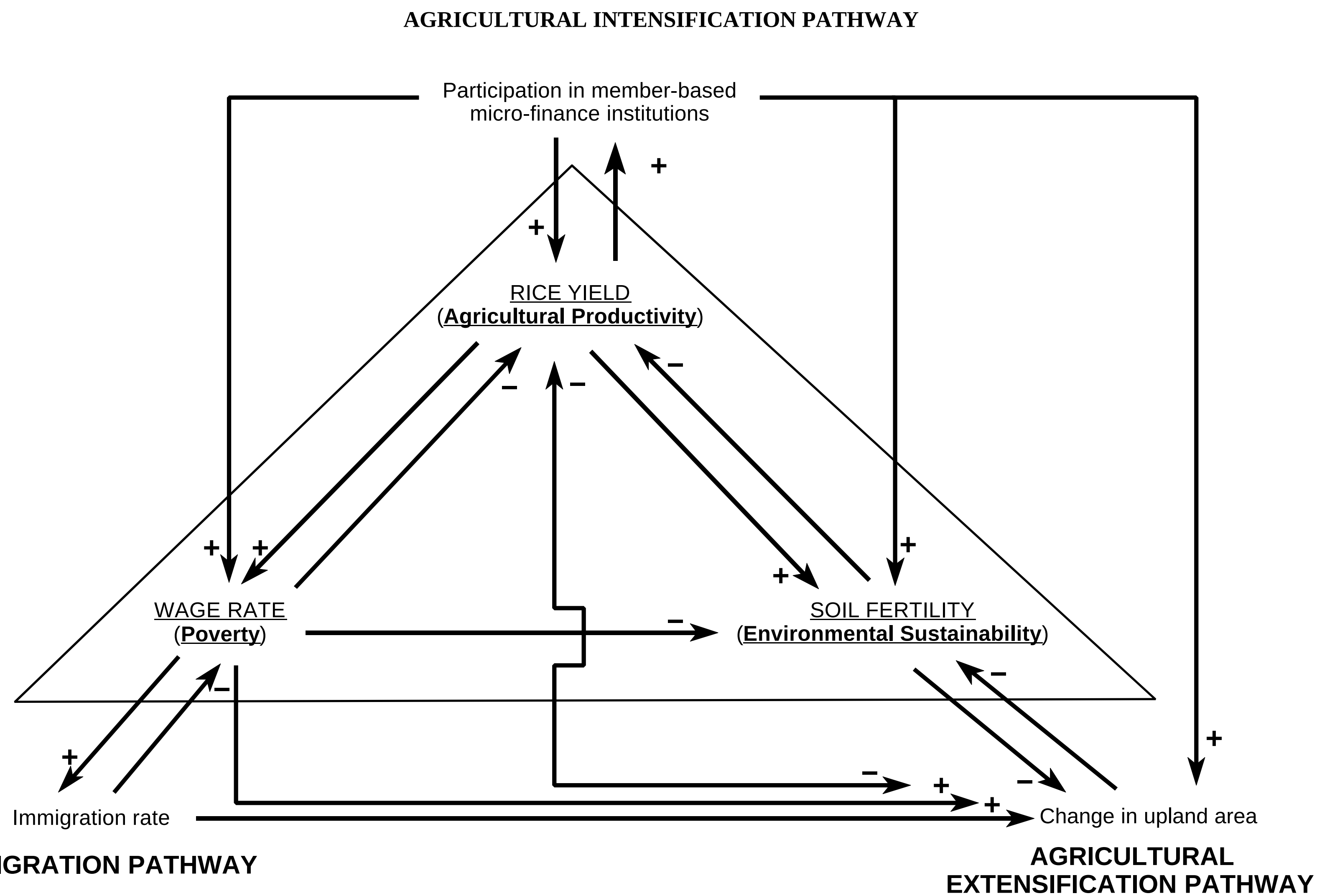
Three major pathways of development are distinguished in this analysis. The first is the extensification pathway, that is, to continue with low-input, low-output agricultural technology by expanding cultivated land area and subsequently reducing fallow years until soil fertility has been depleted. The second pathway is to intensify agricultural production and increase yields by exploiting access to financial and commodity markets, thus adopting more capital-intensive, higher-yielding technology and reaping the benefits of interregional specialization. Migration is the third major pathway that we observe from the data. The migration pathway is similar to the extensification pathway: migrants are attracted by the possibility of farming new land, as we will confirm in the econometric analysis, since the pressure on natural resources is simply shifted from one region to another.

Hence, our conceptual framework stipulates four endogenous outcome variables: rice yield, wage rate, changes in soil fertility, and in the area of upland. These are influenced by three strategies leading to different pathways of rural development. The villagers' choice of strategy is, of course, endogenous as it is influenced by the endogenous wage rate, rice yields, and soil fertility, by the socioeconomic and agroecological characteristics of the region, by the access to financial and commodity markets and public services, and by the various institutional arrangements that regulate the use of common and privately-owned forestland, grassland, and arable land resources.

Figure 1 presents a causal diagram of the critical triangle of rural development. Arrows between the variables represent relationships. A positive sign implies that an increase in the value of the variable from which the arrow originates is expected to induce an increase in the value of the other variable. For example, we hypothesize that higher lowland rice yields will decrease the incentives for further expansion of upland since the returns to lowland rice production become relatively higher. This relationship is reflected by an arrow with a negative sign.

