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Socio-economic diagnosis of a small region using an economic modeling tool (Olympe): an approach from household to landscape scales to assist decision making processes for development projects supporting conservation agriculture in Madagascar.

By Penot Eric.
CIRAD UMR Innovation/URSCA-SCRID, Madagascar

Summary

Two agricultural development projects based on conservation agriculture and agriculture/livestock integration are currently being implemented in Madagascar that takes into account both a “watershed approach” and a “farming system approach” for dissemination of adapted technologies: BV-lac in the area of Lake Alaotra and BVPI-SEHP in Vakinankaratra (Central highlands) and South-East. A farming systems reference monitoring network (FSRMN) has been set up since 2007 with two objectives: i) to help the project in decision making processes for choosing appropriate technologies that will be developed according to a farmer’s typology using prospective analysis, ii) to monitor the project’s economical impact in the short and medium term. A farming system modelling approach using a software developed by INRA-CIRAD-IAMM (“Olympe”, JM Attonaty, INRA), has been developed with project operators in order to cope with the local context and its diversity to promote the best adapted technologies for farmers’ conditions including Direct Seeding mulch-based cropping systems conservation tillage (DMC or Conservation Agriculture) and livestock integration. Meantime a new land titling method through “land certification” has been developed since 2003 to secure land tenure.
The approach is based on partnership (smallholder, farmers’ organizations, project operators and local administration), farming system analysis, and modelling for a Decision Support Systems (DSS) project orientation.
This paper presents the methodology, the tools, and some results from the BV-lac project in the lake Alaotra region. FSRMN and farming system modelling (FSM) linked with innovation process assessment tools lead to identification of local innovation processes, adoption and/or adaptation of DMC systems by farmers in order to understand farmers’ strategies and to adapt technologies to the farmers’ situations and constraints. Adoption of conservation agriculture (CA) represents both a real change of paradigm for local farmers and a real challenge for agriculture and natural resources sustainability.
The model provides economic results displaying the real income improvement and impact on farming practices, labour and organizational changes (credit …). FSRMN and FSM have been so far well adopted as tools at project levels to cope with the best combination between farmers’ needs and the projects’ proposals for DMC techniques. At the regional level, CA adoption and livestock integration at farm level, linked with reforestation and regreening on slopes at watershed level provide positive externalities in terms of erosion protection, soil fertility restoration, production consistency and long term based sustainable patterns of production.

Key words: Farming system, modelling, network, DSS (decision support system), conservation agriculture, watershed, Madagascar.

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Introduction

Why should we model farming systems? A model has two main roles: a figurative role in representing the system (how it functions) and a demonstrative role (possibilities and strategies). Combining these two roles leads to an explanatory model whose function is to represent a specific phenomenon that derives from general phenomena (management, accounting, and so on) as a function of the local conditions that characterise the farming systems. (Nouvel 2002). To understand farming systems as a "productive system" and the logic behind technical choices recalls the "systemic approach" (Badouin 1985), widely used in the classical farming systems approach. The approach described here is based on partnership, farming system analysis and modelling for a Decision Support Systems (DSS) for development projects. In the past, methods and instruments were developed to help individual farmers make decisions (Attonaty and Soler, 1992; Attonaty et al., 1999). Today, we are faced with an increasing number of problems in which the several different stakeholders involved have also different interests. The aim is not to find THE optimal solution as do models based on linear programming (Rieu et al., 1994) or game theory (Thoyer et al., 2001) but to create models that lead to acceptable compromises between the different stakeholders.

1 Method; rationale for using the software "Olympe" for Farming Systems Modelling (FSM)

Detailed knowledge of local farming systems and farmers' strategies in different contexts such as pioneer zones, rehabilitation areas or traditional tree-crop belts can contribute to building improved and better adapted solutions to help farmers make the right decision about their future investments at the right time. In collaboration with INRA[1] and IAMM, CIRAD developed a software called " Olympe " that enables the modelling of farming systems (Penot 2003). Olympe is an economic modelling tool to develop farming simulations in order to help individual decision-making at farm level and may be used for project decision making. There is also a module that allows for analysis at the groups of farms scale. Positive or negative externalities can also be integrated thus enabling an approach that takes into account C sequestration from tree crops, the effects of pollution, or any other negative or positive externalities connected with agricultural production.
The first aim of using "Olympe" as a tool to model farming systems is to improve farmers' understanding of their own situation, and of their socio-economic context. Farming systems modelling associated with a farm typology can therefore be used to help projects test scenarios with various types of technologies in order to assess what is the right technology for the right farmer at the right time. Then, it aims to provide guidelines for agricultural and development policies for institutions and/or donors. Olympe can be used in a variety of situations and with different methodological approaches: comparison of cropping systems, the economics of farming systems and resource management ("farm management counselling"[2]), prospective analysis, regional approach, and even for "role game."

Olympe simulator has been developed by J-M Attonaty (INRA Grignon, France) and associated partners from CIRAD and IAMM. It builds simulations for one or more stakeholders, provides results and summarizes the results as a function of the needs of each stakeholder (Figure 1). On the one hand, the simulator enables the simulation of the three years before the first year of the simulation. In this way, each stakeholder can compare the past as simulated by the model with his own results. And on the other hand, each stakeholder can analyze the results obtained by the model for a given number of years (by series of 10 years) using his own criteria (economics, labour requirements, risk factors, etc…).

