

# The Changing Nature of Agricultural Livelihoods along a Peri-urban to Rural Gradient in Eastern Madagascar

Christoffel den Biggelaar<sup>1,\*</sup>, Maya Moore<sup>2</sup>

<sup>1</sup>Goodnight Family Sustainable Development Dept., Appalachian State University, Boone, NC, USA

<sup>2</sup>Founder and President of Maroantsetra Area Development Association (MADA), Antananarivo, Madagascar

\*Corresponding author: [denbiggelaar@appstate.edu](mailto:denbiggelaar@appstate.edu)

**Abstract** Madagascar is one of the poorest countries in the world, but with high conservation value due to its many unique, endemic species. Rapid population growth and increasing poverty are leading to growing food insecurity and malnutrition especially in rural areas, putting ever more pressure on remaining natural resources. Ecoagriculture is seen as one approach to address these issues, but the success of introducing new practices is contingent on the specific local conditions and situation of individual households reflected in different livelihood strategies. In order to better orient agricultural training and technical assistance provided by the Madagascar Flora and Fauna Group (MFG), a short survey was done in villages in two areas where MFG operates, at different distance from and ease of access to the city of Tamatave: Parc Ivoloïna and the Betampona Integral Nature Reserve. Results show that households in villages around Betampona largely continue to use traditional slash-and-burn methods, with future livelihoods remaining focused on agriculture based on primarily food crop production. Around Parc Ivoloïna, households rely more and more on off-farm and non-farm income made possible by its close proximity to Tamatave. People do farm, but are switching to less labor demanding tree crops and livestock more compatible with off-farm jobs, and to keep ancestral land occupied to provide supplementary food and income. The results confirm that farmers are adaptive resource managers, flexibly redirecting their activities, practices and methods as economic and environmental conditions change or opportunities arise.

**Keywords:** agriculture, rural development, livelihood strategies, madagascar

**Cite This Article:** Christoffel den Biggelaar, and Maya Moore, “The Changing Nature of Agricultural Livelihoods along a Peri-urban to Rural Gradient in Eastern Madagascar.” *American Journal of Rural Development*, vol. 4, no. 2 (2016): 31-42. doi: 10.12691/ajrd-4-2-1.

## 1. Introduction

Madagascar, the world's fourth largest island with a population of 22 million people, is one of the poorest countries in the world. Ninety-two percent of the people live on less than \$2.00 per day, while about 75% experience food insecurity [13]. Production of the major staple crop, rice (which Malagasy eat three times per day, if available) has been decreasing over the last 7 years due to the combined impact of changing weather patterns, advanced soil degradation, decaying irrigation infrastructure, and an outbreak of locusts in the west and southwest of the island. Rice production in 2012/13 declined 18% compared to the average production of the 2007/08 to 2011/12 five-year period [6]. Since the early 1970's, growth in rice production (1% per year) has been much less than annual population growth (2.7%) [18]. The country thus relies increasingly on imports of rice to meet demand, reaching a record 410,000 Mg in 2013 [18]. Very few rural households produce sufficient rice to feed themselves for an entire year leading to growing food insecurity in the country: only 11.3% of rural households were food secure in 2013 [6]. According to [7], the proportion of undernourished people in the country

increased 21% between 1990 and 2014. Rapid population growth, increased poverty and food insecurity put more pressure on Madagascar's natural resources; ecoagriculture is seen as one approach to mitigate food insecurity and protect remaining forests with their plentiful endemic plants and animals.

Changing traditional farming practices is, however, not a straightforward process. As [20] noted, agro-ecosystems have high levels of complexity due to the spatial and temporal variability of the social and ecological resources being used. These systems are characterized by multiple scales of interaction and response, a high frequency of non-linearity, uncertainty and time lags that are opposite to the levels of control and predictability assumed by development assistance [20]. As den Biggelaar had observed working with farmers around Parc Ivoloïna since 2006 (and, earlier, in other African countries), decisions to adopt or not adopt new practices, technologies and methods by individual farmers or households is often dependent on situation, time and circumstances internal and external to the farm. In Madagascar, moreover, farming practices remain tied to traditions laid down by the ancestors. Rural people often employ a 'multiple livelihood strategy' as they can no longer depend solely on farming to feed themselves and ensure a living (if they ever could and did). Livelihood strategy refers to the

particular arrangement of activities and methods to gain a livelihood and food security, chosen and adopted in response to the available biological, physical and economic resources and opportunities in accordance with individual or household goals and preferences. Thus, households may engage in multiple activities involving agricultural production (but perhaps switching to alternative crops and/or livestock for food or cash, either temporarily or permanently); on-farm opportunities outside of production agriculture (value-added processing, crafts, hunting and gathering, petty commerce); or off-farm activities in the formal and especially the informal sectors of the economy. Opportunities for off-farm activities and more market-oriented production, however, may be much more limited in villages further removed from an urban area and/or facing major transportation obstacles. Jacques Dez, a sociologist working in Madagascar during the late colonial period and early years of Independence, already noted the difficulty of changing the traditional practice of tavy (slash-and-burn agriculture) in Eastern Madagascar in absence of good infrastructure to access markets and for the provision and exchange of information on new methods and technologies [4,5,16].

## 2. Methods

To investigate rural livelihood strategies and potential differences therein based on distance from a major urban center and in road infrastructure and accessibility, a survey was done in the Atsinanana region of Eastern Madagascar in two areas in which the Madagascar Flora and Fauna Group (MFG) is active. It was postulated that farmers around Parc Ivoloïna (in the peri-urban area of Tamatave) and in villages around Betampona (in a more distant and difficult to access rural zone) may pursue different activities to ensure their livelihood. Given these differences, agricultural development approaches and activities may have to be different in each location to be locally relevant, feasible, acceptable and affordable. In order to better inform the focus and future direction of Parc Ivoloïna's Model Agriculture Station and its agricultural training and outreach activities, at the Betampona Reserve (Fontsimavo, Ambodirafia, Antananariva and Analamangahazo) and three near Parc Ivoloïna (Vohilava, Ambonivato and Analamalotra) (Figure 1). As local capacity building at all levels of natural resource users is a major goal of MFG, the surveys were administered by the MFG tree nursery operators around Betampona, and a recent graduate (Alain Rasolomampandra) of the University of Toamasina's Natural Resources and Environmental Management Program (GRENE) in the *fokontany* around Parc Ivoloïna.