Let us consider first the arrows that feed into the upland area from the other endogenous outcomes or strategies. These arrows come from access to financial markets, the wage rate, the soil fertility of upland, and the net immigration rate. First, improved access to financial markets—reflected either through lower interest rates, lower

Figure 1—The critical triangle of rural development: Pathways and causes



transaction costs for the clients, or higher amounts available to borrow—will make the capital used in rice production and in upland fields less costly. With the reduced cost of capital, the profitability of these enterprises rises, leading to increases in yields in both lowland and upland areas. Second, with increasing wage rates, farm households will tend to choose more labor-extensive crop production technologies. Since cultivation of irrigated rice is more labor-intensive than crop production, higher wage rates are hypothesized to induce lower labor input and therefore lower yields of rice, but increased expansion of upland area. Third, the expansion of upland area is expected to be positively influenced by a higher net immigration into the village, since migrants are expected to cultivate new lands not already occupied by villagers. Fourth, and last, expansion of upland cultivation will have negative effects on soil fertility due to shorter fallow periods for already cultivated land or result in increased cultivation of marginal or infertile land. The negative arrow from soil fertility to upland area change reflects the vicious, unsustainable cycle of extensification and soil degradation: lower soil fertility will induce farmers to abandon fields after only a few harvests and seek new farmland to cultivate.

Since most investments in conserving soil fertility are labor-intensive (for example, spreading manure, planting trees, or terracing land), rising labor costs will reduce the relative profitability of soil-conserving investments. Moreover, we hypothesize that increased participation in member-based financial institutions will improve soil fertility because it reduces the cost of capital and increase its availability for investment in conservation.

In the causal model of Figure 1, the net immigration rate is perceived to be a function of the endogenous wage rate. We hypothesize that villages with high wage rates will attract migrants. As more migrants come into those high-wage villages, they will increase the supply of labor and therefore push wage rates down, an effect that is expressed through a negative feedback loop. In addition to immigration, wage rates are hypothesized to be influenced by two other endogenous variables: access to financial markets and lowland rice yields. As access to financial markets improves, the cost of capital to the community and its households decreases, thus increasing the marginal return to labor and pushing wage rates up. Similarly, if yields of irrigated rice (a labor-intensive crop) increase, the marginal return to labor used in rice production increases, resulting in an increase in wages.

Lowland rice yields are influenced by four variables. Two of them, improved access to financial markets and wage rates, have already been discussed. We further expect that increases in crop production on upland will reduce incentives for households to intensify rice production, in particular if rice production is more capital and labor-intensive than upland production and if ample opportunities to expand upland continue to exist. The same type of argument can be made for the expected effect of soil fertility of upland on lowland rice yields. If upland soils are fertile and productive, and one can get good harvests on upland, little economic incentive exists for increasing yields of irrigated rice.

We choose to model the access to member-based financial institutions as an endogenous outcome variable for the following reasons. First, as mentioned above, financial institutions that reach smallholders in Madagascar have only been formed during the past 10 years. This is the period of analysis. The placement of financial institutions is driven by a variety of factors that determine directly or indirectly the loan repayment performance or the transaction costs for the financial institution and the client (Sharma and Zeller 1999). Second, as Pitt, Rosenzweig, and Gibbons (1995) demonstrate, failing to correct for the possible nonrandom placement of government programs can result in substantial biases in the estimates of the programs' effects. In the case of Madagascar, one can observe that placement of financial institutions was concentrated mostly in areas with high agricultural potential and above average infrastructure. More particularly, we hypothesize that lowland rice yields are a good indicator of agricultural productivity, and that financial institutions tend to place programs in villages with above-average lowland rice yields in order to increase their performance. There are, as Pitt, Rosenzweig, and Gibbons (1995) argue, other, unobserved variables that determine the placement of programs. In this case, simple ordinary least squares of cross-section data may overestimate or underestimate the effect of access to credit on yields. In order to control for endogenous placement of programs, Pitt, Rosenzweig, and Gibbons (1995) use a fixed-effect model that sweeps out the unobservable characteristics.

The causal diagram in Figure 1 could be further extended by including additional endogenous variables if one would wish to extend the time horizon of the analysis beyond the 10 years considered in this paper. In the very long run, everything is endogenous. We choose to conceive only the six variables shown in Figure 1 to be endogenous during the time span of our analysis. The main reason is that the 10-year period is sufficiently short so that access to public services and infrastructure is not likely to change much because of endogenous processes.

5. ECONOMETRIC MODEL AND ITS RESULTS

With information on endogenous strategies and outcomes at two points in time, the potential biases resulting from unobservable characteristics can be avoided by using a fixed-effect model (Pitt, Rosenzweig, and Gibbons 1995). Figure 1 shows a total of six endogenous variables that depend on each other. To obtain consistent and unbiased estimates, we apply a two-stage least squares model with fixed effects (Greene 1995).[7]

The structural equations of the model are

(1) Participation in financial institutions (Y_1) = f (Y_2, X_i, BANK),

(2) Rice yield (Y_2) = f (Y_1, Y_4, Y_6, X_i, TSTRIZ, PEREAU),

(3) Net immigration rate (Y_3) = f (Y_1, Y_4, X_i, TRANHUMD, MONEYTRA),

(4) Wage rate (Y_4) = f (Y_1, Y_2, X_i, SHARINCO),

[7] The model is estimated with LIMDEP, using a two-way fixed-effects model that, in addition to village-specific fixed effects, measures time-specific effects of the two years, 1987 and 1997 (Greene 1995).

