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Why smallholder farms' practices are already agroecological despite conventional agriculture applied on market-gardening

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Abstract

According to experts, agroecology gathers agricultural practices that improve resource efficiency, that strengthen resilience and that secure social equity and responsibility. The diffusion of this set of principles may innovate in most developed countries where conventional agriculture is widespread but may be questionable by agrarian society of sub-Saharan African country like Madagascar. The Itasy Region has developed there vegetable crops for marketing purpose. Part of the Itasy agricultural practices may be assimilated to conventional ones, justifying research and development action dedicated to the promotion of agroecology. However, a question arises: Are farmers who benefit from conventional agriculture interested in reducing chemical input to meet major principles of agroecology? A research project called SECuRE has deliberately chosen the peri-urban area of Itasy to perform a survey to 171 households that are representative of smallholder farms inside two Communes of Arivonimamo, a District of Itasy. This paper aims to assess how far agroecological practices may be integrated or intensified in their farming systems despite a long-term effect of conventional agriculture. As major results, among smallholder farms' strategy, use of fertilizer is determining agricultural income. Organic fertilizer application is mandatory for almost all the diversified crops whereas mineral fertilizer secures global agricultural margins by smallholder farms. Organic fertilizer sources are managed at farming system scale by associating livestock and by using crop residue to limit as possible export of nutrients on soil by crops. This strategy includes the territorial management of fertility from extended grassland that remains for common use. Finally, whatever the training they may have attended or inherited from parents, farmers grow-up in experience and improve agricultural practice in long term. This study concludes that market-gardening in Itasy mobilizes reduced chemical input at farm scale. Agroecology is quite widespread there according to most of the principles advanced by experts.

Keywords

Agroecology principles, peri-urban agriculture, farming system, organic fertilizer, mineral fertilizer, center highlands, Madagascar

Introduction

Context of the study

In 2019, a high level panel of experts (HLPE) has reviewed the agroecology relatively to scientists' and other experts' viewpoints from its genesis to its current consideration as a science that may be conceptualized. HLPE (2019: 41) synthesizes agroecology as an innovative agricultural approach that respects a set of 13 principles gathered inside three major topics: improving resource efficiency, strengthening resilience and securing social equity and responsibility.

The concerns that are highlighted by these principles are particularly relevant in the context of conventional agriculture

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that is often promoted in developed countries. The collateral damage of conventional agriculture to human existence (health) and to the ecosystem (pollution of air, of soil and of water; loss of flora and fauna biodiversity) due to widespread application of chemical products on agriculture has reached there a high level of threat for a century of its development (Task Group on Agroecological Transitions [GTTA], 2019). Therefore, affected countries, mainly in the United States (US) and in the European Union (EU), have decided to establish laws/directives in their territory (Johnson et al., 2020) to limit the reverse effects of conventional agriculture. In addition to the technical changes that are suggested by agroecological practices, financial incentive is also available to European farmers to accompany their transition to a sensible improvement of agroecosystems, and of food systems (Wirtz, 2019).

As agroecology "recently" appeared in the history of agriculture (HLPE, 2019: 35; Wezel et al., 2009), the scaling-up of this "alternative" agriculture is still nourishing multiple debates (GTTA, 2019; Wirtz, 2019). The paradigm related to the dissemination of agroecology clearly differs according to the welfare status of countries. Developed agricultural economy relies on policy and on financial tools (Hatt et al., 2016; Wirtz, 2019) whereas technical issue is the main focus to establish agroecology principles in developing countries like in Africa (Mugwanya, 2019; Wirtz, 2019). Nonetheless, according to history of innovation processes, decades of technology transfer based on the replication of the package of conventional agriculture (fertilizer use, selected cultivars, chemical control of pests) should have more impacted to agricultural practices (Fuglie et al., 2020) than years of dissemination of the agroecology (organic manure, diversification of crops, biological control of pests) in Sub-Saharan Africa. Considering the assumption that rational action of farmers on agriculture is seeking efficiency of production resources instead of focusing on social equity or on resilience, the relevant question that initiates the current paper is: are farmers who may benefit from the tricks of conventional agriculture interested in reducing chemical input to meet major principles of agroecology? Actually, to respect the above principles affiliated to agroecology, use of chemical input is the critical key point of the acceptation of one practice as agroecological or not (Hatt et al., 2016). The objective of this study is to assess the eventual affinity of farming systems with agroecology inside various cropping systems, including market-based agriculture that is conducted in a conventional manner. Throughout a Malagasy context, the methodology of this work consists on the analysis of the whole farming system in order to evaluate the "weight" of chemical fertilizer by farmers at different level: field, cropping system, and farming system. A survey has been performed to check the farming systems' application of what agroecology is supposed to. The related questionnaire has integrated questions about its whole principles as defined by the HLPE.

Itasy Region, a specific market-gardening practices' site

Itasy Region is located in the center highlands of Madagascar (Figure 1). This Region is convenient for agricultural activities despite the fragile characteristics of local soils (Donque, 1974). Thus, management of soil fertility is determining productivity of crops either on ferralsols (Center and East side of the Region) or on andosols (West side). Despite the tropical status of Malagasy climate, the center highlands beneficiate a temperate regime that shares a year in two distinct seasons: hot and humid from October to March, and fresh and dry from April to September. Cultivation is possible along the year for all crops, temperate crops including many vegetables especially tolerate fresh season during which cultivation may be set wherever a water source is available.

In Itasy, farmers provide fresh products from gardening to the capital city of Madagascar, Antananarivo (Andrianampiarivo, 2016). The cultivation of vegetables offers opportunities of cash to them. All types of vegetables including green harvested product (green bean), leaf (various species), fruit (tomato, squash . . .), grain (bean, peas . . .), bulbs (onion, garlic) and root (potato, carrots, ginger . . .) are produced in the major Regions of the highlands surrounding Antananarivo within 150 km of distance: Analamanga, Vakinankaratra and Itasy (Ministry of Agriculture, 2007 [Les enquêtes connexes]: 142–145). These plants are integrated inside different cropping systems that mainly optimize tight land area: succession of rice with vegetables on lowlands, respectively during the rainy and the dry season; successions of vegetables crops on upland; and the association of vegetables with fruit tree (agroforestry).