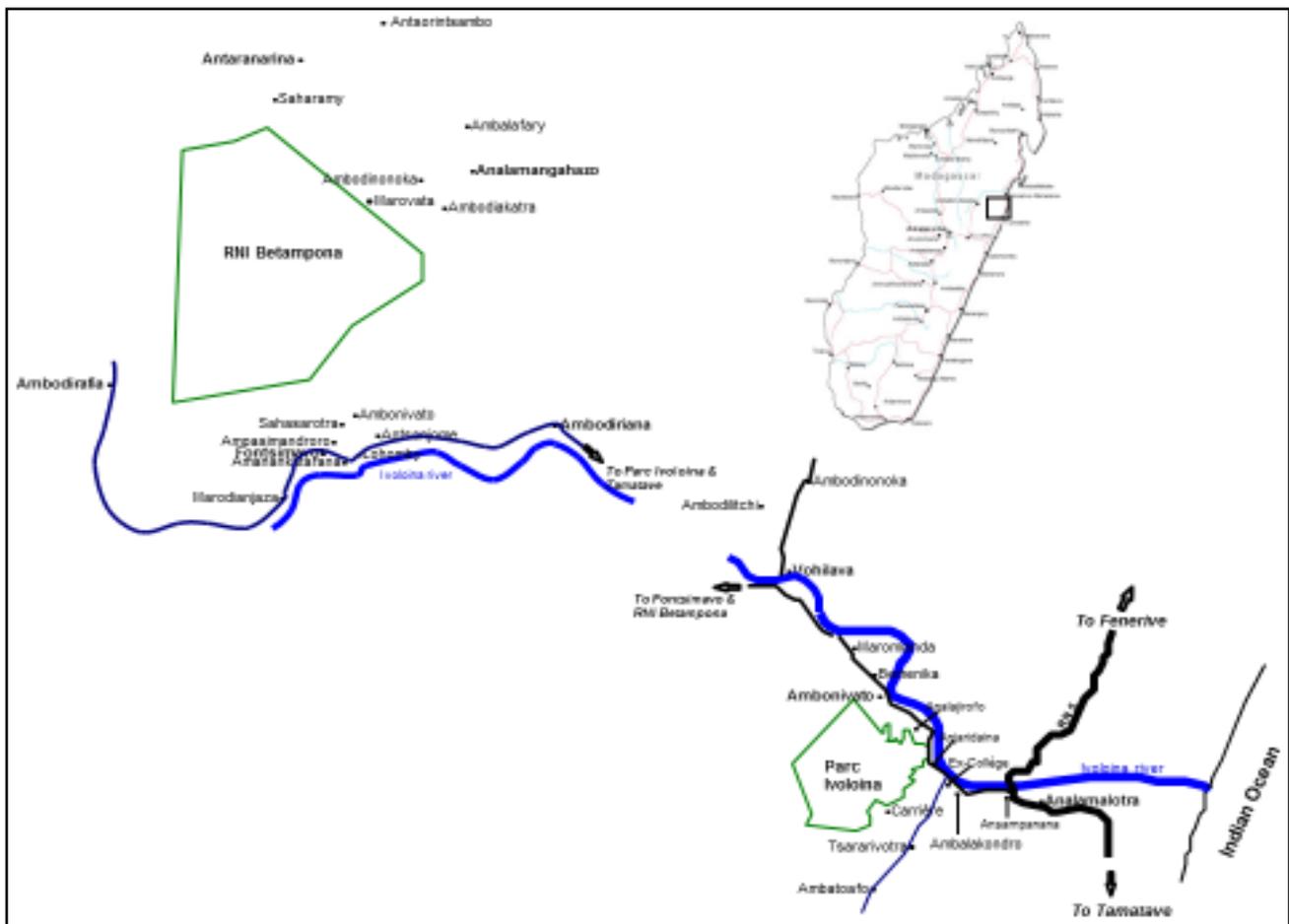


Figure 1. Location of the study area and the villages where surveys were undertaken

The survey instrument consisted of seven questions.<sup>1</sup> The objectives and procedures of the study were explained to the interviewers beforehand; as part of this training, the nursery operators were interviewed using the questionnaire.

Additional explanations were provided to clarify the questions if needed. Data were entered and analyzed in Excel; open-ended questions were entered into Word,

which local staff of MFG at Parc Ivoloïna helped translate from Malagasy into French.

Survey results and data analysis were supplemented by field observations and one-on-one discussions with farmers during an October 2013 visit to the affected villages around Betampona, and with MFG staff and representatives of other organizations made during annual visits to Parc Ivoloïna by den Biggelaar over an eight year period prior to the survey.

### 3. Study Area

The MFG is an association of zoos and botanical gardens undertaking joint conservation activities in the Atsinanana region on the east coast of Madagascar since 1987. MFG manages the 272 ha Parc Ivoloïna Zoo and Forestry Station 12 km northwest of the city of Tamatave, as well as (in collaboration with Madagascar National Parks) the 2,228 ha Betampona Integral Natural Reserve situated 40 km further to the northwest of Parc Ivoloïna. The road toward Betampona used to be paved as far as Sahambala, as (during colonial times) there were many expatriate farms (mostly run by planters from Mauritius and Reunion) producing export crops such as coffee, cloves, vanilla, black pepper, bananas and sugar cane. After Independence, these plantations were nationalized or abandoned, and with it the production and economic fortunes of the area declined. Due to a lack of maintenance very little pavement is presently left; that, and the destruction of a major bridge in a cyclone in 2003, makes a trip that once took about 1.5 hours in 1990 an ordeal taking as much as 5-6 hours now. Villages around the reserve can only be reached by small footpaths; the *fokontany* of Analamangahazo and Antananarina are the most isolated but also in closest proximity to the primary forest of the Betampona Reserve.

Given that slash-and-burn agriculture, the dominant land use in the region, and growing food insecurity directly impact conservation, MFG initiated the Model Agriculture Station [MAS] at Parc Ivoloïna in 2003 to help farmers improve their methods to increase food production. MAS activities involved demonstration of and training on improved agronomic practices to local leaders, farmers and school children. Since 2007, a more regular schedule of farmer training and applied research was initiated focusing on SRI (système de riziculture intensive), organic vegetable and fruit production, composting, and rehabilitating degraded soils to put them back into production. A farmer-leader<sup>2</sup> program was started in 2010 to extend demonstration sites for composting and organic vegetable production to the *fokontany* around Parc Ivoloïna.

Outreach and development activities to communities around RNI Betampona were more limited until 2007. In that year, MFG partnered with Madagascar National Parks and local communities to reforest a 100 meter wide buffer zone around the Reserve<sup>3</sup>. To produce the necessary seedlings (primarily of native species), permanent tree nurseries were established in the communities concerned (Antananarina and Ambodirafia in 2007; Analamangahazo and Fontsimavo in 2009). Participants planted trees on land customarily owned by them both within and outside the buffer zone; both the land and the trees remain their property according to a contract signed by participating

farmers, MFG and MNP. As an incentive to planting trees, between 2008 and 2012 farmers were given clove seedlings (one clove tree for 2 native seedlings); they preferred this species as it does well on marginal soil on sloping land [22], and both cloves and clove oil presently demand high prices on the world market. However, steam distillation of the essential oil from the clove leaves demands a lot of firewood which could lead to excessive tree cutting, potentially negating much of the reforestation efforts [17]. The forest restoration project discontinued handing out clove seedlings in 2012, and used a series of focus groups with participants in July of that year to develop a new incentive program for the 2013 tree planting season onwards. Given increasing food shortages due to irregular weather patterns and pest outbreaks, the incentives are aimed at helping farmers improve their food crop and livestock production practices. However, a major factor that may influence expanded agricultural development assistance is the difficult accessibility of the villages around the reserve.

### 4. Results

A total of 139 usable surveys were collected from the seven *fokontany*; 21 in Fontsimavo (but one was incomplete), and 19 surveys were completed in Antananarina. As per instructions given to interviewers (all men), respondents were chosen randomly from different '*carreaux*' (neighborhoods) of each *fokontany*; no attempt was made to stratify the sample according to population size of each *carreau*, gender or wealth.

Nearly two-thirds of the respondents were men. Respondents' average age was 41.7 for men and 43.3 for women, with a good representation of both younger and older persons of both sexes in each *fokontany*. In some *fokontany*, the sample included widows and single (often younger) men and women.

**Table 1. Activities That Respondents and Their Spouses Are Engaged in to Earn a Living (Up to Three Responses per Spouse Were Recorded)**

		Antananarina	Ambodirafia	Analamangahazo	Fontsimavo	Vohilava	Ambonivato	Analamalotra
Agriculture	M	9	17	19	19	13	12	15
	F	17	17	19	19	17	13	16
Petty commerce	M		1		1	2	2	
	F	2	3		6	4	9	7
Salaried work	M		2			2	4	9
	F					1	2	6
Temporary labor	M				1	9	8	
	F					9	8	5
Fishery, timber	M		1					1
Basketry	F					1	1	
Skilled trades	M		1			6	2	3
Rock mining	M		1				5	
	F						6	
Sand mining	M						3	5
	F							3

In the *fokontany* around the Betampona Reserve, the chief occupation of respondents and their spouses is in agriculture (Table 1). For women, an important, mostly secondary, source of income is running a small grocery store or *hotely* (snack bar selling fried dough balls, noodles with sauce, drinks, etc.). In Ambodirafia, two men had salaried jobs as teachers, while several did small incidental work in construction trades, fishing, and rock breaking.