(5) Change in upland (Y_5) = f (Y_1, Y_2, Y_3, Y_4, Y_6, X_i, TSTPAT, A34BACC2, MARKMAN),

(6) Change in soil fertility (Y_6) = f (Y_1, Y_2, Y_5, X_i, CONFLICT),

where X_i is a vector of exogenous variables, and Y_i (for i = 1,2,3,4,5 and 6) are the endogenous variables. For brevity, the variables contained in X_i are only shown in the regression results itself. They have been included in the regression as hypothesized causal determinants of the independent variables, following the conceptual framework outlined in the previous sections. The variables that are explicitly named in above equations serve as instrumenting variables to identify the estimation.[8] The name, definition, mean, median, and standard deviation of all variables used in the regression model are shown in Table 4.

Tables 5–10 list the results of the regressions for each of the six equations (1)–(6), respectively. With very few exceptions, all signs of regression coefficients are as hypothesized. In general, the models for participation in member-based financial institutions (Table 5) and for net immigration (Table 7) have a low adjusted R^2 of 0.15 and 0.16, respectively. The other models have a higher explanatory power with a R–squared ranging from 0.34 (Table 9) for the change in upland to 0.68 for rice yield (Table 6).

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[8] To test whether these instruments are good ones, an F-test was performed to test the joint significance of the instrumental variables in the first-stage regression. The F-statistic is the ratio of the explained variation in the dependent variable and the unexplained variation, adjusted for the number of independent variables. The probability of error resulting from the F-test for the estimated coefficients of the instrumental variables is 0.74 for equation (1) (OUTREACH), 0.07 for equation (2) (rice yield), 0.00 for equation (3) (net immigration RNETIMIG), 0.08 for equation (4) (wage rate), 0.02 for equation (5) (change in upland), and 0.49 for equation (6) (soil fertility).

DETERMINANTS OF COMMUNITY ACCESS TO MEMBER-BASED FINANCIAL INSTITUTIONS

The participation can be perceived as the joint outcome of determinants of supply and demand for financial services. The model estimates these determinants in a reduced form as we are not interested here in studying the formation of financial institutions (Table 5). The regression results indicate that formal market participation significantly increases with higher yields (YLDRICI) in the village and with higher social capital (SOCCAP). The former effect is likely to be a supply-driven one as program managers seek to place institutions in villages with high economic returns so as to improve loan repayment rates. As most credit programs target agricultural enterprises (Zeller 1998), the yields of rice as the major crop can be a good predictor of such returns. The effect of social capital is interpreted as a demand-side effect: social capital encourages and promotes villagers' participation in semi-formal credit groups or cooperative societies. Social capital is measured by the number of informal self-help groups, multiplied by the number of years of their existence during the previous 10 years. Informal group action is expected to benefit participation in other groups since experiences gained in the formation and management of informal groups make it easier for community members to perform similar functions in member-based microfinance institutions. The identifying variable in the regression is the travel time from the village to the nearest bank branch (BANK). Its coefficient has the expected negative sign but is highly insignificant. All credit programs in Madagascar rely to some extent on branches of the commercial or the agricultural banks for depositing savings, and, in many instances, for channeling lending funds from the donor to the village groups. Since the travel time from the village network to the bank influences the transactions costs of the program, and since credit programs are presumably concerned about cost recovery, villages close to a bank branch are found to have a higher chance to obtain access to credit.

We conclude from this regression that villages with higher agricultural productivity seem to be preferred by financial institutions since most of them lend for agricultural and food-processing activities.

DETERMINANTS OF LOWLAND RICE YIELDS

Table 6 shows the results of the regression concerning rice yields. Again, all signs are as expected. Yields significantly increase with improved access to credit (OUTREACH). The coefficient is very robust to alternative specifications of the model, and is significant at the 1 percent level. The direct marginal effect of an increase of 1 percent more households in the village being a member of a microfinance institution raises average lowland rice yields at the community level by 20 kilograms per hectare. This yields an elasticity of lowland rice yields with respect to credit access of 0.069. This translates into an elasticity of 0.07. This positive and significant effect would not occur if capital were not a binding factor in the farm sector of Madagascar. As Zeller (1994) shows, informal and formal lenders alike frequently ration loans, and about half of the rural sample households have been subjected to credit rationing.

The access to fertilizer markets (A34ACC1) has the expected positive effect on lowland rice yields, but is insignificant. When multiplying access to fertilizer (A34ACC1) with access to financial markets (OUTREACH), the interaction term (OUTRFERT) has a negative coefficient significant at the 10 percent level. This implies that the effect of access to credit on yields diminishes at the margin as access to fertilizer markets improves. Similar reasoning holds for the effect of fertilizer when the access to capital markets improves. This result suggests that access to fertilizer dealers acts as a substitute for access to financial institutions, and vice versa. Indeed, fertilizer dealers have been found to advance loans for fertilizer, and obtain repayment when buying the harvest.[9] Moreover, some of the microfinance programs provide credit in kind, mostly in the form of seed and fertilizer.