Agricultural projects by Malagasy farmers, dominated by conventional trend

After the independence of Madagascar, in 1960, most of national development projects were dedicated to the improvement of irrigated rice productivity per area unit (Fonds Africain de Développement, 1995; Grégoire, 1968; Japan International Cooperation Agency (2009-2020)). Projects related to other crops, including vegetables, have never reached a national importance. Topics related to the efficiency use and the profitability of chemical fertilizer have been systematically integrated to these rice projects in addition to the dissemination of improved cultivars, of agricultural materials and techniques. Unfortunately, innovation processes induce few impacts. Irrigation infrastructure and use of mechanized materials remain very low and chemical input is not even available at space and time scales across the whole Malagasy territory. As example, only 27% of the Communes that compose the country access on fertilizer (Randrianarisoa and Minten, 2003). Moreover, farming systems that exclusively use handled tools are still widespread. The ploughing tool locally called *angady* averages three units per smallholder farm that accounts about three active workers (Ministry of Agriculture, 2007 [Tome 5]: 5). Handled tools are also indicative of the cropping system that is usually developed by farmers. In absence of official statistics, importance of

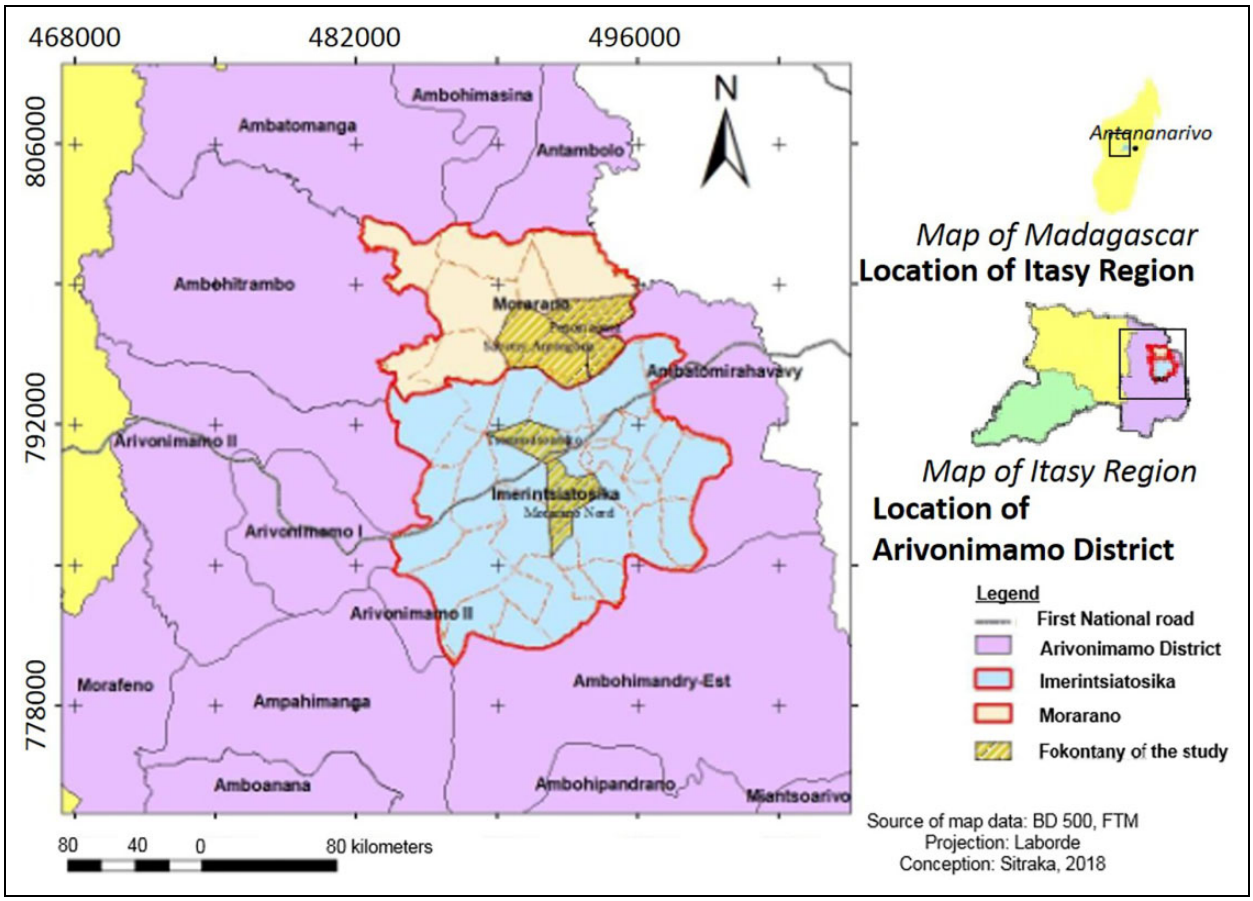

Figure 1. Location of the study site.

vegetable producers may be deduced from the rate of handled watering tool among farming systems. According to the agricultural census in 2004/2005 (Ministry of Agriculture, 2007 [Tome 5]: 27), 40.8% of the farming systems in Itasy own handled watering material instead of 17.0%, for the national average.

In contrast to governmental incentive, a project called MAHAVOTRA conducted in the Itasy Region by an international Non-Governmental Organization (Agrisud International, 1992-2020) may appear as an exception to have promoted agriculture practices in the context of sustainable development. MAHAVOTRA project realized the dissemination of agroecology and agroforestry practices by smallholder farms. Integrating territorial approach, the project has first disseminated woody species (trees and shrubs) by farmers to enrich the landscape of Itasy and then, strengthened local capacity of farmers' associations to increase added values of their agricultural products in order to make the project outputs last.