In the three *fokontany* around Ivoloïna, agriculture remains an important activity, even though off-farm activities are more diversified than around Betampona and are often the main source of income.<sup>4</sup> Salaried income (as teachers, Parc Ivoloïna staff, night guards, ...), temporary employment as day laborers, and work in informal mining (digging sand from the riverbed, digging rocks from the hills and breaking them into gravel) supports many families. Mining is especially important to many migrant families, as they do not own or have access to farmland and thus are completely dependent on income from non-farm activities. In spite of the economic downturn since the coup d'état in 2009, demand for sand and gravel has remained strong due to a building boom in and around Tamatave likely stimulated by the Ambatovy nickel/cobalt mine, the expansion of port facilities and other infrastructure projects, and the building of warehouses and processing operations for litchis and cloves. To service the miners, small grocery stores and snack bars have also increased in number over the last few years, and provide good income opportunities, especially for women, in the *fokontany* of Analamalotra and Ambonivato. In spite of many respondents having off-farm employment and sources of income, respondents indicated that they continue farming to provide food and extra cash, important as wages are often insufficient to support a family. Additionally, it is important to keep farming (in spite of often low yields) to maintain one's claim to the family (lineage) land. Although there are a few (by Malagasy standards, very large) farmers (owning 10-20 ha) who do have formal titles to their land, most land is not legally titled and is held in customary usufruct with 'ownership' residing in the lineage based on land originally settled and farmed by the ancestors (*tanindrazana*).

Vohilava is in a more transitional situation. The *fokontany* is much more agriculturally oriented than Ambonivato or Analamalotra, although (being in Tamatave's urban periphery) does offer temporary employment opportunities as day or seasonal laborers (ex., during litchi harvest). As Vohilava is located across the Ivoloïna River (but reachable with a small ferry-boat), there is less opportunity in mining or small commerce as it does not benefit from the gravel and sand buying traffic or the heavy commercial traffic to the major market centers of Tamatave, or Ambodiriana and Sahambala near the Betampona Reserve.

#### 4.1. Amount and Type of Land Cultivated

Given the continued importance of agriculture, the survey asked some questions about the size and type of respondents' agricultural fields. Field types were grouped into three categories: *tavy* (slash-and-burn) fields; *horaka* (irrigated rice paddies located in marshy valleys); and

home gardens. While the words *tavy* and *horaka* are well defined and recognized, the word for home garden (*zaridainam-pianakaviana* provided by Mr. Gimod) was mostly unknown. Farmers around Ivoloïna seemed more familiar with the term 'abanotrano' (area around the house), whereas those around Betampona used the word 'tsabo' (more or less equivalent to orchard). From observations over the years that I worked at Parc Ivoloïna, I had noted that home gardens as commonly understood by agroforesters<sup>5</sup> are more common in the urban periphery than in rural villages more distant from urban areas. As a result of population pressure and for reasons of security, farmers moved valuable crops (tree foods, coffee, spices, medicinals, vegetables) to their home compound. In more rural areas, permanent crops mostly resided in the *tsabo*, often land around abandoned homesteads located some distance away from the present, more nuclear village.

The second remark concerns the issue of size. While some farmers have a good ability to estimate the approximate size of their fields, others gave the size of their *tavy* and *horaka* fields in terms of *kapaoka* or *vatra* of rice planted. A *kapaoka* is an empty can of sweetened, condensed milk and contains about 200 grams of seed rice; a *vatra*, an empty cooking oil can of 5 liters, equals 80 *kapaoka*. Using the traditional methods, it takes one *vatra* of seed rice to plant one hectare of *tavy* land. *Horaka* rice starts out in a nursery bed and is typically transplanted after eight weeks; inquiries revealed a wide range in the amount of seed used but, on average, farmers use about the same amount of seed rice per hectare in *tavy* and *horaka* fields, i.e., one *kapaoka* provides sufficient transplants for a paddy field of 125 m<sup>2</sup>.<sup>6</sup>

Almost all farmers (80-85%) around Betampona continue to practice *tavy* (Table 2). Most clear one field each year, but several households clear more than one; on average, households have 1.15 *tavy* fields with a mean size of 1.25 ha (ranging from a mean of 1.08 ha in Fontsimavo to 1.47 ha in Ambodirafia). Fewer farmers near Parc Ivoloïna have *tavy* fields at present, especially in Ambonivato (25%) and Analamalotra (35%); in Vohilava, 70% of farmers have *tavy* fields. *Tavy* was much more common in both Ambonivato and Analamalotra a few years ago (as observed by the author), but farmers are increasingly abandoning the practice as the advanced stage of soil degradation no longer makes it worth the effort of clearing and planting rice.

*Imperata cylindrical (tenina)* is also increasingly taking over the terrain after years of *tavy* with shorter and shorter fallow periods, in the last decades reduced to just 2-4 years. Mean *tavy* field size in the Ivoloïna area is slightly lower than around Betampona (1.08 ha), ranging from 0.62 ha in Ambonivato to 1.6 ha in Analamalotra. This field size may, therefore, be a more or less optimal size that a household can manage with available labor and occasional rotating work parties (*lampona* or *fampilatanana*) at peak periods, and perhaps also reflects the field size the ancestors determined to be needed to feed one's family.

More and more, farmers are turning to irrigated paddy rice production if they have access to valley land; 65% (in Ambonivato) to 100% (in Antananarivo) of respondents cultivate paddy fields. The percentage is lower in Ambonivato, where the largest valley marshes were taken over by the French colonial administration for a *Jardin*

*d'Essais* in 1897; the original 250 ha of land grew to nearly 700 ha by 1950. The land still belongs formally to various government institutions (FOFIFA; Ministry of Ecology, Environment and Forests; University of Toamasina), although some of it is used by employees and family members of these institutions (most of the remainder of valley land of FOFIFA is being used for experiments initiated in the 1950's and 1960's but now in different stages of abandonment). Most farmers own and farm a few small plots of valley land for irrigated rice production, but in all *fokontany* there are a few farmers who have large to very large holdings in the valleys (1-5 ha), making the average size of *horaka* land appear much greater than it is for the majority of farmers.

Fontsimavo and Analamalotra reporting such fields with permanent crops. In the other *fokontany*, 50-60% of farmers do. Permanent crop fields are generally small, about 0.03 ha in Analamangahazo and Ambodirafia, and around 0.15 ha in Ambonivato, Vohilava and Fontsimavo. In Antananarina, *tsabo* are an average of 0.85 ha; the average is higher in Analamalotra (1.46 ha), but the number is strongly skewed by two farmers with 14 ha and 2 ha of permanent crops, respectively.