This finding is in line with the negative, though highly insignificant, coefficient of the change in upland area (CHTAN) and soil fertility of upland (SOILFERT). With higher soil fertility of upland, mostly found in the hillsides and slopes, and a greater possibility of expanding upland, the lower is the incentive to intensify rice production, for example, through investments in improving existing irrigation and drainage systems. Similar results are obtained for the possibility of expanding irrigated lowlands (TSTRIZI). If a community still has additional area that can be terraced for irrigation, the yields of rice are, on average, 95 kilograms per hectare lower than in land-constrained villages. Again, if further land expansion is possible—be it upland or lowland, less incentives for agricultural

[9] On interlinked credit-cum-marketing transactions in rural Madagascar, see Barrett (1997).

intensification exist. These results empirically confirm Boserup's induced innovation model: when land becomes scarce and its opportunity cost rises, rural households and communities seek to adopt technology and alter their institutional arrangements for the management of land in order to increase its productivity and return. As expected, higher wages (WAGERATE) reduce the yield of labor-intensive rice, although the coefficient is insignificant. The elasticity of rice yield with respect to wage rate is measured as 0.12. In summary, the most important determinants of the rice yield are the access to financial markets and the availability of idle land that can be used for expanding cultivation.

DETERMINANTS OF MIGRATION

The dependent variable net immigration (RNETIMIG) is the average annual rate of net immigration into a village over the previous 10 years. Table 7 shows the regression results. As expected, migrants respond to wage differentials, although this relationship is highly insignificant. The elasticity of immigration with respect to wage rates is measured at 1.74, that is, a 1 percent increase in wage rates in a village increases the net immigration rate into this village by 1.74 percent. In contrast, the net immigration rate (with a mean of 0.13 percent per year for all villages) significantly increases by an absolute 0.66 percent if a village has possibility to both expand upland and irrigated lowland (TSTRITA). In other words, villages with ample land have a five times higher net immigration rate compared to villages with constraints for future land expansion. The size of this coefficient shows that rural-to-rural migration is largely driven by the possibility of further expanding the agricultural frontier. The negative coefficient for the distance to grazing areas of cattle (TRANHUMD) supports this finding.

Migrants prefer villages that have lower travel time to institutions for transferring money or sending letters (MONEYTRA). As migrant families maintain their ties with their extended family in the home region, sending and receiving money and letters are important. Each additional hour of travel time to the post office or savings bank significantly reduces the net immigration rate by 0.12 percent. This translates into an elasticity of 7. Controlling for all other factors, migrants seem to prefer villages with higher population density, either at the village (FOKDENS) or at the level of district (*Firaisana*) (POPDENS). While the former is significant at the 20 percent level, the latter is not. Social capital (SOCCAP) has a positive, but insignificant effect on the rate of immigration from the village. With an increasing percentage of households owning less than one hectare of upland, the positive effect of social capital on immigration diminishes (LANDSCAP). In other words, as more virtually landless households live in the village, pressure on idle land presumably increases and a countervailing power against further immigration may begin to gain strength, reducing the positive effect of social capital on immigration at the margin. Just as trade unions seek to protect the wages of their members, the landless class in rural villages may be able to form coalitions and exert political voice that perhaps undermines and works against the interest of the land-rich households for importing cheap labor from other regions.

DETERMINANTS OF RURAL WAGES

An improved access by the community to financial markets (OUTREACH) increases the wage rate, although the estimated coefficient is insignificant. Villages with higher population density (FOKDENS) and higher diversification of income sources (SHARINCO) have significantly higher wage rates. These results appear to be caused by the wage-enhancing effects of increased diversification of the rural economy that comes along with higher population density and, linked with this, lower transaction costs in trade. As can be seen from the regression coefficient (RNETIMIG) in Table 8, rural migration depresses wages in villages that receive migrants and increases wages in villages that sent migrants. This result confirms the previous argument that the landless class in migrant-receiving villages may negatively be affected by migrants and therefore built up political and social coalitions that dampen further immigration. As expected, since most wage laborers perform labor services for agricultural enterprises, improved agricultural productivity—measured by the yields of the major crop (YLDRICI)—increases the wage rate through the increase of the marginal product from labor used in rice production. The elasticity of the wage rate with respect to yields is measured at 0.33.

As expected, the consumer price of rice has a negative effect on the wage rate. Since wages are paid in rice, an increase in the price of rice will result in paying less of physical quantity of rice per labor day, if all other factors are held constant. Finally, with an increased self-sufficiency index of rice (a traditional indicator of prosperity of a village), the wage rate increases (see coefficient for variable AUTORIZ). This positive effect becomes smaller at the margin with an increasing price of rice (PRICAUTR).

DETERMINANTS OF EXPANSION OF UPLAND

Holding everything else constant, the agricultural extensification pathway gains in importance for villages with better access to financial institutions (OUTREACH), with higher wage rates (WAGERATE), and with higher net immigration (RNETIMIG). Less forestland and bushland is taken under cultivation if lowland rice yields are higher (YLDRICI) or if soil fertility of upland is higher (SOILFERT). While the direct effect of access to financial institutions (OUTREACH) on upland expansion is positive but insignificant (an absolute 1 percent more of credit program participants increases upland area by 0.247 percent), the indirect effects of improved credit access through other endogenous variables are negative with the result that credit access actually reduces upland expansion. The indirect effects can be calculated from the regression coefficients for credit access (OUTREACH) on other endogenous variables, multiplied by the regression coefficient of the endogenous variable for upland in Table 9. As this has important policy implications, we discuss these results. From Table 6 we see that credit access improves rice yields. In turn, one additional kilogram of rice reduces upland expansion by 0.026 percent. Assuming constant marginal returns, the indirect effect is a reduction of 0.52 percent of upland area with an absolute 1 percent increase in households participating in member-based credit programs. The indirect effects of credit access on upland expansion, through higher wage rates and higher soil fertility, are 0.017 and –0.106, respectively. The combined effects, both direct and indirect, of a 1 percent increase in the number of households participating in a credit program in the village are then a reduction of 0.36 percent in upland area. Thus, improved access to credit markets promotes agricultural intensification and preserves soils and forests.