Materials and methods

SECuRE project's purposes and methodological approach

In order to relieve gap of knowledge related to organic and bio management of crops by farming systems, a team of researchers affiliated to a partnership platform for the sustainable farming system in altitude areas (dP SPAD) has established a project called SECuRE. This research project that follows the first stage of MAHAVOTRA project in Itasy aims to provide Soil Function Restoration practices based on local and scientific knowledges, in order to increase agronomic, socio-economic and ecological performances. The rainfed rice system is chosen as the main interface to agroecological intensification for this purpose. To do so, the project relies on agroecological practices and their inherent principles. Scientific and local assessment of practices with agroecological potentiality was the first major task of the project. A global survey was performed to identify these practices among existing cropping systems.

The current paper deals with the results of the survey to respond to the question: How far agroecological practices are integrated in farming systems that benefit from conventional agriculture in a market-based agriculture scheme?

The survey was conducted inside two Communes of Arivonimamo, a District in the Itasy Region: Imerintsiatosika and Morarano (Figure 1). These communes were chosen accordingly to their contrasted statement toward the access to the First National Road (RN1). The RN1 directly links Imerintsiatosika to Antananarivo within 30 km of distance on asphalt road whereas about 10 additional km are required to Morarano following a secondary road that is difficult to access from Imerintsiatosika, especially during rainy season.

Table 1. Summary of the farming systems' characteristics and of their economic performances in the Commune of Morarano and Imerintsiatosika.

	Morarano (N = 87)				Imerintsiatosika (N = 84)			
	Mean	Median	Minimum	Maximum	Mean	Median	Minimum	Maximum
Agricultural household (AH) size	4.6	5.0	1.0	9.0	5.1	5.0	2.0	11.0
Active worker	3.9	4.0	1.0	8.0	3.9	4.0	2.0	10.0
Total land area (ares/AH)	103	76	5	472	98	70	3	517
Number of crops	7.0	7.0	2.0	13.0	6.5	6.0	2.0	12.0
Number of vegetable crop	2.8	3.0	0.0	7.0	2.5	2.0	0.0	8.0
Number of handled watering tool	2.5	2.0	0.0	6.0	3.5	3.0	0.0	12.0
Global income (US$ PPP/household/day)	14.1	11.2	−0.3	78.9	19.1	13.2	1.0	218.0
Agricultural net margin (US$ PPP/household/day)	8.2	5.3	−1.6	56.6	8.9	6.9	−10.9	52.0
Net margin from livestock (US$ PPP/household/day)	3.3	0.7	−5.6	49.0	1.3	0.7	−11.5	26.6
Off farm income (US$ PPP/household/day)	1.0	0.0	0.0	8.9	2.3	0.3	0.0	31.2
Non-agricultural income (US$ PPP/household/day)	5.3	3.3	0.0	63.8	7.9	3.0	0.0	170.3

The surveyed agricultural households were randomly chosen from four *fokontany* (a *fokontany* is the smallest administrative delimitation in the territory of Madagascar): Fenomanana and Sabotsy Antongona in Morarano Commune, Morarano Nord and Tsenamasoandro in Imerintsiatosika Commune (Figure 1). These *fokontany* were retained accordingly to the density of population defining sampling rates between 10% and 13%. Selection of the surveyed households was made using official election registration. Despite an objective of 50 households for each *fokontany*, 171 households were finally retained.

Data collection and analysis

A questionnaire was elaborated to permit detailed description of any local practice that may improve or restore soil fertility. The inquiry states first the description of the household (components and activities) and then, describes the structure and the functioning of farming system. Information related to agricultural resources, to cropping systems and to economic performance were collected. Economic performance cumulates net margins (operational and financial costs are deducted from domestic gross) of each agricultural or animal breeding activities and wages, if applicable, for off-farm and non-agricultural activities. An additional set of questions was dedicated to ask about the affiliation of farmers with past development projects. Data management permits to illustrate results of the survey accordingly to any requested thematic.

Prices are converted in US$, after adjustment to the rate of the purchasing power parity (PPP) that amounts 1,064.351 Ariary (Malagasy currency) per $ (OECD, 2020). For comparison purpose, the absolute poverty line of US$1.9 PPP per capital per day is considered.

Results

From plot level, market-gardening contributes to relieve precariousness of smallholder farms

The average size of household in the Communes of Imerintsiatosika and Morarano is 4.8 human capital. Accounting 3.9 active workers per household, the integrated farming systems' activities are based on multiple cropping systems coupled with livestock. Household earns an average income of US$16.4 PPP/household/day. Agriculture contributes to 57% of this value (including 12% from livestock) that is completed by income from off-farm (8%) and non-agricultural activities (35%).

Difference in value of 35% between respective incomes is observed in Imerintsiatosika compared to Morarano whereas farming systems have approximately the same characteristics in both Communes (Table 1). The distance of the Commune to the Capital is giving an advantage to the closest one, Imerintsiatosika, in terms of income, especially from non-agricultural activities.

In terms of resources, farming systems present large variability of workforce and of exploited land area. This last parameter particularly stratifies them. Median value of total land area is lower than the mean value, suggesting higher rates by medium and great land owners than by little ones. An average of seven crops by farming system is observed in the study site. Among them, vegetables account for about three crops integrated in multiple cropping systems. In contrast to other agricultural products, vegetables are dedicated to market to provide monetary value. In the study site, vegetables products concern 61% of cases of trading, followed by roots (cassava or sweet potatoes) (23%). Cereals (rice, maize) and legumes (groundnut, *Bambara* peas) are essentially self-consumed (less than 5% of trading operation). Market-gardening contributes to 50% of agricultural margin.

Fertilizer management is determining farming systems' gross product

Due to tight cultivated land area (1.0 ha per farming system), farming systems are assimilated to smallholder farms (hereafter SF). The average number of handled watering material owned by each farmer amounts 3.0. The importance of the production of vegetable is therefore stated in the study site.