### 4.2. Permanent (Tree) Crops

More telling than the estimated size of home gardens is the species composition and diversity. Around Ivoloïna, home gardens contain on average 15 species, more than twice the average number of 6.5 species found in such fields in the *fokontany* around Betampona (Table 3). The greater species diversity can be explained by better access to markets (being closer to Tamatave), as well as the change from annual field crops to more permanent tree crops which are easier to combine with non-farm and off-farm employment opportunities.<sup>7</sup>

The most common cash crops around Betampona are coffee (produced by 76% of farmers with an average of 76 trees), cloves (86% of respondents with a mean of 58 trees), bananas (85% of respondents, mean of 49 stems), and litchi (94% of respondents, mean of 10 trees) (Table 3). Six respondents in Analamangahazo and seven in Fontsimavo reported growing pineapples, with a mean of 708 and 90 plants, respectively. The high number of respondents growing clove trees, and the high average numbers of this species, may be due to the historical importance of cloves in the area as well as the forest restoration project concentrated in the four *fokontany* around Betampona (which provided free clove trees to farmers as an incentive to participate).

**Table 2. Type and Size of Different Fields (1 are = 0.01 ha)**

		Antananarina	Ambodirafia	Analamangahazo	Fontsimavo	Vohilava	Ambonivato	Analamalotra
Tavy	N	17	17	17	16	43	5	7
	# fields	1.1	1.3	1.2	1	1.1	1.4	1.4
	Surface (are)	118	146	128	109	103	62.2	160
Horaka	N	19	16	16	17	18	13	16
	# fields	1.7	1.6	1.3	2	12.3	9	10.7
	Surface (are)	8.6	65.7	21.6	47	88	18.6	39.8
Tsabo	N	12	8	10	7	13	10	8
	# fields	1.5	1	1	1	1.1	1.1	1.3
	Surface (are)	85.5	2.9	2.5	13.1	16.4	15.8	146

Home gardens and *tsabo* are less common field types, with fewer than half the respondents in Ambodirafia,

**Table 3. Most Common Permanent Cash Crops Grown in the Study Areas (Number of Farmers Growing)**

	Antananarina	Ambodirafia	Analamangahazo	Fontsimavo	Vohilava	Ambonivato	Analamalotra
# spp grown	7	6	7	6	16	15	14
Coffee	56.7 (15)	68.0 (15)	78.7 (14)	91.1 (18)	31.9 (8)	31.4 (8)	39.2 (15)
Litchi	15.6 (19)	7.1 (17)	5.5 (20)	12.3 (20)	11.7 (15)	8.5 (11)	49.8 (17)
Clove	42.7 (18)	97.3 (15)	61.4 (20)	29.8 (17)	6.0 (2)	10.3 (3)	31.8 (15)
Banana	45.3 (17)	60.5 (18)	42.9 (18)	48.3 (16)	126.2 (17)	76.8 (12)	20.4 (18)
Bread fruit	5.0 (1)		11.3 (6)	2.5 (11)	11.0 (3)	15.3 (4)	
Jack fruit					17.6 (7)	20.0 (4)	6.5 (2)
Corossol					4.4 (7)	44.0 (6)	21 (3)
Coconut					6.0 (1)	4.0 (3)	15.8 (6)
Pineapple			708.3 (6)	90.0 (7)			25.0 (1)

Around Ivoloïna, bananas are the most important permanent crop; they are grown by 78% of respondents having a mean of 74 stems. Litchi are grown by 72% of respondents, who cultivate a mean of 24 trees, followed by coffee (50% of respondents, mean of 34 trees) and cloves (33% of respondents, mean of 16 trees, although most clove trees are located in Analamalotra where they are grown by 75% of respondents having on average 32 trees). Other fruit species commonly found include jackfruit, bread fruit, corossol (soursop) and coconut. The size of the permanent crop fields appears, at least for some farmers, to be incongruous with the number of trees they

report owning. At times, tree crops are not planted in dedicated fields for such permanent crops, but may be isolated or grouped in small plots on the edge of *tavy* fields.

### 4.3. Livestock

Chickens are the most common livestock kept by respondents. They are kept by 85% of respondents around Betampona, with an average flock size of about 16 birds; for the Ivoloïna area, these numbers are 72% and 12 birds. Ducks were kept by 34% of respondents around Ivoloïna

with a mean of 4 birds, and 37.5% of respondents near Betampona with 4.3 birds.

Around Betampona, 25% of respondents had an average of three zebu, while around Ivoloïna, only 18% of respondents do, with a mean of 2.3 zebu. Pigs are kept by 27.5% of Betampona respondents, who have a mean of 3.3 pigs; only one in eight farmers around Ivoloïna keep a mean of 1.7 pigs. Only one respondent (in Antananarina) reported having a single beehive, and two farmers in Ambodirafia have fishponds. Geese are kept by few farmers, but were more common in Antananarina and Analamangahazo where three and six farmers, respectively, keep a flock of around five geese. Poultry run free throughout the village while pigs and zebu are tied up near the village to forage during the day; all animals are secured near the home for the night.

#### 4.4. Time Devoted to Agriculture

Much of life and work in Madagascar is traditionally governed by *fady* (commonly translated as taboos, but according to Richardson and Cousins (1886), the word also means “abstinence, fasting, prohibition; unlawfulness, incest”).

Among the Betsimisaraka (the dominant ethnic group in the study area), a common *fady* is to not work one’s rice fields on Tuesday and Thursday. In times past, this interdiction affected only work in *tavy* rice fields but, presently, some farmers apply the rule also to *horaka* rice and agricultural work in general. However, not all farmers respect the rule, as some respondents indicated that they work 5-6 days per week on agricultural tasks although they may abstain from working in the rice fields on Tuesday and Thursday. In general, men and women work a more or less equal number of days/week in agriculture; fewer children are engaged in agricultural activities and on fewer days/week. Many respondents indicated that their children go to school, and only help out with farm tasks during vacations and holidays. Adults in Antananarina indicated that they spend the most days/week on farming tasks (5.6 and 5.1 for men and women, respectively), and farmers in Analamangahazo the least (2.8 and 3.3 days/week, respectively).

Around Ivoloïna, respondents and their spouses work a mean of 4.1 days/week in agriculture, despite being engaged in non-farm and off-farm activities. While such activities do provide income, it is rarely enough to meet household needs for food and other necessities. Thus, farming remains essential to meet the needs for food and to provide additional cash for other needs even for those with regular salaried jobs. People with off-farm and non-farm jobs often do farm work before or after their regular job, or on their days off.

It should be noted that workdays may also not be 8 hour days - how many hours people work each day and the number of days of farm work per week may fluctuate during the year depending on the tasks at hand. There are labor peaks during the time of land preparation, weeding and harvesting. In general, the busiest agricultural period of the year is the time of preparing *tavy* and *horaka* fields and the planting of the rice (roughly, between October and December), whereas during the low labor period (June-September) farm work consists chiefly of vegetable production and maintenance of orchards.

#### 4.5. Household Food Security and Strategies to Attain It

As stated in the introduction, rice is the major staple food of Madagascar. In this study, only 11.5% of respondents indicated that they produced sufficient rice to feed their family for the entire year. The vast majority (80%) stated that they produce only enough to feed their families for (on average) about 4.3 months (the remaining 8.5% did not answer the question). The higher ‘no response’ numbers in Ambonivato and Analamalotra were from respondents that migrated to the area from Southern Madagascar and working as watchmen on absentee-owner farms, where they are only allowed to grow cassava using ‘*kapa-kapa*’ methods (land preparation without fire); the question was therefore not relevant to them.

So, what do households do to make up the rice deficit? The different activities and options indicated by respondents reveal clear differences in strategies pursued due to differential access to markets and off-farm employment opportunities. In the *fokontany* around Betampona, respondents’ most important strategy is to intensify and expand agricultural production of both food and cash crops, followed by seeking temporary work as day laborers on farms of others in the area (Table 5). Around Ivoloïna, less than 25% of respondents see increased agricultural production as a solution and, if they do, they wish to do so primarily by expanding cash crop production. In addition, more non-agricultural options are available such as sand and gravel mining, small restaurants and grocery stores, and various types of salaried employment in Tamatave (grouped under “other” in Table 4). Such off-farm options are much more limited around Betampona; small groceries do make sense to provide people basic necessities (soap, cooking oil, sugar, salt and other things they do not produce themselves), but there is a limited demand for these or for small restaurants in the absence of any markets in the *fokontany* surveyed; nor is there any tourism, and the local population has little expandable cash.