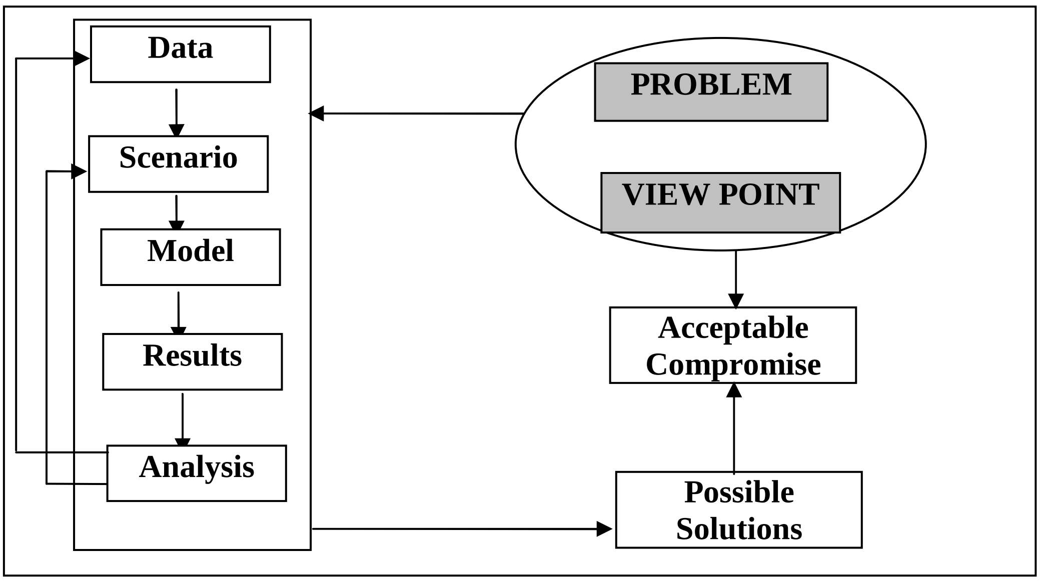
[1] INRA = Institut National de la Recherche Agronomique, IAMM = Institut Agronomique Montpellier Méditerranée.
[2] "Conseil de gestion" in French.

Olympe is based on the systemic analysis of farming systems (see frame 1). The overall objectives of using Olympe are the following:

- To identify smallholders' constraints and opportunities in a rapidly changing environment in preparation for the adoption of new cropping systems or any other organisational innovation.
- To understand farmers' strategies and their capacity for innovation.
- To assess their ability to adapt to changing economic conditions, price crises and technological change.
- To provide a tool to understand the farmers' decision-making process;
- To put information about farming systems in the social and economic context (through a regional approach).
- To undertake prospective analysis and build scenarios based on climatic risks, major climatic events such as "El Nino years" and fluctuating commodity prices.

It is possible to build several scenarios as a function of changing prices, climatic events and different types of risks. It is also possible to calculate impact at the regional scale on various groups of farms (as a function of a given typology). Building scenarios enables this type of prospective analysis as well as the ability to test the robustness of any decision or technical choice. Data analysis obtained with Olympe should be discussed with farmers using a participatory approach in order to validate scenarios and guarantee a high degree of representativeness and accuracy. For instance, a network of selected representative farms can be monitored for several years with two main objectives: firstly, to diagnose constraints and opportunities and, secondly, to measure the impact of technical change. One of the main outputs of such an approach is the assessment of the impact of technical alternatives or choices at the level of the farming system, both from an economic and environmental point of view. Olympe is fed with data from appropriate farming systems surveys and can then provide key information in terms of diagnosis and later, in terms of prospective analysis (see frame 2).
A module in the software enables to deal with farmers' groups at the regional levels. This function can be used to understand various types of flows (inputs requirements and expenses, incomes, amount of credit, products …It has been traditionally used for irrigated schemes in North Africa.

Fig. 1: An iterative analysis of the problem.



Frame 1: Methodological systemic approach for farming systems research.

The **methodology** is based on the following stages that create a framework for implementation:
Diagnosis

---> A preliminary diagnosis based on the study of all available information (bibliography, data collections, key-informants), and an exploratory survey.
Survey of the characteristics of the farming system
---> To understand the constraints, opportunities, income and labour productivity of each cropping system and farm activities. The data analysis should provide an operational typology and a clear identification of constraints and opportunities.
Identification of an on-farm experimentation program
---> The identification of a potential on-farm experimentation program aimed at overcoming technical constraints (technical innovations) or social constraints (organizational innovations). On–farm trial protocols should be identified as a function of the typology. Experiments should be listed in order of priority.
Implementation of on-farm experimentation
---> Implementation of on-farm experimentation using a participatory approach in an "on-farm trials network".
Monitoring farming systems
---> Implementation of a "farming systems monitoring network of reference" in order to monitor technical change and the adoption of innovations, and to assess their impact and externalities at the scale of the farming system and at the regional scale.
Analysis and re-assessment of the research program
---> Feedback analysis with farmers, extension agents and research institutions and the re-assessment of the on-farm trial in a constantly ongoing process of R-D

An agronomic approach comprising of on-farm experimentation linked with a socio-economic approach (farming systems analysis, typology, etc.) provides suitable technical pathways or improved cropping systems for farmers and also ensures adequate conditions for the adoption and appropriation (of innovations) by farmers as a function of the different situations encountered in terms of further rubber development.

The **main tools** used in this type of research process are:

- A network of on-farm trials to test technical innovations.
- The use of a participatory approach to obtain adoptable and more operational technologies more rapidly.
- "Inter-village exchange visits" between farmers from different locations to obtain feedback and to encourage discussion between farmers who have a research plot and those who do not.
- Surveys aimed at on-farm characterisation.
- A network of demonstration plots for the diffusion of information about technologies that have already been adapted and other technologies from on-farm trial results.
- A farming system reference network to monitor changes and evolution as well as prospective analysis

The **results and outputs** are the following:

- Annual and perennial cropping patterns and technologies (technical pathways for monoculture, intercropping, agro-forestry systems, etc...).
- Demonstration plots for information diffusion (trials that succeed can subsequently be used as demonstration plots).
- Manuals and publications for extension and information diffusion.
- An operational typology of situations and farmers leading to the identification of "topics of recommendations".
- A global overview of the possible adoption of rubber technology as a function of farmers' strategies and local conditions.
☛ An ongoing and dynamic database on farming systems using Olympe software.