The effect of population growth (RNATPOP) on upland area is very small. A 1 percent increase in the mean population growth rate increases upland by only 0.0092 percent. This shows that other factors play a much more important role in explaining expansion. Research in other countries also shows that the effect of population growth on the expansion of cultivated area and resource degradation is mediated through and often overshadowed by pressures arising from changing market, policy, or institutional conditions (Cropper and Griffiths 1994; Foster, Rosenzweig, and Behrman 1997; Jodha 1985).

More land is put under the spate (*angady*), if the villages still possess the possibility to extend its agricultural frontier (TSTPAT). The increase in upland is 16.7 percent higher in such villages. With improved access to markets for non-rice crops (A34BAAC2) that are usually cultivated on upland, the villagers seek to expand their upland area: with an increase by one in the qualitative indicator for access to non-rice markets, the upland area increases by an absolute 19 percent. The positive effect of access to non-rice crop markets significantly diminishes at the margin with a higher consumer price of manioc (MARKMAN). The results further suggest that the expansion of arable land can be slowed down by rural electrification (DELEC). Electricity provides an alternative energy source for the few that currently can afford it. More important, access to electricity enables a range of food processing, trading and off-farm enterprises that increase the demand for labor and offer alternative employment for the poor.

DETERMINANTS OF SOIL FERTILITY OF UPLAND

The descriptive analysis showed that soil fertility has declined over the past 10 years. What caused this degradation? As shown in Table 10, holding all other determinants constant, an increase in upland (CHTAN) significantly reduces soil fertility (SOILFERT). Two effects explain this result. First, as more land is put into cultivation, more and more infertile soils are taken. Second, as the demand for land increases, the time for fallow is reduced, giving upland less and less time to regenerate.

As expected, improved lowland rice yields, that is, agricultural intensification, have a positive effect on soil fertility of upland as higher productivity of lowlands reduces the incentives to mine upland soils. An increase in the index for soil fertility of upland by 0.2 percent is associated with a 1 percent higher yield of lowland rice. The results show that soil fertility can also be enhanced by improving the community's access to financial markets (OUTREACH).[10] Given that rural households in Madagascar face credit

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[10] As Pender and Kerr (1996) point out, improved access to credit (or higher initial liquid assets of the household or village) is not expected to have an effect on conservation investment and soil fertility, if capital markets are perfect, that is, every household can borrow and save as much as it wants at the prevailing market rate. However, empirical evidence leads to the rejection of the assumption of a perfect credit market in rural Madagascar.

constraints, improved access to credit reduces the opportunity costs of capital, leading to lower discount factors or time preference rates when valuing future income streams against current ones. A major hypothesized determinant of the decline in soil fertility is the high time preference rate that poor households use for discounting the value of future use of soils.

A third potential option to preserve soil fertility is to improve access to input markets (ACCINPUT). Yet, the coefficient on this variable is highly insignificant. As was the case for yields, the interaction term (OUTRINPU) between input and credit access is negative and significant, indicating that the two types of access can act as substitutes for each other. Population growth (RNATPOP) and its squared term (PSQRNAT) lead to improved soil fertility, perhaps indicating that as land gets scarcer through population growth, institutional arrangements and response mechanisms can be found to improve soil fertility. However, these results are highly insignificant. More conflicts over grassland and forest resources (CONFLICT) in the village during the previous 10 years are used as an indicator of insecurity of land tenure. As tenure insecurity increases, investment in the maintenance of soils is reduced as the investor cannot be sure to be able to reap the benefits of his or her investment. The sign of the regression coefficient confirms this hypothesis, although the result is not statistically significant. Lower access to school education, reflected by the travel time from the village to primary and secondary schools combined (EDUC), appears to have a negative influence on soil fertility.

Social capital of the village significantly contributes to preserve and maintain soils (SOCCAP). The results confirm the notion that common property management requires collective action, and that collective action, in turn, necessitates social capital. It is further interesting to note that the rice-self sufficiency index in the village (AUTORIZ) has a significant and positive effect on soil fertility, confirming our hypothesis that a high dependency on highly seasonal markets for buying rice increases consumption and production risks that negatively impacts on the overall investment capacity of households. In other words, if one has to rely on uncertain provisions of rice by the market, one wants to reduce this dependency by growing more food even if this is at the expense of soil fertility and future food production. The results suggest that improved access to financial and agricultural input markets can help to preserve soil fertility, and—through the negative effect of soil fertility on change in upland—to slow down the expansion of agriculture into hillsides.

6. CONCLUSIONS

The agendas of environmental sustainability, economic growth, and poverty alleviation are linked: pursuing one without regard of the other two is a pathway to failure in the long run (Vosti and Reardon 1997). Addressing this critical triangle means putting rural households and communities first. The critical triangle—and its specific problems and ramifications in Madagascar—point to one overarching issue that needs to be better understood: what makes households and individuals choose the environmentally more sustainable intensification pathway over the extensification pathway, and how can macroeconomic and sectoral policies and institutional and technological innovations in the financial, agricultural, health, and education sector contribute to make the intensification pathway more attractive in the short and long runs.