Table 4. Household Strategies to Address Rice Production Deficits

		Antananarina	Ambodirafia	Analamangahazo	Fontsinavo	Vohilava	Ambonivato	Analamalotra
Seek temporary work	In town	1	1	1				
	With other farmers	6 6	10	10	1	6		
Dig up/collect sand							2	2
Mine and break rocks			1				3	
Charcoal making			1		1	4		1
Portering goods				3				
Run a small snackbar		1	1	1		2	4	2
Run a small grocery		1	3	6	3	3	3	2
Plant other crops	For food	17	14	19	16	1	4	
	For cash	18	15	19	18	5	3	2
Other			1		1	8	4	7

Respondents were further asked to specify which food and/or cash crops they planned on expanding as a way to improve their food and income security. Around Betampona, cassava was mentioned most often (mean of 87.5% of respondents), followed by sweet potatoes (45%), maize (42.5%) and rice (37.5%). Cassava was the most important alternative in all four Betampona *fokontany*, but there were some differences in preferences for the other crops between *fokontany*. As for cash crops, preferences were for coffee (53.8%), clove (50%), litchi (45%), and bananas (41.3%). Around Ivoloïna, few respondents specified the type of alternative crops they were interested in to address rice production shortfalls (but perhaps the interviewer didn't ask respondents specifically). Seven respondents indicated that they wanted to increase the production of bananas, while two respondents (one each in Vohilava and Analamalotra) plan to add litchi trees.

#### 4.6. Response to Unexpected Events

Given that many rural households experience chronic or temporary, seasonal food insecurity, any unexpected events can have serious impacts on food and economic security. Such events include cyclones, which can cause flooding and landslides and damage from powerful winds; accidents; illness and deaths; animal and crop diseases; and uncertain and fluctuating market prices. We asked respondents about strategies they use to cope with these events and emergencies, giving examples of these as a sub-note to the question. Interviewers sometimes listed these examples when posing the question, but in some cases did not. Thus, responses in some cases referred only to farmers' responses to cyclones (in Fontsimavo, where 12 persons responded "repair damage to homes and fields quickly"), in other cases to family or animal emergencies (disease and mortality), or were more general in nature. In Ambodirafia, no one responded to the question, but perhaps interviewers omitted the question during survey administration. Table 5 groups all answers for the different types of emergencies together.<sup>8</sup>

**Table 5. Household Strategies to Deal with Emergencies and Unexpected Events**

	Antananarina	Ambodirafia	Analamangahazo	Fontsimavo	Vohilava	Ambonivato	Analamalotra
Seek off-farm work	14	4			1		1
Ask aid from family	6	2			8	2	4
Ask aid from friends or neighbors	3				2	2	3
Ask aid from village committee or association		1					1
Ask salary advance							4
Borrow money (from family, friends, neighbors)	10	13				3	
Borrow money at OTIV							1
Borrow rice	1	1					
Sell crops						2	
Sell household items	4						
Sell livestock	3	3				2	
Rock mining						1	
Nothing						7	2

The results show that farmers pursue different approaches to deal with emergencies in the *fokontany* around Betampona compared to those around Ivoloïna. In Antananarina, Analamangahazo, and to a lesser extent, Vohilava, people depend more on kin networks and family and friends in case of need, either to ask for material assistance or to borrow money (*troso*). In Antananarina, many respondents also indicated that they would seek temporary employment on other farms in villages not affected, or in town to ensure some income to feed the family; others would engage in self-employed non-farm work such as making and selling charcoal or mining and breaking rocks into gravel. Around Ivoloïna, fewer people borrowed money from family or friends, and more would rely on their own savings or would ask their employer for an advance (those who have regular, salaried, jobs). One person indicated borrowing at the OTIV (rural savings cooperative).

Selling off crops and especially livestock is done by some, but for a few in Antananarina without any livestock to sell, selling household items (pots, pans, or furniture) was mentioned as a strategy. Farmers in Analamangahazo stated doing emergency slaughter of diseased livestock (before they die) and selling the meat quickly, often at below normal meat prices. Discussions with farmers during a visit to the villages around Betampona at the start of this survey revealed that this is a common practice to at least recuperate some money from the animals.

#### 4.7. Future Livelihood Strategy

Lastly, respondents were asked to indicate what approach they consider the best way to assure a livelihood in the future. Respondents were given four options (concentrate on food crops; concentrate on cash crops; concentrate on livestock; or seek employment outside of agriculture), but could choose more than one answer which many did. The question was included to give a better indication about whether or not people around Betampona and Ivoloïna see a future in agriculture, and, if so, what type of agriculture.

**Table 6. Households Future Livelihood Strategies**

	Intensify food crop production	Intensify cash crop production	Intensify livestock production	Seek work outside agriculture
Antananarina	19	12	18	2
Ambodirafia	18	10	8	16
Analamangahazo	19	19	5	
Fontsimavo	19	14	6	6
Vohilava	2	12	7	5
Ambonivato	5	4	14	7
Analamalotra	8	4	4	8

Results are provided in Table 6. Nearly all farmers around Betampona continue to see a future in agriculture with a mix of food crops, cash crops and livestock. However, the emphasis on the latter varied between *fokontany*, with livestock more important in Antananarina, and cash crops in the other three *fokontany*. Sixteen out of 20 respondents in Ambodirafia indicated off-farm work as their second choice, even though food crop production remains important to them. The reason for this is not entirely clear, as there are few options within the *fokontany* or Sahambala *commune* for off-farm work. Around Ivoloïna, the picture is more mixed, but generally,

interest in food crop cultivation is low (less than 50% of respondents in each *fokontany*). Responses also were more single strategy oriented (1.2-1.5 choices/household) compared to Betampona (2.1 to 2.7 choices/household). Households in Vohilava are most interested in cash crops, followed by livestock production; in Ambonivato, 70% are interested in livestock and 35% in off-farm employment.

## 5. Discussion

During the September through December 2013 period the first author (on sabbatical at Parc Ivoloïna) was surprised to see so few *tavy* fields being prepared during hikes around the park compared to what was observed in past years. People were working to clear the meager vegetation, but primarily, the fields were being planted with cassava rather than rice. When survey respondents around Ivoloïna were asked why they were no longer practicing *tavy*, the answer often was that it was no longer worthwhile to bother planting rice - advanced soil degradation and competition from *tenina* (*Imperata cylindrica*) made harvests too low to recoup one's investment in seed and labor. What is surprising is that the *tavy* method of rice production has not collapsed sooner, as reports from French scientists in the early 1960's mentioned that even at that time, fallow periods averaged 3-5 years and soil degradation was already well advanced [3,10].

Several factors may have mitigated the impact of advancing land degradation and the decline in production of staple crops (especially rice) on the local economy around Ivoloïna, which can be summarized as follows:

- The development of alternative off-farm income opportunities locally (temporary and permanent employment at Parc Ivoloïna; basalt mining and its transformation into gravel; the mining of sand from the Ivoloïna river for the construction industry; and charcoal production for the market in Tamatave).
- In spite of the economic downturn in Madagascar since the coup in February 2009, demand for gravel and sand increased due to a building boom in Tamatave that continues to this day.
- Various jobs (permanent, temporary and seasonal) in nearby Tamatave as watchmen, laborers, factory or construction workers and in petty commerce.
- Increasing demand for local fruits and vegetables in city markets in Tamatave, as produce from the central highlands is becoming expensive due to rising fuel prices resulting in higher transport costs, and unusually high winter rainfall around Antananarivo flooding paddy fields where vegetables are grown during that season. This creates opportunities for cultivation of these crops within or close to the villages around Parc Ivoloïna for sale locally and in Tamatave.