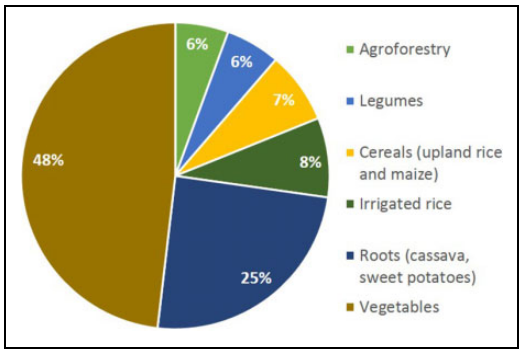

Figure 2. Allocation of organic fertilizer to crops by smallholder farms.

Use of mineral fertilizer concern 85% of SF but the managed quantity is relatively low. About 23 kg per SF are dispatched to many crops that are managed by a farming system. Market-gardening beneficiates about 90% quantity of mineral fertilizer by SF and part of organic fertilizer. However, mineral fertilizer application is effective inside multiple cropping systems on 36% of cultivated land, including agroforestry fields. The applied doses of mineral fertilizer on vegetables are set between 5 and 122 kg·ha^{-1} according to the type of crop and to the frequency of application. In contrast, application of organic fertilizer or mixed fertilizer (combining organic and mineral but not synthesized matters) is quite mandatory in smallholder farms' agricultural practices to intensify their production (Figure 2). Exception is observed to legumes that are cultivated without any fertilizer. One SF produces about 2.9 tons of organic fertilizer a year (average value).

Vegetables, including but not limited to tomato, leaves and green bean consume about 45% of available organic fertilizer within an application dose of about 5 tons·ha^{-1}. Besides, vegetables associated to fruit tree inside agroforestry system also beneficiate additional organic fertilizer. Despite an application dose that is lower than recommended by technical guidance that suggests 10 tons·ha^{-1} and even more, farmers struggle to make these types of fertilizer available. Capacity of farmers to collect organic and similar fertilizer depends either on cattle properties or in financial availability. Breeding cows or oxen that permits to produce an average of 2.2 tons of cattle manure a year concerns 37% of the smallholder farms. However, apart from the number of animals, this quantity is conditioned by the dynamic collection of biomass (grass plants from meadow or crop residue, essentially from rice) that is combined to animal manure. Workforce is necessary to collect and to transport biomass, otherwise purchasing becomes necessary. Without cattle, SFs are valuating manure from pork or poultry livestock. These concern respectively 25% and 18% farms, within respective production means of 0.5 and 0.2 tons a year. The formal compost that is regularly advised by developer agent is inventoried among the organic fertilizers of Itasy, applied by 9% of the surveyed farmers producing each an average quantity of 0.8 tons a year. In absence of animals or in order to supply organic fertilizer, "*zezi-pako*" that literacy means fertilizer of rubbish is manufactured. Herbaceous plants from common meadow, crop residue (not limited to cereal sub-product), even garbage from the kitchen are gathered in a hole, that is dug close to homestead or to the field, to be burnt or decomposed after regular watering. Soil particle may be deliberately or not integrated inside the *zezi-pako*. Only 5% of farms produce *zezi-pako*, each of them gather about 0.6 tons a year. Once gathered, priority of the dispatching of organic fertilizer is given to vegetables (48%), then to roots (25%) (Figure 2).

Efficiency of these types of organic/mixed fertilizer is admitted by farmers according to the prices that are attributed to each of them. The poultry and the pork manures are the most expensive, amounting respectively US$200.3 PPP and US$156.9 PPP per ton, followed by compost that costs US$68.7 PPP per ton and at last, the cattle manure costs US$62.2 PPP per ton. Even though *zezi-pako* is less traded than the other organic fertilizers, 1 ton is valued US$29.9 PPP. Farmers with high land area mostly purchase organic/mixed fertilizer by other farms. Net margins provided by vegetable crops are positively related to the application of mineral or organic fertilizers (Figure 3).

Development project does not sufficiently stimulate economic and ecological environment of farmers

Only a few number of farmers in Itasy have experience in development projects, about 14.0%. Even for the MAHAVOTRA project that is specific to the Region, only 4 out of the 171 surveyed farmers were affiliated to. Even though farmers participate to further development projects than those initially predicted in the context of the study, topics related to the improvement of market-gardening is observed within specific value chains: bean and green bean with the project PROTANA and with the firm Lecofruit, respectively (Table 2). Experience of farmers with fertilizer (mineral or organic) is associated but not mandatory with their participation to different agricultural training. To this purpose, projects and institutional structure that support farmers do not particularly provide fertilizers except with the firm Lecofruit that collaborates with local producer of guano fertilizer (GUANOMAD) to ensure bio label of their products. Farmers have to purchase, or to manufacture fertilizer by their own mean and within their cumulative knowhow.

Apart from providing vegetal materials (seeds and plants) that enrich local biodiversity, activities of development projects induced by private or public initiative mainly focus on technical and financial empowerment of farmers (Table 2).