The analysis in this paper points to a number of implications for policy and further research. Access to member-based financial institutions, such as credit groups, village banks, or savings and credit cooperative societies, seems to play an important role for enabling an agricultural intensification pathway in Madagascar. We find that access to financial institutions has significant positive effects on lowland rice yields and on soil fertility of upland. However, participation in member-based financial institutions also leads to the expansion of upland, as capital becomes cheaper and more available to farmers. The combined effect of access to financial institutions on upland is the sum of the direct effect on upland change and the indirect effects of credit access through higher yields, higher soil fertility, and higher wages. The sum of all effects shows that increasing the percentage of households participating in a microfinance institution by one percent reduces upland area by 0.36 percent. We conclude therefore that promoting microfinance institutions for rural households can have beneficial effects on agricultural productivity, poverty, and natural resources.

Our research further suggests a positive effect of improved access to markets for rice and agricultural inputs on rice yields, on soil fertility of upland, and on the reduction of newly cultivated hillsides. Yet, improved access to output markets for non-rice crops that are grown on upland seems to lead to an expansion of cultivated upland in the short run. As such market access increases, farmgate prices increase while farmers' transaction costs for selling and buying crops decrease, ultimately pushing up the value of land. Investments in soil conservation will consequently become more economical. Neglecting the build-up of rural infrastructure and markets would only condemn rural villages and households to continue with the low-input, low-output, but land-mining agricultural strategy.

We find that a major incentive for migration is to seek out villages with further possibility for expanding the agricultural frontier. In so far as migrants search for better living conditions, poverty in the villages and regions sending migrants (namely the Faritany of Fianarantsoa) is a driving force for natural resource degradation elsewhere on the island. Thus, alleviation of poverty through improving access to public services, such as schools and health services, enhancement of domestic trade, and generation of off-farm income opportunities has beneficial effects on conservation of soils and natural resources. Our analysis weakly suggests that as land becomes scarcer, conflicts about common property may reduce investments in soil conservation because of tenure insecurity. On the other hand, social capital is found to significantly enhance soil fertility, presumably by enabling villagers to agree on more sustainable property rights regimes.

While the potential of generating employment and income opportunities in Madagascar's rural nonfarm sector should not be underrated, we note that most rural households will have to continue to depend either directly or indirectly on agriculture and related animal production. Agricultural intensification in the major food crops, i.e., rice, cassava, potatoes, and maize, is therefore called for: Madagascar is a country where the Green Revolution still needs to take place. The results strongly suggest a greater role of public policy in improving agricultural productivity on irrigated lowlands and hillside uplands through increases in investments for agricultural research and extension.

Because of lack of data, the analysis could not properly include a number of factors that deserve further research. These include (1) the interdependence between food security, health, and nutritional status and related pathways of rural development, (2) the linkages among livestock, cropping, and off-farm income generation within the household and village economy, (3) the role of (changing) property rights and related determinants and institutional processes of change, and (4) the determinants of formation and maintenance of social capital and of local-level institutions that enhance sustainable use of forest and arable land.

TABLES

Table 1—Indicators of economic growth, poverty and resource degradation: Rice yields, wages for rural laborers, and fertility of upland soil, by region and year

	Majunga: Plaines		Majunga: Plateaux		Fianar: HT		Fianar: Cote/Falaise		Vakinankaratra		All regions	
	1987	1997	1987	1997	1987	1997	1987	1997	1987	1997	1987	1997
Yield irrigated rice	2,664	2,246	1,927	1,470	1,705	1,611	1,475	1,213	1,854	1,852	1,765	1,540
Number of *kapaoka* of rich paid per day worked	9.5	8.5	14.7	8.0	4.2	3.7	6.1	5.0	5.3	6.7	7.6	5.7
Index for change in fertility of upland soil		1.3		1.2		0.3		0.9		0.9		0.8

Source: IFPRI/FOFIFA Community Survey 1997.

Note: The index for soil fertility has the value 2 if no change over the past 10 years. The other values recorded are 3 = improved, 1 = reduced, 0 = severely degraded.

Table 2—Indices of change in area of grassland, forest, arable upland and irrigated lowland during past 10 years

	Majunga Plaines	Majunga Plateaux	Fianar HT	Fianar Cote/Falaise	Vakinankaratra	All regions
Index for increase in *kijana* area 1987 = 100	79.2	86.7	67.5	86.5	84.3	79.9
Index for increase in primary forest area 1987 = 100	83.5	88.5	43.3	73.0	69.8	67.4
Index for increase in secondary forest area 1987 = 100	80.4	79.8	63.2	76.3	67.5	72.0
Index for increase in *tanety* area 1987 = 100	131.6	129.6	134.2	107.3	119.8	124.0
Index for increase in tanimbary area 1987=100	112.6	104.6	105.7	104.0	105.7	105.3

Source: IFPRI/FOFIFA Community Survey 1997.
Note: The figures are indices for which the value 100 was given for the area held in 1987 by the community. For example, an index of 120 implies a 20 percent average increase in the area of the sample villages belonging to a particular region.

Table 3—Participation in microfinance programs and travel time to financial institutions, by region and year

	All regions	
	1987	1997
Rainy season travel time in hours to nearest bank	4.3	4.8
Rainy season travel time in hours to nearest post office or postal savings bank	3.6	4.0
Percent of households participating in credit	0.0	11.4

Source: IFPRI/FOFIFA Community Survey 1997.