Opportunities for off-farm income are very limited in the villages around Betampona, and agriculture remains the dominant means of livelihood. Despite it being illegal, *tavy* is still widely practiced, as evidenced by the many smoke columns, slashed and recently burned fields observed during author's visit to the area in mid-October

2013 to initiate the survey. At times, one wondered why farmers had cleared and burned certain fields, given the very steep slopes and/or the high percentage of fields occupied by rocks and boulders (Fig. 2).



**Figure 2.** A recently cleared field of rocks near Ambodirafia, Oct. 2013 (Photo C. den Biggelaar)

A second observation during the visit concerned people's response to growing food insecurity and longer periods of '*soudure*' (period of food shortages between harvests), estimated by [6] at eight months on average for Atsinanana due to structurally insufficient agricultural production. Although *tavy* rice is (was) traditionally planted at the start of the long rainy season (i.e., late November through December), we noted several fields with rice that was planted after the heavy rains (about 135 mm) in the first three days of October 2013. Other fields were in the process of being planted in mid-October, but it is not sure how well any of these early-planted fields fared during the unusually long hot dry spell between October 4 and November 24, 2013 (with only 25 mm of rain in this period on October 29) (Figure 3).



**Figure 3.** Tavy field about 7 km North of Ambodirafia, Oct 19, 2013. Based on size, rice and corn were planted about 10-14 days earlier, probably right after the unusually heavy rains in the first four days of that month (Photo C. den Biggelaar)

Increasing population and declining yields related to advancing soil degradation due to shorter fallow periods and increasing pest problems contribute to growing food insecurity even in the very rural, predominantly farming communities around Betampona. The need for food is forcing farmers to start planting earlier in spite of increasingly uncertain and irregular rainfall patterns. The early planting of *tavy* fields may be an act of desperation rather than a deliberate strategy to increase production, as there is a greater chance of crop failure thus increasing food shortages.

Irrigated paddy rice production counter-seasonally has been practiced for many years on marshy valley bottoms,

but we observed many newly made terraces on toe- and mid-slopes (similar to those of the Betsileo in the central highlands of Madagascar) in several villages (Figure 4). These terraces were being irrigated by small streams and springs higher up on the slopes, and the production from these paddies may provide a welcome addition to a family's food supply. It is not known how well these terraces will hold up to the heavy rains in the January to April period. Terraced irrigated rice production as is common in the Highlands is the stock solution provided by researchers of FOFIFA and staff of the regional office of the Ministry of Agriculture (see, for example, Hume 2005) to increase rice production around Tamatave, but there is no evidence that such terraces are technically possible on the soils, steep slopes and the high rainfall of the Atsinanana region. It is also less of a solution for farmers around Ivoloïna, where there are few (or no longer any) streams and springs that can provide sufficient irrigation water for such counter-season rice production. The irrigation infrastructure that once existed around Ivoloïna has largely fallen in disrepair and is no longer usable.



**Figure 4.** A terraced rice field between Antananarina and Analamangahazo, Oct. 2013 (Photo C. den Biggelaar)

An unintended consequence of the more irregular planting of *tavy* fields and counter-seasonal paddy rice may be an increase in rice pests, particularly cutworms (*Spodoptera spp.*) and stems borers (*Maliarpha separata* ['borer blanc'] and *Sesamia calamistis* ['borer rose']), diminishing yields considerably [1]. As rice planting is now being produced more or less year-round, it offers greater opportunity for multiple generations of moths to develop, thereby increasing damage over a wide area leading to greater yield losses.<sup>9</sup> Further contributing factors to the increase in rice pests may be ecological disequilibria in predator/prey relationships due to climate change, more area being cleared for agriculture and advancing land degradation, as well as an increase in commerce of agricultural products facilitating the movement of crop pests.<sup>10</sup>

Almost all study respondents around Betampona indicated interest in cassava as an alternative crop to rice to address food deficits.<sup>11</sup> The 2013 FAO/WFP report on food security in Madagascar noted that people increasingly turn to substitute rice with alternative foods; in 2013, production of cassava and sweet potatoes increased in the Atsinanana region compared to the year before (by 14 and 20%, respectively). Cassava is a high-caloric crop that can be used as food for humans as well as livestock, especially pigs. Even without any addition of

compost or manure (animal or chemical), cassava can yield 3-5,000 kg ha<sup>-1</sup> of roots [12], which is far more than the 500-1000 kg/ha of rice or maize presently produced on *tavy* fields. Reference [8] reported cassava yields of 7-12 Mg ha<sup>-1</sup> in trials around Lac Aloatra which, with good fertilization, could go as high as 60 Mg ha<sup>-1</sup>. Given much greater planting distances of cassava (1 x 1 m) compared to maize or rice, it may also be easier for farmers to add at least some compost to each cassava cutting at planting to increase yields. Further processing and transformation may be necessary to bring the crop to market, but does not require sophisticated technology; such value added processing can also provide additional employment and income opportunities.

In both Ivoloïna and Betampona, farmers stated that they want to increase tree crop and livestock production, although (especially for trees) the species they are interested in differ in the two places. The interest in trees is a positive sign, as it may provide a 'pull factor' in expanding agroforestry (rather than MFG or other organizations trying to 'push' the technology onto farmers). Although agroforestry is not known as such, people do practice it. Around Ivoloïna, a diverse mixture of tree crops is grown around the home as well as in fields a little further from the village. People around Ivoloïna are interested in increasing the number and diversity of tree crops as they are more compatible with off-farm employment than more labor and attention demanding seasonal crops. A major constraint for further expansion is the lack of markets, storage facilities and transformation industries for many tree crops in the region. These do exist for the traditional colonial export crops (coffee, vanilla, clove, cinnamon, and litchi), but not for many other, more perishable fruits crops.

Around Betampona, farmers' *tavy* fields, where agroforestry would be most beneficial, are often located far from present villages, which limits the potential for expanding the practice, especially with woody cash crops. Already, farmers cited the long distance to their fields as problematic, not only for working the land but in dealing with rising theft of produce.<sup>12</sup> Given the distance of Betampona from major markets and the state of the road and trails, the choice of species is limited mostly to crops with a high value per unit of weight or volume such as spices (clove, cinnamon), coffee or charcoal; fresh fruits are, for the most part, too fragile and perishable to make the arduous trek to Tamatave and there is only a limited local market for them. Spices can be dried and stored, or turned into higher value products (essential oils), making them lighter and easier to transport over longer distances. Additionally, such value-added transformation creates local jobs.

Farmers near Betampona have planted many clove trees over the last few years, many of these provided as an encouragement to participate in the buffer zone restoration. Farmers have also rehabilitated old clove orchards to put them back into production. The historical information about clove production compiled by [22] shows that it is also a rational choice, as the species is well adapted to the zone and can grow well on slopes and degraded soils. Cloves are problematic only because the process of distilling essential oils demands a lot of firewood: around 1,000 kg per 24 hour distillation period, yielding about 2 kg of essential oil from 350 kg of dried clove leaves [15].