Frame 2: Type of data required for farming systems modelling using Olympe

Olympe is based on the characterisation of farming systems using a systemic approach. Consequently all the standard information that qualifies the structure and components of production factors of the farm is required. This information can be obtained by means of a traditional survey and as Olympe focuses on the origin of the different sources of income and provides an economic analysis, all this information should be collected:

- cropping systems: crops are divided into annual crops, perennial crops (minimum 5 years) and multi-annual crops (typically banana, pineapple and cassava, between 1 and 5 year cycles),
- Livestock and animal husbandry systems of whichever type of animal
- Off-farm activity: all activity that is not directly linked with agricultural or livestock production, including processing of primary products…

In these three systems, information concerning the cost of production, inputs, outputs and yields should be included here, i.e. all operational costs. If externalities can be quantified, they should also be included at this level. Labour requirements also have to be identified in order to calculate the return to labour, which is a very important factor in making decisions for farmers.
Production system is the "farm level" including the decision maker (the producer) and a strategy for the combination of production factors.
All non operational costs are considered here. So all sources of capital (income, including off farm credits, loans), and all other expenses should be included here. Family accounts and business accounts can be separate but should be recorded. All commodity prices should be collected keeping into account and putting special emphasis on local variations as well as international historical series of prices that will enable the building of potential scenarios.

2 Diversification and DMC/CA as alternatives for sustainable development

The sustainability of agriculture is becoming a major concern. The main questions concerning "ecological sustainability" are linked to the problems of degraded environment and fragile soils and thus fertility, biodiversity, and the protection of watersheds. Crop diversification and rapid technical change characterise the evolution of existing farming systems. It is important therefore to analyze and understand the key elements of the history of these innovations and innovation processes so as to be in a position to make viable recommendations for development. Among other technologies, DMC triggers a real change of paradigm for local farmers. Besides those constraints, DMC techniques, though yields might not be significantly above that of tillage systems, provide a more sustainable production pattern through the climatic buffer effect of mulching and cover-crops.
Frame 3 gives a definition of DMC. According to K Naudin (Pers comm., PhD in progress), DMC "Direct-seeding Mulch-based Cropping system" can be seen as synonymous with CA.

Framed 3: Definition of DMC (systems SCV in French)
DMC which stands for "**D**irect seeding **M**ulch covering **C**ropping patterns" is where the permanent soil cover resembles the natural process of un-ploughed forest ecosystems. The ground is covered permanently by dead or live biomass that comes from the residue of the preceding crop or of an intercrop, such as a legume. This cover intercepts the sun's rays and thus theoretically prevents the development of weeds while also limiting evaporation. A micro climate is established under the cover: the moisture of the ground is preserved and in parallel, the temperature variations of the ground are limited. This, combined with the suppression of ploughing creates an environment favourable to the development of bio-activity in the soil. The cover rich with organic matter then increases the mineralization and the fertility of the soil. The sharp cover allows for physical soil reorganization via its root system and plays the role of a biological pump: just as in agro forestry systems. It allows the recycling of the lixiviated elements, the mobilization of poorly assimilated elements and the use of deep groundwater in the dry season. The suppression of ploughing combined with the limitation on the development of weeds and thus with a suppression of weeding decreases labour and increases labour productivity. This complies with FAO definition of conservation agriculture (CA).

However, we will use DMC because it is clearer and less ambiguous than CA. Although CA has been correctly defined, it is still often used to refer to cropping systems without permanent cover and/or without adapted crop rotations (Baudron, 2005, Ribeiro, 2005), or with topsoil disturbance Ambiguity is greater still with terms such as “conservation tillage” or “minimum tillage” which do not imply the use of crop rotation or cover crop and can imply “tillage” at least within the row and sometimes up to 100 % of the soil surface.
The notion of “economic sustainability” places emphasis on the profitability of specific technical choices such as analysis of margins, generation of income, return to labour and capital as a function of a specific activity, analysis of constraints and opportunities, etc...From the point of view of farming systems, both at the regional scale, and at the level of the “community” where there are serious constraints in land availability, and in access to capital and information. Analysis of farming systems and knowledge about smallholders’ strategies in the different contexts are key factors that should be taken into account. As sustainable development is becoming a new “priority objective”, the rehabilitation of formerly intensively managed agricultural or degraded land also merits consideration. The impact these strategies have on land control, land-use dynamics (agreement on the definition of new types of “territories” between stakeholders) and relations between stakeholders including those not directly involved in agricultural production, should be major topics of research if we are to gain a better understanding of farmers’ strategies in the present context of multiple crises. A constant factor that underlies such strategies is innovation: both the process of technical innovation (technical pathways) and of organisational innovation (farmers’ organisations, access to credit, etc…) are key elements to understanding and qualifying change.