Discussion

Status of target agents of agroecology diffusion in center highlands of Itasy

Agriculture ensures part of the own food and the subsistence of smallholder farms in Itasy Region, the final beneficiaries of development projects. However, agriculture

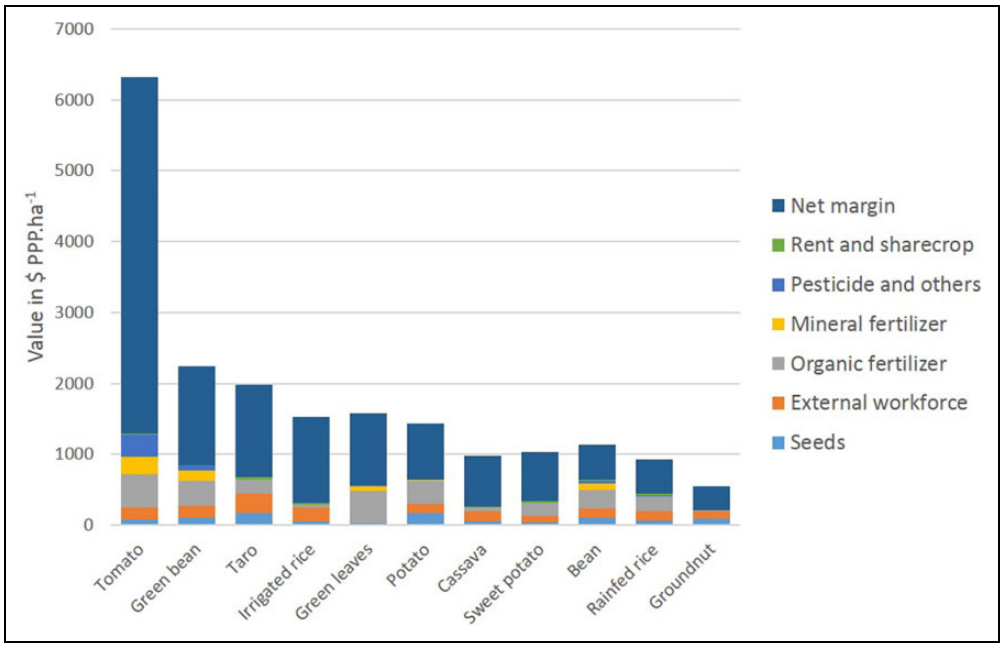

Figure 3. Deduced net margins from the decomposition of gross product of crops in Itasy.

Table 2. Experience of smallholder farms with agricultural and development projects (N = 171).

Project	Promotor	Years	Topics	Number of farmers	Activity
PROTANA	Private	2015–2016	Value chains: bean, orange tree and local chicken species	9	Improvement of the agricultural production (bean, orange) and livestock (poultry) by training and by delivering seeds and plants
MAHAVOTRA	Private	2012–2015	Agroecology and agroforestry	4	Training, delivery of tree plants
PROSPERER	Public	2008–2011	Handicraft	3	Training and professionalization of farmers
KOBAMA	Public	1984–1993	Wheat value chain	2	Developing contractual agriculture with farmers
PSDR	Public	2000–2002	Project Supply to farmers	2	Citrus value chain
Land'O Lakes	Private	2008–2012	Milk value chain	2	Improvement of the livestock system through milk production
BTM credits	Public	1967	Bank of Supply to Farmers	1	Credit, material support
Lecofruit	Private	2007	Green bean value chain	1	Developing contractual agriculture with farmers

BTM: *Bankin'ny Tantsaha Mpamokatra* (Farmers' Bank); PSDR: Rural Development Support Project.

does not warrant all of their livelihoods procurements. Non-agricultural activities contribute to extract some farming systems from absolute poverty line fixed by the World Bank. Proximity to the capital city raises the agricultural income of farming systems in the study site located at the East side of Itasy. Its value is 38% higher than that of the whole Region, US$6.2 PPP, according to the Institut National de la Statistique (2013). Compared to those from Analamanga or Vakinankaratra Regions, close to the Capital city, farmers from Itasy generate higher agricultural income. The standard living in the study site is also higher than national average, as 60.8% of the sampled households are above the poverty line compared to 21.2% for the whole population. Among reasons, Arivonimamo District particularly benefits multiple economic opportunities from this proximity to Antananarivo. Apart from market demand of fresh agricultural products like vegetables that develop jobs along the overall food chain supply, the city also supplies jobs to hand workers and to officer agents. This variability of the sources of income helps households in Itasy to cumulate global income that is about twice fold more important than national average cumulating US$6.9 PPP per day (Sum of US$5.3 PPP from Agricultural activities with US$1.6 PPP from non-agricultural business) (Institut National de la Statistique, 2013).

Market-gardening that provides half of agricultural income remains strategic for these farmers of the center highlands. Even though livestock and non-agricultural activities also engage SF's resources, when combined, these relatively generate the same income than cultivation (47% and 45% respectively). In many Regions of Madagascar, agricultural margin is warranted either by natural

capital throughout soil fertility or by tropical climate providing abundant rainfall and extended sun exposure. For instance, the recycle of biomass naturally occurred in complex agroforestry systems that are enriched by flora biodiversity in the East Regions (Kull et al., 2013). The center highlands do not hold such physical characteristics. Local farmers have to deal with organic or mineral fertilizer to make their vegetable products profitable due to low status of soil native fertility and to limited access to watering.

Organic or chemical input: How to decide?

Chemical footprint on Malagasy agriculture. Malagasy agriculture does not consume a large amount of mineral fertilizer. Average amounts between 3 and 7 $kg{\cdot}ha^{-1}$ per cultivated area are applied across the country, within variabilities between Regions (SNE [National Strategy for the Development of Fertilizer Use], 2006). In terms of quantity, rice fields receive the major part of the available mineral fertilizer, far forward the other food crops (cereals and legumes) (Randrianarisoa and Minten, 2003). Industrial crops do not consume tenth of available fertilizers in the whole territory due to low rate of area coverage (SNE, 2006) whereas cash crops like vanilla are the last ones, in terms of quantity, to consume mineral fertilizer at national scale. Vegetables and plants producing spices, infusions, essential oils or fruits (tropical or temperate fruits) are not accounted by statistics among crops to which fertilizer is dispatched. Yet cultivation of vegetables explains the high rate of fertilizer appliers among farmers in Regions surrounding Antananarivo that account for 39.9% and 48.0%, respectively in Analamanaga and Vakinankaratra (Randrianarisoa and Minten, 2003). Market-gardening practices are therefore concentrated in peri-urban area of Antananarivo, inducing the low national rate of mineral fertilizer users, 16.6% of farmers, essentially in order to fertilize rice. Despite a relative high application doses of mineral fertilizer on vegetables, the managed quantity is not threatening ecological equilibrium and human existence due to limited cultivation area by SF that does not exceed 1.0 ha per farming system in the whole territory.