Table 4—Descriptive statistics of variables used in regressions (n = 376 from 188 villages)

Name of variable	Definition	Mean	Median	Standard deviation
OUTREACH	Percent of households participating in credit program	5.68	0.00	29.28
RNATPOP	Annual natural population growth rate in percent	3.56	3.45	3.33
RNETIMIG	Net annual immigration rate in village in percent	0.01	0.00	0.87
WAGERATE	Number of *kapoaka* of rice per labor day	6.67	5.00	4.36
CHTAN	Index for increase in *tanety* area 1987 = 100	111.98	100.00	25.55
YLDRICI	Yield irrigated rice	1,652.40	1,500.00	760.22
SOILFERT	Soil fertility change 3=improved, 0=very degraded	1.40	2.00	0.80
ACCINPUT	Mean of indices of access to seven agriculture input markets, 100 = 1987	0.99	1.00	0.26
A34ACCI	Change in access to fertilizer dealers during past 5 years, 1=no change, 0=worse, 2=better	0.92	1.00	0.42
A34BACC2	5 year change in access to other crop buyers, 1=no change, 0 =worse,	1.04	1.00	0.46
MARKRIZ	Interacted term: price of rice * index of access to rice markets	89.43	59.52	78.44
MARKMAN	Interacted term: price of manioc * index of access to nonrice agriculture output markets	96.90	50.91	109.64
BANK	Rainy season travel time in hours to nearest bank	4.54	3.00	6.19
BANKRISK	Interacted term: BANK times number of covariate risks in last 10 years	33.00	0.00	75.13
MONEYTRA	Rainy season travel time in hours to nearest post office or caisse épargne	3.81	2.00	5.25
DELEC	Electricity in village 1=yes, 0=no	0.05	0.00	0.21
EDUC	Rainy season travel time to education institutions	2.09	1.33	2.67
HOSPITAL	Rainy season travel time to hospital or health post	2.11	1.50	2.86
PEREAU	Percent of rice land irrigated	50.01	60.00	37.81
SHARINCO	Share of primary income source in village income	60.43	60.00	16.20
PRIZ	Consumer price of 1 *kapaoka* of white rice	63.30	60.00	38.85
PRICAUTR	Interacted term: price of rice (PRIZ) * rice self-sufficiency index (autoriz)	73.11	50.71	86.79
FOKDENS	Number of people per square kilometers in village	231.19	92.86	496.21
POPDENS	Number of people per square kilometers in *firaisana*	67.43	34.83	103.26
LANDLTI	Number of households in village owning less than 1 hectare of upland (*tanety*)	29.59	20.00	29.93
LANDSCAP	Interacted term: social capital (SOCCAP) with LANDLT1	2,211.52	0.00	14,235.01
SOCCAP	Social capital: number of present informal groups* years of existence	68.24	0.00	360.96
UPLAND	Average upland holding in hectare per household	1.51	1.15	1.20

(continued)

Table 4 (continued**)**

Name of variable	Definition	Mean	Median	Standard deviation
PRICAUTR	Interacted term: price of rice (PRIZ) with LANDLT1	1,945.07	1,000.00	2,677.87
AUTORIZ	Index of rice self-sufficiency of village, 100 = 1987	1.07	1.00	0.41
TSTPAT	Possibility of extension of *tanety* 1=y, 0=n, 1987=1	0.79	1.00	0.41
TSTRIZ	Possibility of extension of rice land 1=y, 0=n, 1987=1	0.75	1.00	0.43
TSTRITA	Interacted term: tstpat*tstriz	0.67	1.00	0.47
CONFLICT	Number of conflicts about grassland/*kijana*	0.15	0.00	0.97
TRANHUMD	Distance in kilometer from village to cattle grazing area	28.35	10.00	34.57
PRICEREL	Consumer price of rice divided by price of manioc	0.80	1.10	1.69
WATPAT	Interacted term: WAGERATE* TSTPAT	5.00	5.62	5.07

Source: IFPRI/FOFIFA 1997 Community Survey.

Note: All descriptive in this and the following tables are weighted averages, using the sampling weights computed for the stratified random sampling frame.

Table 5—Determinants of participation in member-based financial institutions

Variables	Coefficient	Standard error	t-value
YLDRICIR	0.12817E-01	0.71157E-02	1.801**
BANK	-0.21288	0.72728	-0.293
DELEC	15.190	22.492	0.675
SOCCAP	0.18258E-01	0.11007E-01	1.659**
FOKDENS	-0.10264E-01	0.13716E-01	-0.748
LANDLT1	0.20022	0.17806	1.124
LANDSCAP	-0.16480E-03	0.28227E-03	-0.584
Constant	-19.687	13.338	-1.476*

Notes: Dependent variable is OUTREACH with mean of 5.68 and standard deviation of 29.28. Number of observations: 376. Degrees of freedom = 179.
R-squared 0.59 and adjusted R-squared = 0.15.
*, **, and *** indicate significance at the 15 percent, 10 percent, and 5 percent level.

Table 6—Determinants of yields of irrigated rice

Variables	Coefficient	Standard error	t-value
CHTAN	-0.47583	3.5631	-0.134
SOILFERT	-36.605	114.32	-0.320
WAGERATE	-30.095	32.101	-0.938
OUTREACH	20.107	7.6738	2.620***
OUTRFERT	-12.407	6.6113	-1.877**
PRIZ	-3.6858	2.7553	-1.338
MARKRIZ	0.39802	0.94583	0.421
MARKMAN	0.45386E-01	0.46810	0.097
TSTRIZI	-95.094	91.067	-1.044
A34ACC1	136.62	105.60	1.294
PEREAU	2.8289	2.6442	1.070
PRICEREL	83.247	21.707	3.835***
PRICAUTR	-1.1088	1.7382	-0.638
AUTORIZ	-269.62	256.21	-1.052
Constant	2,177.7	588.08	3.703***

Notes: Dependent variable is YLDRICIR with mean of 1,652.40 and standard deviation of 760.22.
Number of observations: 376. Degrees of freedom = 172.
R-squared 0.86 and adjusted R-squared = 0.69.
*, **, and *** indicate significance at the 15 percent, 10 percent, and 5 percent level.

