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

E. Penot

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Organizers:
Jean-Laurent Pfund (j.pfund@cgiar.org) and Laurène Feintrenie (l.feintrenie@cgiar.org)

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

Abstract
Two agricultural development projects based on conservation agriculture and agriculture/livestock integration are implemented in Madagascar with both a "watershed approach" and a "farming system approach": the BV-lac project in the area of Lake Alaotra and the BVPI-SEHP project in Vakinankaratra (Central highlands) and South-East. A farming systems reference monitoring network (FSRMN) has been set up 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. The farming system modelling approach is based on a software developed by INRA-CIRAD-IAMM ("Olympe", JM Attonaty, INRA), 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. 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.

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

Introduction

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. To understand farming systems as a "productive system" and the logic behind technical choices recalls the "systemic approach", 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 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 or game theory 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[*] 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 at regional level with farm groups that allow the assessment of various types of flows between groups (farmers' organisation, villages ….).

Farming systems modelling associated with a farm typology can therefore be used to help projects in testing scenarios with various types of technologies (and risks) in order to assess what is the right technology for the right farmer at the right time according to farmers' strategies. 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"[†]), prospective analysis, regional approach, and even for "role game."

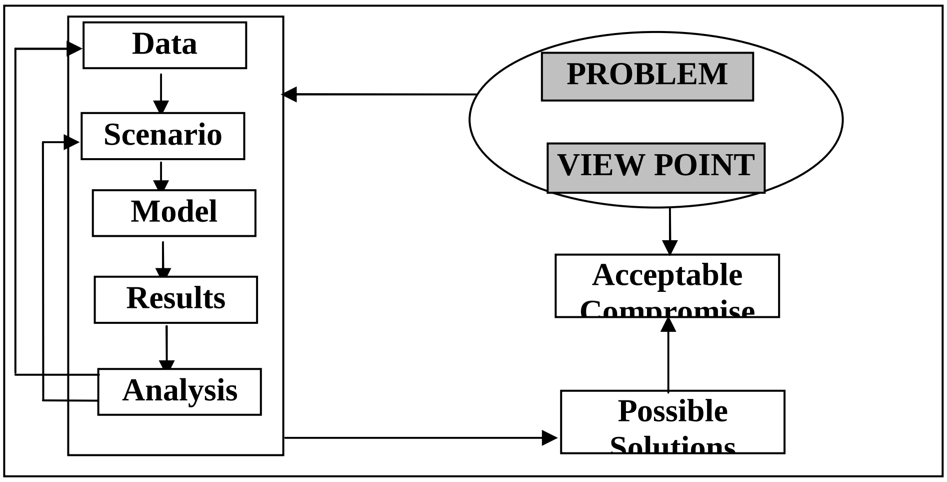
Olympe simulator has been developed by J-M Attonaty (INRA Grignon, France) and associated partners from CIRAD and IAMM. It builds simulations by series of 10 years for one or more stakeholders, provides results and summarizes the results as a function of the needs of each stakeholder (Figure 1). Olympe is based on the systemic analysis of farming systems. The overall objectives of using Olympe are the following: i) 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 and to understand farmers' strategies and their capacity for innovation., ii) to assess their ability to adapt to changing economic conditions, price crises and technological change, iii) to provide a tool to understand the farmers' decision-making process and to put information about farming systems in the social and economic context (through a regional approach), and iv) to undertake prospective analysis and build scenarios based on climatic risks and fluctuating commodity prices.

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 trough prospective analysis allows to test the robustness of any decision or technical choice. Data analysis obtained with Olympe should be discussed with farmers in partnership in order to validate scenarios and guarantee a high degree

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

of representativeness and accuracy. For instance, a network of selected representative farms can be monitored for several years to diagnose constraints and opportunities and 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 from an economic and environmental point of view.

Fig. 1: An iterative analysis of the problem.



2 Diversification and CA (Conservation Agriculture) as alternatives for sustainable development

The sustainability of agriculture is becoming a major concern. Ecological and agricultural sustainability are linked trough degraded environment, fragile soils, 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 innovation processes so as to be in a position to make viable recommendations for development. Among other technologies, CA techniques are based on 3 main items: no tillage, associated permanent covercrops and crop rotation. CA triggers a real change of paradigm for local farmers. Besides those constraints, CA 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.

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.

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 in a sustainable development perspective 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' livelihood 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.

From farmers to developers
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 to test the robustness of technical choices. 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.

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. 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 drop 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 game. 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. Farming system modelling through a FSMN enables to effectively assess at the farm level risks and expected outputs from a choice.

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

A References Farming System Monitoring Network (RFSMN) is a set of representative farms that show various agricultural situations dependent on soil/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 (Penot, 2008). 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 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.

Parallel to the RFSMN, 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 "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.

Identification of a regional operational typology:

The criteria of discrimination for the farm typology are the following: i) access to various types of soil with referring cropping systems (irrigated rice plantation, poor water management rice fields, upland crops on "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).157 farms were surveyed in 2007/2008. 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 48 farms. 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 120 cropping patterns that took into account: varieties, plot position on the transect and practices.

Construction of standard cropping patterns according to the system of dichotomic keys.

The use of simple dichotomic keys for selecting the right technologies apparently most adapted to local plot conditions (soils, climax, etc…) are currently used. 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. We currently use several modalities to identify the adapted cropping pattern to be recommended: i) the use of local plot databases as presented above. ii) the use of the official recommendations from GSDM, synthesized in tables of description of cropping patterns from the CA handbook (O Husson et al., 2009) with generic dichotomic keys, 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) in 2010.

Indicators of management and measurement of risk

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 traditional economic variables of management. 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. 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 (lake Alaotra and Vakinankaratra). 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. Processes of innovations are better recorded and integrated into the analysis. The farming system approach allow as well to better consider other level of action such as farmers' organisations for services (required for CA adoption such as information, credit, access to inputs or marketing…) or the regional level (watershed, village area, community territory…).
The case of CA 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.
There still is a need to implement a value analysis in the near future of the results obtained from the more interesting scenarios compared to what effectively happened in the last 5 years.

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