Organic influence on local agricultural practices. Although use of organic and mineral matter for fertilization purposes has been observed by farmers since centuries in the center highlands, since the ancient *Imerina* era , effectiveness of the use of organic fertilizer is less documented in Madagascar. Practically, organic fertilizer use is mandatory by SF. Even though the organic fertilizers that are available by Itasy farmers are diversified (Razafimahatratra et al., 2020), none of them can substitute mineral fertilizer, especially in vegetable cropping systems where both types of fertilizer are applied in priority. Market gardening consumes almost all available mineral fertilizer but also, about half of organic ones. As none of them is free of charge but essential to the productivity of crop according to farmers' practices, additional investments for purchasing or for manufacturing fertilizers are covered in return by selling the related products. However, farmers also attribute value to organic fertilizer investment when applied alone. As consuming a quarter of available organic fertilizer, roots also are inserted inside rationale of profit as being the second most important agricultural goods for trading purpose. Thus, among agroecology principles, use efficiency of organic fertilizer is already sought by SF, justifying the valorization of any organic, even mineral, components of such matter that restores soil fertility and that ensures agricultural productivity.

Economic and historical drivers to farmers' agricultural strategy. According to Itasy farmers' strategies, fertilized crops have the priority for trading purpose. Vegetables are dedicated to city market whereas roots contribute to feed animals by farmer breeders. It is a mean to get return of investment and to generate income within the gained margin. Market gardening is the most efficient cropping system by providing half of agricultural income with a third of the land resource. However, the production of vegetables is limited in the space due to scarce resources (land, water supply), to limited workforce (using handled tools) and to affordable input. Vegetable crops generate secured margin with help of the cost of fertilizer. The return of investment (ROI) that highlights the economic benefit from purchasing fertilizer balances agricultural net margin with the costs of fertilizer. An estimated ROI between two and six fold the invested fertilizer input is set from vegetables production. Nonetheless, this value may be slightly overestimated due to additional costs of pesticide that is much more required to marketing-gardening compared to other cropping systems (Figure 3).

In absence of market-gardening, farmers' practices of Itasy may be assimilated to organic farming. Less fertilized crops like legumes are mostly dedicated to self-consumption. As staple food, cereals products have to satisfy self-consumption prior to trading purpose even though rice beneficiates minor part of available fertilizer. Maize is consumed in farm either by people or by poultry.

History of the knowledge and the know-how about market-gardening was not accurately defined neither during the survey due to limited questionnaire nor in the literature. However, as many Regions surrounding Antananarivo, presence of ancient *colons* is supposed to have induced change in food system during colonization era, between 1896 and 1960, stimulating the production of vegetables and the related marketing (François, 1969). Besides, related input, essentially seeds and mineral fertilizer, would have been transited to Antananarivo throughout the RN1, from Arivonimamo Commune that hosted the first international airport in Madagascar. Since then, habitants of the Capital city have integrated various vegetables in their dietary habits. Besides, public department of the Ministry of agriculture has locally established centers of production and of merchandizing of vegetable seeds before privatization process occurred to the sector at the beginning of the 21st century. In contrast, Madagascar is still importing almost all of its mineral fertilizer needs from abroad.

Reconsidering domain of agroecology, necessary to refine dissemination approach

This recent history of Madagascar has favored the diversification of the production by farmers. A progressive enrichment of the set of edible plants was occurring from the urban consumers to the rural supplier. In parallel, incidence of chemical fertilizer does not induce a globalized conventional agriculture in absence of local manufacturer. These situations likely contribute to facilitate the dissemination of agroecology. Despite multiple understandings of the term (Bellwood-Howard and Ripoll, 2020), agroecology is expected to define a type of agriculture that is in synergy with global environment (ecological, social or economic issues) of crops and animals. Conversely, confusion occurs to reach such objective when balancing concept to practice. Current consideration of agroecology as science or as movement (Wezel et al., 2009) gives importance to concept instead of practice that lays on technique. As a result, agroecology seems to be scarce among agricultural practices because promotors like scientists or activists further appear as "teachers" to farmers than as "learners" from.

Agroecology as practice. Among the whole principles of agroecology (HLPE, 2019), the Itasy case study practically shows that SF have many tricks to optimize available resources for agricultural production purposes, integrating livestock, crop residue and spontaneous vegetation. Mineral and organic sources to improve fertility of soils both contribute to develop their cropping systems. Mineral fertilizer use is particularly efficient to vegetables (first set of agroecological principles).

Usual practices are induced by cumulated knowledge along years (third set). As projects do not impact so much, due especially to time requirement of the internalization of innovation process (Rogers, 1983; Temple et al., 2015), it is advanced that transfer of knowledge between successive generations of farmers efficiently occurs. Hence, approach of short time project does not influence practices so much compared to long time farmers' interaction (second set).

Agroecology as concept. The dissemination of agroecology as concept often has the difficulty to distinguish the border with other forms of agriculture that partly share its principles. This concern was already demonstrated by Therond et al. (2017) for any agriculture model and stated by Findlater et al. (2019) for the case of Conservation Agriculture. The movement currently suggests the reduction of chemical input application in developed countries like in the EU (Hatt et al., 2016) as agroecological measure to fulfill requirement of practices that address more respect of the milieu. In developing countries, like in Madagascar, such recommendation sounds obsolete due to the current low application of mineral fertilizer that ensures the return of investment of the farming systems. That is why some analysts are skeptical about the relevance of agroecology by least developed countries. What does it provide as new and as better than that is already performed claimed Mugwanya (2019) and Wirtz (2019), respectively. However, apart from the necessity to fix a common definition of agroecology through formal debate instead of opinion battle online (Bellwood-Howard and Ripoll, 2020), scientists have to significantly enhance the impact of their research on fields, especially those related to the evaluation of local knowledge and practices. This study has particularly highlighted agroecology as ancient practices that are still applied by SF within limited resources.