To ensure that the adoption and appropriation of technology by smallholders is effective, further research is required on innovation processes and technical change using socio-economic tools. Negotiations between stakeholders and better knowledge of the relations between the State and farmers are essential if we are to improve the effectiveness of future projects and development actions. The main objective of topic-oriented research centred on the analysis of decision-making processes at different levels (farms, community, projects, and regional or national policy makers) would thus be to provide socio-economic information to policy makers to improve decision-making processes in agricultural development. The processes of innovation (farmers) and of decision-making (both farmers and developers) are key research topics in sustainable development. And the analysis of farming systems, the characterisation of agrarian systems and the identification of stakeholders’ strategies are key components to a better understanding of these issues.
The factors that determine change and the discriminators to be taken into account for the sustainable development of these commodities need to be related to each specific context. Important issues such as the effect of decentralisation, globalisation and its effects on prices, as well as on local economies and public policies, environmental topics (biodiversity, sustainability) are impossible to circumvent.
One expected output would be the clear identification of the conditions required to ensure future projects are viable at the decision-making level. Farming system modelling through a farming system reference monitoring network provides a tool for technical choices made by decision makers with respect to agricultural policy.

The main aim of this paper is to describe a possible global approach using a modelling tool which includes the identification of knowledge gaps and opportunities to promote actions and projects or the implementation of policies that respect the need for sustainable development, as well as those of local stakeholders, developers and researchers. The historical dimension is very significant in this type of analysis even if economic commodity cycles can be very rapid. So far, rebuilding the past with a modelling tool and creating new evolution scenarios through prospective analysis can be linked to improve the efficiency of development-oriented research. The impact of technical change should take into account the effect of sustainability on both farmers‘ livelihoods and on the environment. Success in diversification strategies requires a certain number of conditions: access to capital or credit, technical options (innovations), access to information, markets, and to farmers’ organisations in order to improve marketing, and so on.

3 The References Farming System Monitoring Network (RFSMN): a comprehension tool of farmers' strategies and follow-up evaluation.

3.1 the use of the software Olympe for modelling and simulation

Olympe

The use of Olympe enables a comprehensive understanding of how a given farming system functions and provides as well a tool to model prospective technical choices, price scenarios, and even ecological scenarios (for example the impact of "El Nino" in given years to test the robustness of technical choices and their adaptability in new conditions or environments). These tools can be used at different scales: that of the local community, or that of regional, national or international scale, depending on the stakeholders and on the commodity involved. Emphasis should be on the farmers and on the other people directly involved in the farmers' environment, including the government (development policies at the national level). Participatory and partnership approach, Action–Research (RD) are the main methodologies used in the approach proposed by CIRAD partners.

Management, along with characterisation, is one of the main functions of Olympe and the detailed description and understanding of economic mechanisms at the level of the farm that produce income. Olympe can be used for the management of any agricultural enterprise (whether smallholdings or not, and irrespective of the size of the enterprise) linked to a true contextual socio-economic analysis so as to take into account the overall environment (including its history). In the case of BV lac: modelling here concerns small size familial farms as well as estates (commercial farms). The financial impact of agricultural and off-farm activities on the farm's immediate environment can be assessed through quantifiable positive or negative "externalities". A pragmatic and realistic use would be farming counselling using adaptable and refutable data. Such data should be used in a process of validation by farmers through "feedback meetings". FSM will be used for two main purposes: direct "farming counselling" with commercial farms and perspective analysis with scenarios on technical change with projects and associated operators to identify relevant technologies for the relevant type of farmers. Olympe is not only a tool with an apparently "mechanical" approach to budget calculations. Coupled with the socio-economic analysis of decision-making processes (linked with innovation processes), it importantly reveals farmers' strategies and trajectories. Coupled to the analysis of constraints and opportunities, and taking into account social and environmental variables, Olympe makes it possible to quantify technical decisions from an economic point of view. Economic analysis (budgets, margins, incomes, cost-benefits etc... linked with non-economic factors and in particular social factors, enables the use of Olympe as a tool for dialogue, mostly for representation purposes but sometimes for awareness raising of stakeholders though negotiation.

A prospective tool to assess the resilience of systems in the face of risk

In this case the focus is on providing decision-making aid to administrators, projects, and decision makers as well as to farmers themselves. Analysis of climatic events or the impact of price volatility, or any other economic risk allows the definition of scenarios where the resilience of a given farming system can be quantified. As S Bourfa (CEMAGREF; pers com) pointed out, care needs to be taken into account for the possible or induced perverse effects of "playing with scenarios" whose only validity is how representative they are. Olympe can also be used to reveal such induced or perverse effects. A typical example is that of the introduction of drip irrigation to save groundwater that eventually leads to over-consumption of water. The "revealing character" of FSM leads to enhanced sensitivity by stakeholders to problems that are not initially obvious. In this case, its use is very close to that of role playing

Risk assessment through prospective analysis

Most farmers will already have developed a diversification strategy in the face of market uncertainties, price volatility and climatic risks. They may also have integrated local opportunities for particular crops (for example oil palm with private estates that provide development schemes). As a consequence, prospective analysis may provide ideas for the future, potential or possible trajectories, an assessment of the impact of a technical choice or of several different strategies, assessment of the

robustness of farming systems as a function of fluctuations in commodity prices or of climatic risks, and perhaps the definition of “thresholds” for risks, profitability and viable alternatives. In this section, we will explore how Olympe can provide data on such hypotheses and how scenarios can be built which are then discussed with the farmer to validate the simulation. First of all, the data set needs to be clearly defined. Farming systems are created in Olympe according to a typology that may change as a result of the prospective analysis. The scenarios have to be defined as a function of real possibilities. Historical records and data on prices, and agrarian history can help to identify the scenarios. The prospective analysis is used for the following purposes: i) to test the impact of price volatility of commodities/inputs, to assess the impact of climatic events and reduce risks and test the robustness of technical choices in the short, medium and long term, ii) to assess the impact of farmers’ strategic changes on the structure of farming systems and income, iii) to define financial or economic thresholds beyond which profitability becomes too low or risks become too high, iv) to measure capital/credit requirement to fund any technical change (intensification or diversification..) for technology adoption or adjust the structure of the farming system, v) to measure input and output flows and to assess the impact of any decision on profitability, returns to labour and returns to investment.
From a farmer’s perspective, the objective is clearly to assess the potentials and risks, and to trace potentially profitable farming pathways through the range of possibilities. From a developer’s perspective, better knowledge of the potential economic impact of decisions helps to define better farm counselling, and to measure the potential impact of extension activities and recommendations. For the developer, better knowledge helps to define common descriptors for development, risks and the impact of agricultural policies and markets for both farmers and developers.