Even though MFG stopped providing clove seedlings in 2012, farmers continue to plant them, sourcing seedlings from nurseries operated by local farmers in the area. Thus, it would be good to sensitize them about the need to plant fast-growing fuelwood trees as well to fuel the alembics.<sup>13</sup> Both *Acacia mangium*<sup>14</sup> and *Eucalyptus spp.* are good candidates; the former is a nitrogen fixer and therefore provides a secondary benefit to degraded soils, the latter grows back faster after coppicing and can also provide termite-resistant poles for the house construction.<sup>15</sup> Given the rapid rate at which forests are disappearing (esp. in Sahambala commune where Ambodirafia fokontany is located<sup>16</sup>), it would be in farmers' own interest to address future fuelwood needs now to ensure a long-term viable essential oil industry for the area in the future.

The relatively low numbers of respondents indicating livestock production as a livelihood strategy may not reflect actual interests farmers have in livestock. Farmers would like to expand livestock production, but are reluctant to do so because of frequent, recurrent outbreaks of classical and African swine fevers among pigs, and fowl cholera and Newcastle's disease in chickens that decimate flocks and herds every few months. Emergency slaughter and sale of meat at a discount are common to recoup at least some income from diseased livestock, but the downside of the practice is that it is pathway to spread the very infectious animal diseases between households and villages (although it is officially illegal to do so [14]). This practice promotes the chronic recurring cycles of disease outbreaks that circulate in the villages, leading to high mortality every 4-6 months. Thus at present, increasing livestock numbers is not a viable strategy for most households. Training in better husbandry practices and quarantine zones around areas where the disease occurs may reduce the spread between villages.<sup>17</sup> Livestock vaccination campaigns may change interest in the future, especially if they are seen as effective in terms of costs and higher productivity.

Secondly, while animals are presently fed mostly with byproducts (rice bran, peels of fruits and cassava roots) and kitchen leftovers, this may provide insufficient feed for an increased number of animals. Thus, to meet the nutritional needs of expanding herds and flocks, farmers will need to plan for, and actually produce, additional crops to meet that need. Cassava and maize are options, but so are various tree crops (both native and exotic) producing fruits, nuts and leaves. Again, opportunities exist for agroforestry to produce these crops; additionally, those trees can be planted as living fences around animal enclosures, or within those enclosures in the case of chickens, minimizing transport of these products to the animals.

## 6. Conclusion

For development to happen, any assistance provided to rural people needs to be locally relevant and adapted to people's own needs, desires and goals. It also needs to be flexible to be able to change approaches and messages as circumstances change, as this is the way that people themselves approach livelihood security. This is clearly revealed in the differential livelihood strategies pursued by farming households in different villages in this study,

at least at this point in time. Longitudinal observations over the years of our work around Ivoloïna showed that farmers often move in and out of agriculture or the production of certain crops to pursue other, more lucrative opportunities as the need arises; it reflects the flexible, non-linear approaches pointed out by Sayer and Campbell in the introduction. As these authors point out in their concluding chapter, successful development projects are ones that nurture and accompany local change processes (by listening to and empathizing with local resource users) rather than imposing technological solutions (that are often locking farmers into specific linear, non-flexible paths that may reduce rather than enhance their future livelihood security).

The findings of this study largely confirm the theory on rural economic development that Jacques Dez advanced 50 years ago. The lack or bad state of infrastructure 'traps' farmers into maintaining their traditional methods as these are perceived to be the best option for livelihood and food security even if at minimal levels and in spite of growing food insecurity. This is the case for farmers in the villages around Betampona, where *tavy* remains the main form of agricultural production. There is little incentive to modernize and increase production in the absence of markets (or only distant, very difficult to reach ones), or on rural markets where prices are generally low. The lack of (good) infrastructure also limits the provision of information and services (farm inputs, credit, extension and training) to those villages. Development assistance around Betampona needs to simultaneously address both physical infrastructure and technical assistance and services to have a positive impact on people's lives as well as on limiting further environmental degradation. But, as [21] noted, equally important for sustainable livelihoods is an approach that addresses socio-political, environmental and economic difficulties (such as poor education; poverty; health; mentality; gender, race and class tensions; very poor soils; and un- and underemployment) faced by people on a daily basis.

Farmers around Parc Ivoloïna do benefit from a decent road network giving more ready access to markets for their products and to a growing number of AgriVet supply stores to buy needed inputs (seeds, tools, pesticides, veterinary medicines), as well as cell-phone services. Nevertheless, good infrastructure and access to information are no guarantee that farmers will accept and adopt new methods and technologies. This reluctance to improve agricultural practice may seem contradictory to the theory, but makes sense knowing the larger context and history of the area. Farming around Ivoloïna is no longer a prime component of most households' livelihood strategy as advanced soil degradation from a long history of dense human settlement depending on *tavy*-based agriculture has exhausted the soil to the point that (for many) it is no longer worthwhile to farm. This, combined with more unpredictable weather patterns, has led many farmers to seek alternative means to securing a livelihood (either temporary or permanently) in the formal and informal sectors made possible by the proximity of Tamatave. As respondents themselves indicated, the future of agriculture around Ivoloïna may lay more in the growing of tree crops and livestock (products that require less labor and thus are more easily combined with off-farm work) or vegetables (which can be intensively

farmed on small plots because of their high value) rather than extensively grown field crops (rice, cassava, maize).

This survey confirms that farmers are adaptive resource managers, often showing more flexibility in redirecting their activities, practices and methods as economic and environmental conditions change or opportunities arise than scientists and development 'experts' do. Since a major objective of MFG is capacity building to improve the ability of natural resource managers at all levels, we should measure success or failure not only according to adoption and acceptance rates of new farming methods and techniques, but, as Sayer and Campbell (2011) concluded for their work in Zimbabwe, according to the adaptive learning that our research and development assistance fosters. This study can thus be viewed as a step in meeting MFG's objective to function as a catalyst in enabling and strengthening villagers' own capacity and ability to improve their lives and become active participants in their own development, whether that is in agriculture or other sectors of the economy.

## Notes

1 The translation was done by Mr. Gimod Ramahavory, a retired primary school teacher who has been actively working with MFG's Environmental Education (Saturday School) program since its inception in 1994.

2 In the farmer-leader program, ten farmers were chosen (two each in five *fokontany* around Ivoloïna); they were provided training in composting and intensive organic vegetable and improved fruit production methods. Participants would then implement these on their own land to serve as an example for other farmers. They received monthly visits to assess how well they did, diagnose any problems and suggest solutions.

3 Originally, the Reserve did have a buffer zone demarcated by *Eucalyptus robusta* planted on its outer perimeter; sections of these eucalypts still remain. However, land within the buffer zone was transferred to farmers during the Ratsiraka presidency (1974-2002) in order to increase local food security (Jean-Jaques, Madagascar National Parks' Toamasina regional director, personal communication).

4 The survey did not include questions about relative contribution of each activity to household income.

5 Reference [11] defined homegardens as integrated tree – crop – animal production systems, often in small parcels of land surrounding homesteads, and primarily found in tropical environments. These agroforestry systems are often cited as the epitome of sustainability.

6 Farmers could substantially reduce the amount of seed rice used if they would change from traditional to SRI or SRA practices in their irrigated (*horaka*) rice fields, but neither of the improved techniques has really taken off in the study area.

7 Similar trends were observed by [24] in Nicaragua.

8 This survey did not ask specifically about so-called "famine foods" (tubers, fruits and other edibles collected in the wild) that people may resort to during times of food insecurity (*maitso-ahitra*). A future survey may be done to obtain information about this, and to learn more about the species and locations from which they are collected.

9 A similar situation was noted by the senior author during a visit to the Plaine de Iazafo in November 2013.

Farmers there grow paddy rice year-round, but not on a simultaneous timed schedule. Thus, individual rice plots were anywhere in the crop cycle, from field preparation to harvest throughout the year. And, given that it is the only crop being grown, rice pests (esp. *Hispa gestroi* and damage by *Maliarpha separattella*) were easy to spot and affect yields considerably according to the farmers we talked to there.