How relevant agroecology is by smallholder farms of Itasy

The importance of agricultural activities remains high by SF. It directly provides food and indirectly, incomes. The limitation of tight cropland that is a fact in Itasy does not open much more options. If the trend of exploitable resources (land) and that of the agricultural supply (availability of input) continue to decrease, households will further supply this activity with small businesses or administrative work that the proximity of urban area allow. Peri-urban locations do not only profit from market of agricultural products, it also opens many job opportunities.

In the case that farmers are willing to pursue and to intensify agricultural activities, to be convincing, the agroecology concept that is developed by scientific knowledge has to reach in practice, the performance of conventional agriculture in terms of productivity without engaging further resources (land, workforce . . .). That strengthens the overview according to fertilizer as a critical key point, not only to the adoption of agroecology, but also for agronomical purposes. What would be the destiny of products: for food or for sale? Smallholder farms' practices admit that use of any fertilizer limits as possible export of nutrients by applying available input (mineral or organic) on almost all crops, especially when fertility of soil is deficient. However, the more the investment is high, the more merchandizing becomes necessary.

The option of SECuRE project to address agroecological innovation to rainfed rice is opportune. Actually, the economic concern of the investment in agroecology is determining to induce or not farmers' incentive. If ROI of agroecology practices is less than or similar to that of usual cultivation of upland rice, farmers may not be motivated enough. Value of ROI, twice the value of complex N-P-K investment on irrigated rice, and of optimal dose of Triple Super Phosphate on rainfed rice, was determined by past research projects (Projet Engrais Malagasy in 1992 and Overcoming Phosphate Deficiency on Irrigated and Rainfed Rice in Madagascar in 2009–2013, respectively). These scientific evidences were not enough to increase use of mineral fertilizers on rice cropping systems at national or regional scales in Madagascar (Razanakoto et al., 2018; SNE, 2006). Yet, rainfed rice itself may not mobilize many new adopters in Itasy unless the related economic may overcome the current performance of market gardening. Besides, agroecology option does not offer any label that may improve the price of the produced rice to motivate farmers to retrieve land resource from gardening area, and workforce from non-agricultural activities. This statement

reinforces the initial assumption of the economic based rationality by farmers.

Thus, future research might be oriented to the effectiveness of agroecology concept on market-gardening practices to make intensification significant in a site where agroecology is already, even unintentionally, respected by farmers with regard to the major principles advanced by experts: use of most chemical fertilizer in cropping systems including gardening is already limited in quantity (reduced input); crop residue and home rubbish are re-used for fertilizing purpose (recycling); synergy is observed toward cropping systems and livestock; economic diversification affects cropping systems and activities throughout the household activities in non-agricultural sectors (strengthening resilience); connectivity mainly acts to transfer knowledge between generations; farm activity relies on fair use of resources that limits extension of cultivated area to each property (secured social equity through land tenure).

Conduction of future projects should also be rectified. Interest of farmers, either economic or cultural, should be further stimulated inside research or development project' topics. Actually, with regard to the manner to valuate organic matter, farmers also positively assimilate knowledge inherited from ancestor's practices by inserting them inside habitual action instead of that from project incentive. Despite the limited spatial and temporal framework of projects, the scope of the provided topic should further match to the major activities and interest of the beneficiary. Agroecology concept may have been further attractive for Itasy farmers in case it provides improvement to the market-gardening cropping systems and not to compete against it in the allocation of resources. This criticism may be sensible to any development project as MAHAVOTRA that intends to affect farming systems without considering local variabilities as preconized by Gassner et al. (2019).

Conclusions

This empirical study has permitted to strengthen that environmental and social concerns determine the necessity or not of agroecology extension in a given location with stratified farming systems. In contrast to first sight, use of chemical input does not reach a critical threshold in Itasy Region. The managed quantity of mineral fertilizer among farming systems remains low by SF due to a restricted area dedicated to vegetables crops. Nonetheless, the way to scale-up the agroecology principles, when necessary, also differs according to agrarian culture. The "traditional" epistemology of project that refers to result-based activities impacts less on agricultural practices than knowledge that is transferred from generation to generation and integrated as habitual action.

Compared to initial purpose of the SECuRE project that initiates the intensification of agroecology, consideration of local statement and dynamism should be more implemented in future projects. If most of agroecology principles, even the reduced input application, are already integrated inside farmers systems of Itasy, the trajectory of their transition tends more to diversification of activity with off-farm and non-agricultural activities instead of the exclusive intensification of current agricultural practices (Andrianampiarivo, 2016). However, both possibilities may lead to progressive transformation of food system (HLPE, 2019: 26).

The progressive disinterest to agricultural activities is related to land access limitation even though food insecurity is a reality in Madagascar that is still facing rapid demographic growth. Yet, land grabbing has occurred in Madagascar for a while, for multiple purposes (bioenergy, pharmacology . . .) that mostly profit to firms (Gingembre, 2015; Neimark, 2012). For further social equity, local government has the duty to facilitate land access to smallholder farms to ensure their existence and to control food sovereignty.

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References

Agrisud International (1992-2020) MAHAVOTRA III: Forestry, Agroforestry and Land-Use Planning—Itasy Region. Available at: http://www.agrisud.org/en/pays-nosactions/madagascar/ (accessed 14 February 2020).

Andrianampiarivo T (2016) *Les petites prospérités rurales en Itasy, Madagascar. Apport d'une analyse microéconomique des classes sociales intermédiaires dans l'étude des dynamiques du changement structurel*. PhD Thesis, Université de Bordeaux, France.

Bellwood-Howard I and Ripoll S (2020) Divergent understandings of agroecology in the era of the African Green Revolution. *Outlook on Agriculture* 49(2): 103–110.

Donque G (1974) L'agriculture et l'élevage à Madagascar (premier article). *Cahiers d'Outre-Mer* 106(avril–juin): 105–127.