Olympe software provides the ability to answer different questions in the study of farmers’ behaviours and to assess the impact of different activities, the changes in farming practices and the decision-making processes. Simulations of farming potential, risk factors and decisions concerning the assignment of production factors (capital, work, land) in the medium and long term are a clear advantage over other tools that are basically more focused on annual results. The economic forecast of incomes, monthly treasury, and labour availability per activity allows the evaluation of the viability of technical or organisational choices to define technical thresholds and possible scenarios for change. FSM makes possible the readjustment of an observed reality of an existing farm, and its future change (real and potential through prospective analysis) and the different impacts these decisions will have.,

The use of FSM has shown that simplification of a given situation is not synonymous with a reduction in, or a loss of information, and consequently is (not) a failure to understand the implementation of systems. FSM generally provides a tool for dialogue and for awareness raising among the different stakeholders, including the producers themselves. When properly validated by those involved, FSM is an operational representation of the decision-making process and of its components.
Modelling therefore allows scenarios and potential pathways to be designed as a real function of needs, requirements and possibilities, at the same time taking into account all non economic factors that specifically characterise the rural world and agricultural production. Farmers do in fact produce a large variety of goods and services in addition to agricultural production; i.e. the conservation of biodiversity, the sustainability of the land and so on. These contributions include the multifunctional aspects of agricultural activities and have to be integrated into management and the design of strategies.

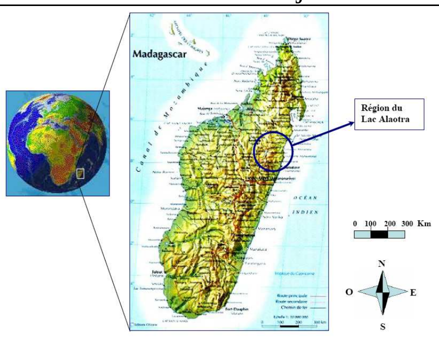
On the other hand, when FSM is linked only to the farmer (as a producer), the need quickly appears to couple this “single-player” farm analysis with other players involved (traders, other producers, decision makers, transporters, etc.) so as to include the significant interactions between markets, stakeholders and the environment. Results obtained with Olympe should be coupled with other tools, particularly for better spatial representation (SIG) or interaction (MAS).
Farming systems modelling can be used as a prospective tool to build scenarios about potential farm pathways, and to define agricultural policies, recommendations, to test the viability of recommendations as a function of local constraints, to assess different impacts, and the matching of policies to the real situation faced by the farmers. Risks analysis is a key component in this approach.

A very recent article from Greiner, R, Patterson and L Miller (2008) suggests that "*One tool for achieving environmental improvements in agriculture is the design and promotion of region-specific 'best management practices' (BMPs). The results demonstrate clear correlations between both motivations, and risk attitudes, and the adoption of BMPs… concluding that a sound understanding of farmers' motivations and risk attitudes is required*". Farming system modelling through a FSMN enables to effectively assess at the farm level risks and expected outputs from a choice. Projects promote generally what they believed are BMP's (including DMC in the case of the lake Alaotra project "BV-lac").

3.1 A tool initially developed in France and adapted for tropical agriculture

A References Farming System Monitoring Network (RFSMN) is a set of representative farms that show various agricultural situations dependent on morpho-pedological and climatic units as well as socio-economical situations, resulting from a typology. Farms are surveyed in-depth then followed and updated every year in order to measure i) the impact of the projects' implementations, ii) the development policies in progress, iii) the resulting innovations' processes. The objective through a follow-up is to measure the impact, the evaluation, the prospective analysis and decision-making process inside projects (choice of technologies to be promoted and level of intensification according to farm types for example…). A prospective analysis (framed n° 3) allows the comparison between potential scenarios and reality. The final objective is to allow development operators in contract with projects to measure impacts and re–orientate rapidly their actions. Data are obtained by farm characterization surveys, carried out in 2007, that collect detailed information on the processes of innovations, the sources of agricultural and non-agricultural incomes according to their technical pathways for all cropping and livestock systems, the various activities and overall constraints and opportunities which affect farmers' strategies. 157 exploitations have been surveyed in zones covered by operators. A meeting of "restitution" on the principal results to the operators leads to a dialogue and identification on a final typology and the final choice of representative farms of the network (see Table 1). Farming systems modelling use the Olympe software. The unit of analysis is the "system of activity" composed of a household and a farm, including all agricultural and not agricultural activities, and sources of incomes and household expenses.

Parallel to the RFSN, the project sets up procedures of plot and farms levels data acquisition whose objective is to obtain detailed and precise data allowing simulation and further prospective analysis,. A general "plot database" common to all contracted operators allows the identification of cropping pattern, with data effectively observed in the fields, that will feed the simulation. With the adoption of "farming system level approach", rather than the traditional "plot level", the project sets up "farming books", on a voluntary basis in order to record farm evolution, description of cropping systems and main simple economic factors and analysis (gross and net margin, return to labour) and to observe tendencies and farms' trajectories.



