Use of relevant economic indicators for the evaluation of farming systems in terms of viability, resilience, vulnerability and sustainability: the case of the Lake Alaotra region in Madagascar

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Résumé

L'initiative de l'Observatoire des Agricultures du Monde (OAM) vise à construire un observatoire mondial permettant de donner des informations sur les agricultures des différents pays ainsi que sur leurs évolutions. Madagascar est un des pays pilotes choisis, avec le Lac Alaotra comme zone d'étude. Les concepts de vulnérabilité, résilience, durabilité et viabilité,ont guidé le choix, le calcul et l'analyse des indicateurs qui ont structuré la conceptionde l'observatoire. Trois bases de données différentes ont été retenues dans le cadre de cette étude : i) labase de données du Réseau des Observatoires Ruraux (ROR), qui fournit des données annuelles de 2005 à 2008 pour 500 ménages, ii) La base de données du diagnostic agraire BV-Lac de 2007 avec 110 fermes et iii) la base de données du Réseau de Ferme de Référence (RFR) avec 48 fermes en 2009, du projet BV-lac. Cette communication explicite les concepts et les indicateurs utilisés pour évaluer les systèmes de production étudiés et propose une illustration des résultats à partir d'un calcul des indicateurs appliqué au changement technique par adoption de l'agriculture de conservation.

Mots clé : observatoire, indicateurs,vulnérabilité, résilience, durabilité, viabilité, Madagascar

Summary

The WAW initiative (World Agricultures Watch)intends to elaborate a worldwide observatory collecting information on agriculture in different countries and its evolution. Madagascar has been chosen as one of the pilot countries. The geographical area of the study which has been chosen is the lake Alaotra. The study of the notions of vulnerability, resilience, durability and viability has been the main point concerning the choice, the calculation and the analysis of the necessary indicators leading to the elaboration of the observatory.Three different data lines have been chosen: i) The database from the ROR, with annual data from 2005 to 2008 for 500 households ii) The database from the agricultural diagnosis BV-Lac in 2007 (110 farms) and iii)The database from RFR, with 48 farms in 2009 .This paper presents some results with farming systems modeling using the two databases from the BV-lac development project showing the indicators used through the example of a technical change with adoption of conservation agriculture.

Key words :world observatory, viability, vulnerability, resilience, durability, indicators,Madagascar

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Introduction

Recent food crises, persistent pressure onagricultural commodity marketsand concerns about land appropriation insouthern countriesplaceagriculture at the heartofpublic policyand raise questions about farming systems capacity to react to local environments and changes. In Madagascar, as in many developing countries, agriculture remains the foundationof rural society. Agricultureis undergoing profound changesandhas to facemany challenges. Reducingrural povertynecessarily involvesagricultural productivity improvement, crop and

activitiesdiversification, abetter market access, while preservingnatural resources. Such challenge requires a better knowledge on farming systems trajectories and evolution.The main issuesrelate tothe vulnerability, sustainabilityand resilience of “activities systems” (a household+ a farm) that is our main system presented in this paper.
What will be farmers‘strategies toprevent or to respondto a shock?
Which householdsare mostvulnerable? What are the strategiesthat increasefarm’s resilience? What are thecharacteristics of differenttypes of agriculture, their dynamicsand their impactsin terms ofsustainable development?
Thisstudy (funded by the OAM/WAW project) focuses onan example located at lakeAlaoatrain Madagascar calculatingsocio-economic indicatorsofsustainability, vulnerability, and resilience in order to discuss about the most adapted farming systems to different type of shocks. It is based on2 farms databases from the “Bvlac” development project:the 2007farming system diagnosis (Durand et Nave 2007) and the 2010 Farming System ReferenceMonitoring Network (Penot, 2008).LakeAlaotrais located in the provinceof Toamasina, northeastof the capital Antananarivo,at 750mabove sea level.It is avast flatlandsurroundedbyhills(*tanety)*between750 and1500mabove sea level, characterizedbyaquite aggressive erosion process (*lavaka).*It is a majorrice-growing areawith over 110,000hectares of rice fields fromwhich30 000ha are irrigated with the restintraditional perimeterwithoutfull water control. It can be considered as a " slow pioneer front”(GarinandPenot, 2011) with a high population pressure on *tanety* and upland soils leading to erosion andsilting ofirrigation schemes. Since the disengagementof the State in 1991, maintenance ofirrigation networksbecomes more difficult. The 2000’sare characterized bythe revivalof local development projectsamongwhich the projectBV-Lake is the most important. It focuses since 2003onwatershed protection, land certification, diffusion of conservation agriculture, livestockimprovement and farmers’ capacity building.

1 A focus on risks with upland agriculture and farming systems’ resilience

The Lake Alaotra region is rich in information and results of various studies or surveys (Farming System References Monitoring Network/FSRMN, plots and farms databases, livelihood Monitoring Network ...) that enable to test and apply tools and methods presented in this paper. Risks are assessed through a sensibility analysis using different scenarii based on real events (prices series, climatic effects and variations , cyclonic effects …). Resilience is assessed through impact assessment of one or several combined shocks on farm structure, labor use, net annual income and net annual cash balance. Viability is assessed trough income evolution on a 10 years basis as well an accumulated cash balance to identify farm status: capital accumulation (and potential investment), static situation or de-capitalization leading to disappearing.
Sustainable agriculture is composed of productive and commercial functions but as well environmental and socialfunctions which are not “merchant”.Rural societies are deeply affected by changes in agricultural policies, trade globalization, privatization of services and sectors and demographic pressure. Farmers and other actors make their choices in this changing environment, without complete knowledge on further consequences. They try to improve their livelihoods and escape poverty through production intensification (when inputs prices do allow it), diversifying products, or looking for off-farm activities. In agriculture, the