Findlater KM, Kandlikar M and Satterfield T (2019) Misunderstanding conservation agriculture: challenges in promoting, monitoring and evaluating sustainable farming. *Environmental Science and Policy* 100: 47–54.

Fonds Africain de Développement (1995) *République de Madagascar, Rapport d'achèvement, Projet de Développement Rizicole Phase II*. Report. Abidjan: AFDB. Available at: www.afdb.org/fileadmin/uploads/afdb/Documents/Project-and-Operations/ADF-BD-IF-96-44-FR-SCANNEDIMAGE.191.PDF (accessed 4 September 2015).

François JF (1969) Places des légumes et feuilles vertes dans l'alimentation malgache. *Terre Malgache. Tany Malagasy* 5(2): 29–65.

Fuglie K, Gautam M, Goyal A, et al. (2020) *Harvesting Prosperity: Technology and Productivity Growth in Agriculture*. Washington, DC: World Bank. DOI: 10.1596/978-1-4648-1393-1. License: Creative Commons Attribution CC BY 3.0 IGO.

Gassner A, Harris D, Mausch K, et al. (2019) Poverty eradication and food security through agriculture in Africa: rethinking objectives and entry points. *Outlook on Agriculture* 48(4): 309–315.

Gingembre M (2015) Resistance or participation? Fighting against corporate land access amid political uncertainty in Madagascar. *Journal of Peasant Studies* 42(3–4): 561–584.

Grégoire R (1968) L'opération de productivité rizicole. *Terre Malgache. Tany Malagasy* 4: 5–12.

Hatt S, Artru S, Brédart D, et al. (2016) Towards sustainable food systems: the concept of agroecology and how it questions current research practices. A review. *Biotechnologie, Agronomie, Société et Environnement* 20(S1): 215–224.

HLPE (2019, July) *Agroecological and Other Innovative Approaches for Sustainable Agriculture and Food Systems that Enhance Food Security and Nutrition*. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. Rome: FAO.

Institut National de la Statistique (2013) *ENSOMD (National Survey for the Monitoring of Millenium Development Goals)*. Report. Madagascar: Ministry of Economy and Industry, Antananarivo.

Japan International Cooperation Agency (2009–2020) Projet d'Amélioration de la Productivité Rizicole sur les Hautes Terres Centrales « PAPRIZ ». Available at: https://www.jica.go.jp/madagascar/french/office/others/publications01.html (accessed 14 August 2017).

Johnson AC, Jin X, Nakada N, et al. (2020) Learning from the past and considering the future of chemicals in the environment. *Science* 367: 384–387.

Kull CA, Carrière SM, Moreau S, et al. (2013) Melting pots of biodiversity: tropical smallholder farm landscapes as guarantors of sustainability. *Environment, Science and Policy for Sustainable Development* 55: 6–16.

Ministry of Agriculture (2007) *Recensement de l'Agriculture (Agricultural Census). Campagne Agricole 2004–2005*. Antananarivo: MAEP.

Mugwanya N (2019) Why agroecology is a dead end for Africa. *Outlook on Agriculture* 48(2): 113–116.

Neimark B (2012) Green grabbing at the 'pharm' gate: rosy periwinkle production in southern Madagascar. *Journal of Peasant Studies* 39(2): 423–445.

OECD (2020) Purchasing power parities (PPP) (indicator). DOI: 10.1787/1290ee5a-en.

Randrianarisoa JC and Minten B (2003) Accessibilité et utilisation des engrais chimiques à Madagascar. In: *Conférence "agriculture et pauvreté,"* Antananarivo, Madagascar, 20 March 2003. Antananarivo: Programme ILO. Available at: http://www.ilo.cornell.edu/polbrief/03conv/pb1-1.pdf (accessed 24 March 2018).

Razafimahatratra HM, Bélières J-F, Raharimalala S, et al. (2020) Production et acquisition de fumure organique pour la gestion de la fertilité des sols par les exploitations agricoles du Moyen-Ouest de la région Vakinankaratra et de la zone Est de la région d'Itasy, Madagascar. *Journal de l'Agroécologie* 9: 13–25.

Razanakoto O, Razafindraibe R, Andriamananjara A, et al. (2018) Failures in agricultural innovation due to poor understanding of farmers' predispositions. *Development in Practice* 28(5): 691–704.

Rogers EM (1983) *The Diffusion of Innovation*, 3rd ed. New York, NY and London: The Free Press, Division of Macmillan Publishing Co. Inc./Colliers Macmillan Publishers.

SNE (2006) *Stratégie Nationale pour le Développement de l'Utilisation de l'Engrais*. Antananarivo: Ministère de l'Agriculture, de l'Élevage et de la Pêche.

Task Group on Agroecological Transitions (GTTA) (2019) Promouvoir l'agroécologie scientifique en Afrique n'a rien d'immoral. *Tribune*. Available at: www.afrique.latribune.fr/think-tank/tribunes/2019-07-12/promouvoir-l-agroecologie-scientifique-n-a-rien-d-immoral-823476.html (accessed 25 July 2019).

Temple L, Touzard JM, Kwa M, et al. (2015) Comparaison des trajectoires d'innovation pour la sécurisation alimentaire des pays du Sud. *Biotechnologie, Agronomie, Société et Environnement* 19(1): 53–61.

Therond O, Duru M, Roger-Estrade J, et al. (2017) A new analytical framework of farming system and agriculture model diversities. A review. *Agronomy and Sustainable Development* 37: 21.

Wezel A, Bellon S, Doré T, et al. (2009) Agroecology as a science, a movement and a practice. A review. *Agronomy and Sustainable Development* 29: 503–515.

Wirtz B (2019) Exporter l'agroécologie en Afrique est immoral. *Tribune*. Available at: www.afrique.latribune.fr/think-tank/tribunes/2019-06-07/exporter-l-agroecologie-en-afrique-est-immoral-tribune-819747.html (accessed 25 July 2019).