Map 1 : location of the project BV_lac : Lake Alaotra.

3.2 Identification of a regional operational typology:

The initial criteria of discrimination are the following: i) access to various types of soil with referring cropping systems (irrigated rice plantation, RMME, baiboho, tanety), ii) rice self-sufficiency and farm size, iii) level of intensification and use of inputs and production target (subsistence farming, sale…), iv) off-farm activities and diversification (agricultural productions and non agricultural activities, v) type of labour and material (manual, animal traction, motorization or combined traction) and type and use of labour (familial and external).

Among these criteria, 3 principles were used to identify the typology on the basis of 157 farms surveyed in 2007/2008: rice self-sufficiency, access to various soils and off-farm activities (see table 1).

Table 1 : Farm typology for Alaotra region

TYPES	Criteria 1 : self-sufficiency for rice regarding paddy field type	Criteria 2 : diversification	Criteria 3 : use of external manpower or off-farm activities
A : great rice producer	Irrigated paddy field (5 ha) Self sufficient for rice + selling	Upland field (tanety) (> 4 ha) From low to no cultivation rate Extensive crops	Use of external manpower > 300 of human labour
B : rice producer with irregular yield	Poor control of paddy fields, RMME Self sufficient for rice + sales	Upland field (tanety) + alluvial field (baiboho): 2-3 ha, entirely cultivated Average intensification Cash crops	Use of external manpower > 200 days of human labour
C : self sufficient rice producer cultivating tanety	Irrigated paddy fields + Poor control paddy fields (2ha) Average risk Self sufficient for rice	Upland field (tanety) + alluvial field (baiboho) : 3 ha, entirely cultivated Intensive cash crops	Use of external manpower = 100 days of human labour Off farm activity= services
D : farmers who diversify their production	Poor control paddy fields, (1.5 ha) heavy risk Not self-sufficient for rice every year	Upland field (tanety) + alluvial field (baiboho) :1 to 2 ha. : entirely cultivated Cash crops Breeding	Use of external manpower = 100 days of human labour If area < 1 ha => off farm work
E : non self-sufficient, farm worker	Few or no paddy fields Heavy risk Not self-sufficient for rice	Upland field (tanety) + alluvial field (baiboho) < 1 ha : Very intensive cash crop	Use of external manpower = 0 days of human labour Off farm activity = farm worker
F : fisherman who cultivates	Poor control paddy fields (1 ha) Not self-sufficient for rice	Upland field (tanety) + alluvial field (baiboho) < 0.5 ha : Intensive cash crops	Use of external manpower = 0 days of human labour Off farm activity = fishing
G : landless	Landless Not self-sufficient for rice	Landless	Off farm activity = farm worker

Source : Stefanie Nave et Claire Durand, 2007, revu Penot et BV-lac : 2008.

Modelling of standard representative farms

For each identified type, four farms were modelled with the Olympe software, in 2007/2008, and were supplemented by a series of additional farms essential for a good follow-up/evaluation. The final network was composed of 40 farms. It is very important to preserve a certain degree of operationality in the implementation of the RFSMN. The modelling of real farms is a real challenge in the objective of a final consensus of all final users to promote final appropriation of the tool by operators. Rules and standards were thus defined to obtain a functional modelling (with the participation of Méduline Terrier in 2008, MsC student from SUPAGRO Montpellier) on the following points: balance between operationality and detailed structural farm definition, taking into account of subsistence farming, calculation of an “agricultural income” (without subsistence farming), definition of a total income including off-farm, identification of simple ratios of farm management to assess risks, definition of several categories of “cropping systems” for further simulation.

4 types of cropping patterns were identified:

- traditional cropping patterns
- Traditional “improved” cropping patterns: already including knowledge and know-how from various projects
- Standard “cropping patterns" resulting from plot database analysis used for the prospective analysis in order to identify the best technologies for each farm type taking into account access to markets, knowledge, etc ….
- “standard intensive and/or officially recommended cropping patterns” by GSDM, resulting from the practical DCM handbook (tome II by Olivier Husson et al., 2008)[3] (see table 2).

Identification of accurate cropping patterns is a key function in farming system modelling for decision making process support. Some other models like crop rotation generating tools have been developed and in particular ROTAT (Dogliotti *et al*., 2003), ROTOR (Bachinger and Zander, 2007) and PRACT (K Naudin, PhD in progress). ROTAT is very close to what is intended with PRACT : “*The program combines crop from a predefined list to generate all possible rotations. The full factorial number of possible combinations of crops is limited by a number of filters controlled by the user. These filters are designed to eliminate crop successions which are agronomically unfeasible and form farm-specific reasons that are not practical or desirable. The filters represent expert knowledge in a quantitative and explicit way*” (cited by K Naudin). Such tools can be very useful to effectively select the Best Management Practises (BMP), which can potentially be extended by projects. A close collaboration has been established with PRACT developer (K Naudin, CIRAD, PhD in process, pers comm). BMP are then entered as cropping patterns in Olympe for Decision Support Systems (DSS) for project .

3.3 Use of the “plot databases” from project operators for the construction of “standard cropping patterns”.

The databases of local operators (AVSF, BRL, SD-Mad…) provide reliable indicators on farmers’ technical plot pathways which are monitored by the project so as to build average standard cropping patterns. We need at least a minimum of 10 plots with a homogeneous average of production (Coefficient of variation lower than 30%). The most complete database (from BRL/Madagascar), integrates 2800 plots. A complete review of the main results of these databases led to the identification of more than 50 cropping patterns that took into account: varieties, plot position on the transect, (in particular for Rice cultivation with Poor Water Management, RPWM), level of intensification, access to water during out of season cultivation, etc...