Table 7—Determinants of migration

Variables	Coefficient	Standard error	t-value
WAGERATE	0.17356E-01	0.70694E-01	0.246
WATPAT	-0.87747E-01	0.52580E-01	-1.669**
TSTRITA	0.66022	0.39019	1.692**
HOSPITAL	0.12580	0.85311E-01	1.475*
EDUC	0.38938E-01	0.83788E-01	0.465
MONEYTRA	-0.12592	0.46989E-01	-2.680***
POPDENS	0.13163E-03	0.20789E-02	0.063
TRANHUMD	-0.58849E-03	0.29993E-02	-0.196
SOCCAP	0.36156E-03	0.45638E-03	0.792
LANDSCAP	-0.12310E-04	0.11700E-04	-1.052
FOKDENS	0.84745E-03	0.60349E-03	1.404
Constant	-0.25177	0.59452	-0.423

Notes: Dependent variable is RNETIMIG with mean of -0.07 and standard deviation of 1.21.
Number of observations: 376. Degrees of freedom = 175.
R-squared 0.61 and adjusted R-squared = 0.16.
*, **, and *** indicate significance at the 15 percent, 10 percent, and 5 percent level.

Table 8—Determinants of rural wage rate

Variables	Coefficient	Standard error	t-value
RNETIMIG	-0.45322	0.38361	-1.181
YLDRICIR	0.13507E-02	0.12537E-02	1.077
OUTREACH	0.87814E-02	0.26850E-01	0.327
FOKDENS	0.27656E-02	0.15360E-02	1.801**
PRIZ	-0.21659E-02	0.17181E-01	-0.126
AUTORIZ	2.4720	1.6974	1.456*
PRICAUTR	-0.21634E-01	0.10671E-01	-2.027***
SHARINCO	-0.59400E-01	0.30764E-01	-1.931**
Constant	6.3875	3.5893	1.780**

Notes: Dependent variable is WAGERATE with mean of 6.67 and standard deviation of 4.36.
Number of observations: 376. Degrees of freedom = 178.
R-squared 0.7961 and adjusted R-squared = 0.56.
*, **, and *** indicate significance at the 15 percent, 10 percent, and 5 percent level.

Table 9—Determinants of expansion of arable upland

Variables	Coefficient	Standard error	t-value
YLDRICIR	-0.26405E-01	0.14709E-01	-1.795**
SOILFERT	-14.013	6.3488	-2.207***
WAGERATE	2.0264	1.4973	1.353
RNETIMIG	1.4897	3.2619	0.457
OUTREACH	0.24726	0.24391	1.014
TSTPAT	16.705	5.4775	3.050***
DELEC	-28.826	23.325	-1.236
AUTORIZ	-21.228	14.796	-1.435
PRICAUTR	0.17182	0.87940E-01	1.954**
PRIZ	-0.25321	0.14753	-1.716**
MARKRIZ	0.37519E-01	0.48049E-01	0.781
MARKMAN	-0.12102	0.44332E-01	-2.730***
A34BACC2	19.863	9.5550	2.079***
RNATPOP	0.55790	0.70146	0.795
PNATPAT	-0.41441	1.1443	-0.362
PRICEREL	2.0634	1.3793	1.496*
Constant	159.26	36.857	4.321***

Notes: Dependent variable is CHTAN with mean of 111.98 and standard deviation of 25.55.
Number of observations: 376. Degrees of freedom = 170.
R-squared 0.70 and adjusted R-squared = 0.34.
*, **, and *** indicate significance at the 15 percent, 10 percent, and 5 percent level.

Table 10—Determinants of soil fertility on upland

Variables	Coefficient	Standard error	t-value
CHTAN	-0.82909E-02	0.39462E-02	-2.101
YLDRICIR	0.17701E-03	0.24547E-03	0.721
OUTREACH	0.76829E-02	0.13813E-01	0.556
OUTRINPU	-0.19943E-01	0.12347E-01	-1.615
EDUC -0.41241E-01	0.37853E-01	-1.090	
ACCINPUT	0.59672E-02	0.21238	0.028
CONFLICT	-0.56723E-01	0.54192E-01	-1.047
AUTORIZ	0.35286	0.18792	1.878
RNATPOP	0.23778E-02	0.18927E-01	0.126
PSQRNAT	0.75183E-03	0.15944E-02	0.472
LANDLT1	-0.59350E-02	0.42577E-02	-1.394
FOODPOOR	0.16124E-04	0.28418E-04	0.567
LANDSCAP	-0.68352E-05	0.62478E-05	-1.094
SOCCAP	0.53611E-03	0.29026E-03	1.847
Constant	1.9094	0.73036	2.614

Notes: Dependent variable is SOILFERT with mean of 1.40 and standard deviation of 0.80.
Number of observations: 376. Degrees of freedom = 172.
R-squared 0.77 and adjusted R-squared = 0.50.
*, **, and *** indicate significance at the 15 percent, 10 percent, and 5 percent level.

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