10 Stem borers were observed in SRI plots at Parc Ivoloïna's Model Station for the first time during the 2013-14 crop cycle.

11 Cassava was once widely cultivated around Betampona, especially around Analamangahazo, the home village of Maurice Vony, an administrator (*sous-gouverneur*) in Tamatave in the late colonial and early independent governments. According to Gimod Ramahavory (personal communication, October 2013), Vony required each household to grow one hectare of cassava.

12 This was cited as the reason for one of the tree nursery managers in Antananariva to move his family from the village proper to take up residence on his ancestral land 5 km away.

13 An alembic is an alchemical still consisting of two vessels connected with a tube, used to distill chemicals and essential oils. Source:

<http://en.wikipedia.org/wiki/Alembic> accessed May 14, 2013.

14 *Acacia mangium* has naturalized in some areas of Madagascar, but it is not an invasive species. The tree has been widely used in Madagascar as a nurse tree for later planting of native tree species.

15 When managed well, *Eucalyptus* spp. can be coppiced for many years. In Rwanda, farmers discovered through trial and error that 7 years was the optimal interval between coppices, and 6-10 sprouts were left to grow afterwards. The stumps of Eucalypts managed in this way inventoried in den Biggelaar's dissertation research in Rwanda were often 50-60 years old. It can thus be considered a sustainable practice [2].

16 According to [23], forest loss in Sahambala *commune* was 3.89% per year in the 1990-2000 period, and 0.97% per year between 2000 and 2005, which is much higher than the average of 0.83% and 0.53% per year for Madagascar as a whole for these same periods, respectively. Deforestation at a rate of 3.89% per year translates into a loss of nearly one-third of forests in a ten year period.

17 In most of the developed world, outbreaks of swine fever are contained by culling the affected herd; disinfection of the premises; a ban on movement of any pigs within the village/area of outbreak; and the institution of at least a 5 km quarantine zone for at least 3 weeks that bans any moving of pigs or pork meat in and out of the area. In Madagascar, quarantines and a ban on the movement and sales of pigs and pork may, however, be impractical, esp. since farmers often slaughter sick animals and sell the meat quickly at a low price to recoup at least some of the value of the animals.

## Acknowledgement

The authors wish to thank the eight tree nursery managers and Alain Rasolomampandra for fielding the surveys, and Gimod Ramahavory and Patrice Saby for

their help in translating the survey instrument and the results.

## References

- [1] Appert, J. "Les Insectes Nuisibles aux Cultures de Madagascar (Notes Techniques)." *Bulletin Agronomique No. 22*. Paris, France: Institut de Recherches Agronomiques Tropicales et des Cultures Vivrières, 1967.
- [2] den Biggelaar, Christoffel. *Farmer Knowledge and Experimentation with Trees and Tree Cultivation in Agroforestry Systems in Rwanda*. Ph.D. Dissertation, Department of Forestry, Michigan State University, East Lansing, 1994.
- [3] Chabrolin, R." La riziculture de tavy à Madagascar." *L'Agronomie Tropical*, Extrait No. 1, Janvier 1963.
- [4] Dez, Jacques. "Tradition et développement rural." *Annales de l'Université de Madagascar 7*: 73-115, 1968.
- [5] Dez, Jacques. "Développement économique et tradition à Madagascar". *Humanités, Economie, Ethnologie, Sociologie, Série V* No. 4, 1962.
- [6] FAO/WFP. *Mission FAO/PAM d'Evaluation de la Sécurité Alimentaire à Madagascar. Rapport Spéciale, 27 Octobre 2013*. Rome: UN Food and Agriculture Organization and World Food Programme, 2013.
- [7] FAO/IFAD/WFP. *The State of Food Insecurity in the World*. Rome: UN Food and Agriculture Organization and World Food Programme, 2015.
- [8] Francois, Edmond. "Le manioc, sa production et son utilisation." *Revue de Botanique Appliquée et d'Agriculture Coloniale* 18 (204-205): pp. 533-573 and 18 (206): 692-707, 1938.
- [9] Hume, Douglas W. 2005. *Agriculture in Madagascar: Conservation and Cultural Meanings of Rice*. Ph.D. Dissertation, Dept. Of Anthropology, U. Of Connecticut.
- [10] Kiener, A. " Le Tavy à Madagascar: Ses différentes formes et dénominations. Bilan de tavy et problèmes humains, moyens de lutte." *Revue Bois et Forêts des Tropiques* 90: 9-16, Juillet-Aout 1963.
- [11] Kumar, B.M. and P.K.R. Nair, eds. "Introduction." *Tropical Homegardens: A time-tested example of sustainable agroforestry*. Dordrecht, Netherlands : Springer, 2006, 1-10.
- [12] Mémento de l'Agronome 3<sup>ème</sup> édition. "Manioc" and «Riz". Paris: République Française, Ministère de la Coopération, 1980, 502-512 and 526-556.
- [13] Radasimalala, Vonji. "Quatre million de Malgaches menacés: La célébration de la Journée Mondiale de l'Alimentation, hier, a été avare de bonnes nouvelles. La sécurité alimentaire s'aggrave." *Express de Madagascar*, 17 octobre 2013.
- [14] Randrianantoandro, Tiana N., Hiroichi Kono and Satoko Kubota. "Knowledge and behavior in an animal disease outbreak – Evidence from the item count technique in a case of African swine fever in Madagascar." *Preventive Veterinary Medicine* 118: 483-487. 2015.
- [15] Ramalanjaona, C. and E. Jourdan. *L'essence de girofle de Madagascar: Technologie - Distillation - Emballage*. Antananarivo: Institut de Recherches Agronomiques à Madagascar, Division de Technologie Agricole, 1961.
- [16] Ravalitera, Pela. "Notes du passé: Les régions à tavy peu desservies par des routes." *Express de Madagascar*, 8 juin 2015.
- [17] Ravatsy, Patrick Engels. *Evaluation ex-post et appui à la réorientation stratégique d'un projet de restauration forestière autour de la Réserve Naturelle Intégrale de Betampona - Madagascar*. Rapport de Stage, Université d'Auvergne-Cerdi, 2013.
- [18] RFI (Radio France International). *Madagascar n'a jamais importé autant de riz qu'en 2013*. [Online] Available: [http://www.rfi.fr/Agriculture et Pêches Madagascar](http://www.rfi.fr/Agriculture%20et%20Pêches%20Madagascar) [Accessed March 14, 2015].
- [19] Roubaud, Francois. *La question rizicole à Madagascar: Les résultats d'une décennie de libéralisation..* Antananarivo, Madagascar: Projet MADIO Rapport No. 9653/E, 1996.
- [20] Sayer, Jeffrey and Bruce Campbell. *The Science of Sustainable Development – Local Livelihoods and the Global Environment*. Cambridge University Press, Cambridge, UK, 2004.
- [21] Small, Rob ad Femke Hoekstra. "Growing a sense of place and community in Cape Town." *Farming Matters* 32 (2) 14-17. 2015.
- [22] Tiollier, Marine. *L'implantation de la Culture du Giroflier à Madagascar*. Rapport du Stage, SupAGRO Institut des Régions Chaudes. CIRAD Montpellier, France, 2012.
- [23] USAID, Conservation International and Ministère de l'Environnement, Forêts et Tourisme.
- [24] *Evolution de la Couverture des Forêts Naturelles à Madagascar: 1990-2000-2005*. Antananarivo, Madagascar, USAID, 2009, 30-31 and A25-A26.
- [25] Vandermeer, John and Ivette Perfecto. *Breakfast of Biodiversity: The Truth about Rain Forest Destruction*. Institute for Food and Development Policy, Oakland, California, 1995.