Meanwhile, operators quickly understood that such activities are a way of interesting adding value of their databases. The recognition and the effective formalization of standard cropping patterns force them to interpret these databases and to discover some realities in terms of real input use, output, strategy and global results of crops on plot under their supervision. For instance, concerning the preferred levels of fertilization by local farmers, they are generally close to “F1” level (“average/low” fertilization). In certain zones, this type of fertilization does not produce significant results: in particular on “*tanety*” poor soils (upland hilly soils) for rice, cowpeas and niébé and RPWM rice. On the other hand, chemical fertilization on *Baiboho* soils (grounds with water capillary increase during dry-season) enables DMC cropping patterns with significant cover crops/mulch.

[3] We have two cases then: A) “cropping patterns” with an intensive fertilization of type F2 (F0 = 0 manure and F1 = low amount average) in order to be able to also propose intensive systems for those interested in intensification: generally farmers after 4 our 5 years of DMC practice for example) B) cropping patterns resulting from the GSDM recommendations according to a series of manual dichotomic keys

These observations allow for a rectification of the technical recommendations (and associated actions on credit …) so as to adapt the technical proposals of operators to farmers types and the actual situations and constraints (risks, degree of confidence, type of adoption, level of intensification, level of modification on cultivation methods…). Recording the innovation processes becomes a priority. It was clearly shown the importance "to clean" these databases in order to eliminate distortions and poor or incomplete data. The analysis of these databases largely calls upon the cross dynamic tables for which the operators were formed. Figure 3 and table 2 displays some results.

Figure 3: yield, labour and return to labour for rice and maize based DMC per year of adoption

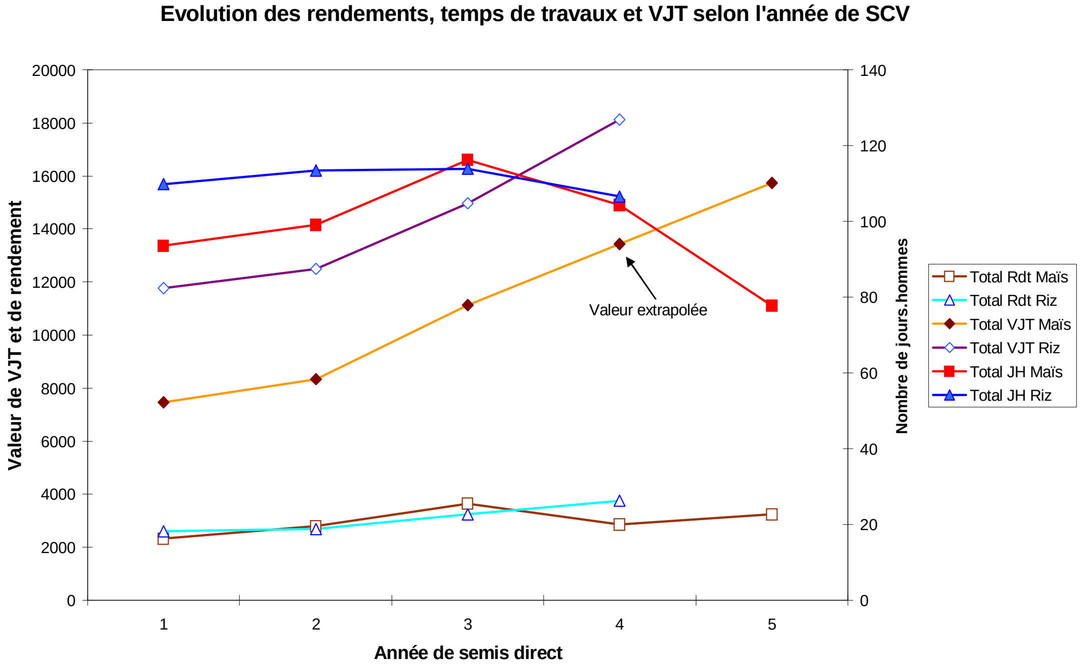


Tableau 2: yields, number of plots for several cropping patterns according to soils sequences (with and without tillage and cover crops)

Cropping systems	Ploughing/DMC	Topographic situation	Average yield (Kg/ha)	Plot Number	ET[4]	Min	Max
Upland rice	Ploughing	Tanety	1947	232	786	400	4615
		Baiboho	2422	513	928	188	5700
	DMC	Tanety	1887	116	839	451	4286
		Baiboho	2450	365	889	227	7143
Specific Upland rice* (Sebota type)	Ploughing	RMME	2737	49	886	101	5000
	DMC	RMME	2516	68	843	643	5027
Maïze + leguminous	Ploughing	Tanety	1984	163	806	458	4333
		Baiboho	2096	45	971	375	3686
	DMC	Tanety	2148	127	766	814	5700
		Baiboho	2475	30	916	1044	4400

* rice with flexibility grown on partially irrigated or upland situation (Riz poly-aptitudes in French)

0[4] Ecart type

3.4 Construction of “recommended” standard cropping patterns according to the system of dichotomic keys.

GSDM promotes the use of simple dichotomic keys for selecting the right technologies apparently most adapted to local plot conditions (soils, climax, etc…). Modelling “step by step” with Olympe is done in the form of a prospective analysis by testing scenarios differentiated according to the farming and socio-economic situations. The definition of the dichotomic keys remains a big step in the process of choosing technologies promoted by projects. 3 sources of information have been used: i) local project plot databases, ii) the official recommendations from GSDM, synthesized in tables of description of cropping patterns from the DMC handbook (O Husson et al., 2009) with generic dichotomic keys (Table 3 provides an example for non compacted upland soils/tanetys), and iii) the use in the long term (2010) of a software tool specifically developed for selection of cropping patterns according to morpho-pedological constraints, “PRACT” developed by K Naudin (CIRAD/URD SCRID): a tool dedicated to selecting the best technical recommendations taking into account the local constraints, supplemented by a second software “GANESH” at farm level

3.5 Indicators of management and measurement of risk

The global approach is based on the “farming system approach” (taking into account the farm level and not the plot level), knowledge on innovation processes and farmers’ strategies and farming system modelling for prospective analysis through a reference farming system monitoring network. The software enables the creation of scenarios based on various types of adoption and modification of technical patterns (cropping or livestock), more or less intensive. Then, the objective is to test the robustness of technical choices, and then the impact on production systems caused by climatic risks (cyclones, output lower due to the attack on a plant’s health, excess or lack of water, etc…) or economic (impact of the volatility of the farm prices and the inputs). Indicators (standard formula Excel type) allow to calculate ratios and variables of management such as: return to labour and capital, total calculated income before self-consumption, net income per familial labour unit (person effectively working on the farm), real net income (after subsistence and self-consumption) equivalent to “net balance” as well as indicators on the control of self-consumption with a comparison to farmer’s declaration, subsistence farming being a very important factor and economic ratios allowing to measure risks (compared to credit): return to capital, debt ratio….

The identification of simple ratios and the consequent analysis of the financial farm situation after a technical choice, a real or simulated one, largely facilitated the appropriation by operators and led to a better integration of their recommendations, while taking into account the concepts of risk for the farmer (in particular with respect to the credit of countryside). For example: where is the best output from an investment of 2 bags of NPK: fodder for dairy production, DMC on upland, DMC on lowland, irrigated rice, dry-season crop? Such an approach allows operators to better include and understand farmers’ strategies in production factors allowance and finally in the farmers’ priorities of resource allocation according to their knowledge, their own experimentation, their potential opportunities and their current situation.

Risks lead to shocks and disturbances. Impact strength can be regarded as the capacity of a system to overcome disturbances while maintaining its vital functions, its structure and its capacities of control. It is thus important for the capacity of a system to be able to resist by maintaining the essence of its structure and “modus operandi” while including the possibility of any change. It is based on the conditions which maintain an initial balance though potentially unstable which can lead to another balance. One can measure it by the magnitude or the level of disturbances a system can resist or absorb until the rupture or the change of that system’s structure. The robustness can then be interpreted like a particular impact strength according to a definition close to that used in statistics.

Risks are assessed through the use of the “hazard module” in Olympe which enables the creation of scenarios with any changes in inputs/output prices as well as production and yield.

Conclusion

3 RFSMN’s are currently been set up: i) with the BV-lac project in the area of lake Alaotra, the most advanced and already operational, ii) with SCRID in the commune of Andranomalanetra, Vakinankaratra (highlands), which could be used to test the impact of new systems containing rain-fed rice and iii) the network in construction of the project BVPI (Bassin Versant/Périmètres irrigués, Watershed and irrigated schemes) in Vakinankatratra. Farming system analysis, training and modelling with a simple tool (Olympe), linked with the use of existing plot databases managed by operators contributed largely to the effective development of a real “farming system approach” in these projects. Training and the use of the tool lead to a real pedagogic impact on various operators. Extentionists and staff managers start to adapt their recommendations and feel more empowered to take responsibility in their extension activities. Counselling from plot to farm level is a real challenge, supported by an effective tool which eventually does become easy to handle. However adaptation and modelling conventions did take almost one year to be set-up. Processes of innovations are better recorded and integrated into the analysis.

Those involved now have two tools at their disposal that permit them to realistically measure the impact of their actions on the change of technique, the returns, on the evolution of agricultural exploitation, and on the future of certain technologies that became innovations. The case of SCV is a strong example that has also largely contributed to the adaptation of its very particular and specific agricultural systems towards a stronger more encompassing adaptation (simplification, adaptation, medium/low intensification, increase of the possible range of the techniques functioning for the local specifics). The idea for support of the different services for agriculture (dispersion, credit, supply, commercialisation) were changed and their importance finally accepted by the operators whose initial goals were simple and concise: to have the maximum of parcels improved without regard for the type of exploitation. The installation of tools has therefore vastly contributed to the strengthening of the approach itself and its usage and acquisition by the development operators in a type of “learning by doing” training approach. A key element was equally the participation of the genuine partners since the beginning of the operation in July 2006 at Lac Alaotra. The concept, the approach, the donations, and the results were all explored, analyzed, and validated by the operators which in turn strengthen their will to understand, master, and use the tools presented in this text.

It still remains, at this time, to implement adaptations to render the RFR operational and especially to find the best equilibrium among the simplicity of the tool, its representativeness, and its level of complexity in order to maintain a tool that does not twist or lose the initial objective. The numerous complementary studies on the abandonment of the SCV (Narilala Randrianarison, 2007), on dairy production (Randrianasolo Jery, 2007, et Marta Kaspryck, 2008), on the integration of agriculture and animal husbandry, and on the practice of credit (Maud Oustry, 2007) gives a clearer picture by complementing the necessary information so as to describe the practice and the itinerary techniques. The training of project personnel and operators on the techniques of simulation and the construction of the scenarios is long and almost permanent in the beginning (at least for the first year).

If the goal of this article is to present the approach and the tools actually used and placed in the projects of BV-lac and BVPI, there still is a need to do the value analysis in the near future of the results based on the data obtained from the parcels and those of the more interesting scenarios coming from the work of each development operator in his respective zone.

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