scientific community search for methods and tools to assess farm sustainability and resilience in a context of global uncertainty. The selected indicators identified as relevant should reflect the issue centered on the various forms of farming, on viability, sustainability, vulnerability and resilience of agricultural activity. The central hypothesis is that the way agricultural activities are organized affectsrenewable resources, environment with social and economic dimensions. The selected indicators will be used to understand the strategies of households and notably their contribution to sustainability. These indicators concern the “activity system activity”(Chia, 2005) defines as a farm + a household as, indeed, in many situations, off-farm incomes directly contribute to the sustainability. This approach is consistent with the conventions adopted by the FAO which defines several farm categories according to the share of agricultural income in total income.

Once the concepts of vulnerability / resilience have been defined, selected indicators should reflect the evolution of agriculture in time and structure. Indicators are tools for monitoring, evaluation, forecasting and decision support (both at farmers and project level). The main quality of an indicator is its ability to report concisely complex phenomena. They are defined with reference to goals or issues previously determined by actors. These indicators should be consistent with those defined at international level for comparability, but also in order to potentially extrapolate results to larger groups. They should be selected to identify relevant sustainable development issues at regional or local scale. Monitoring indicators are used to describe the links between the nature of farming systems (familial, entrepreneurial ...) and their characteristics in terms of vulnerability and sustainability.

2 Methodology and data

Data are providedfrom two databases (BV-Lake project). The first farm database concerns the diagnostic 2007 survey (Durand, Nave & Penot, 2007) on 110 farms, used as a basis for the creation of a farm typology and aFarming System Reference Monitoring Network(FSRMN). It serves as a reference for project operators to measure the impacts of current actions and innovation processes. The second database is the FSRMN (Penot, 2008) which is a set of representative farms of different farming situations, monitored from 2007 to 2011to measure the impact of innovations and farm trajectories (48 in 2008, 14 in 2011). The resultsalso allow prospective analysis to test new scenarios. The comparison between the potential scenarios and reality at the end of each year improves project decisions on extension.

The FSRMN provides relevant information on the following points: i) gross or net margins / ha, labor productivity, income distribution between activities and different strategies, ii) adjustment ofproject recommendations to real trends and farmers possibilities (technical advice, credit, annual work planning….), iii) costs for differentlevel of intensification for members of farmers’organizations (FOs) to improve ability to negotiate commercially with traders, iv) also allows a better understanding of global impact on farms’trajectories, v) anticipate problems (marketing, access to inputs ....) and vi) better estimate the possible degrees of empowerment of actors (producers and FOs) based on economic performance actually observed. Data have been processed using “Olympe”, a farming system economic simulation software, widely used in Madagascar (Penot, 2012). Olympe is first used to process data on an expost basis in order to provide a real image of the existing situation. A further prospective analysis (ex ante) is therefore performed to explore scenarios with extensionists and identify the best alternatives according to farm types. Simulations are based on results obtained from the previous ex post analysis

3 The relevant concepts

Viability is the main chosenconcept used to qualify indicators (Loyat, 2008). It is used to measure the performance of different types of activity systems (farm + household). Viability is used in its raw definition:the ability of territories or any entity to survive; or more widely as the character to survive, last and grow. Farm viability implies to survive in the long run. There are different ways to measure viability:i) the ability of a system to experience some disruptions or shocks while maintaining vital functions and control capabilities through the concept of resilience, ii) the ability of a system to survive through the economic, environmental, social and institutional sustainability.Viability is assessed trough resilience and sustainability. We include the notion of "vulnerability" (possibly a permanent state for the poorest) into farm resilience (a global capacity). Vulnerability is the capacity of a system to effectively suffer from a shock leading to an increased fragility and a lesser resilience.

The concept of sustainabilityis usedsince the 1990sto describethe configurationof a human societythat is perennial. Such human organizationis based on maintainingasustainable environment and both aneconomic developmentthrough anequitablesocial organization. Ittakes into account thesocial aspect throughthe challenge against poverty, inequality and social exclusion. In 1987 theBrundtland Reportdefined sustainable developmentasthe goal ofdevelopment compatible with theneeds of future generations: it isthen defined as"a development that meetspresent needs withoutcompromising the ability offuture generationsofmeet their own needs". ForLandais(1998)agricultureissustainableif itisenvironmentallysound: itmustpreserve the qualityof natural resources andimprove the dynamicsof the entireagro-system.

There are manydefinitionstodefinevulnerability. Itcan be described asa functionofreducedrisk and threatofadaptivefarmers'responsesto issues.In a pragmatic perspective, vulnerability and sustainabilitycan be seenas two sidesof the same coin(Winograd,2006). The notion of resilienceisoften associated withvulnerabilityyet these twoconceptsare quite different: i)theresiliencehadits originsin the theoryof psychological and human development(Lallau, 2011). This wordgenerally describesthe abilityof the individualto faceadifficulty ora major stress.There are tworelevantdefinitionsof resilienceaccordingto Guderson&Holing(2002) (Gunderson,2002): i) The firstisa "traditional" resiliencethat determines the level ofvulnerability of a systemsubjectedto random disturbances(ie not-expected) thatexceedthe control capacityof the systemto failure. It is based onthe optionsof stability,resistanceto disturbance andspeedofreturn to equilibrium.Theseauthorsdefine it as "engineering resilience"; and ii) the second definition considers resilience as the ability of a system to experience some disruptions while maintaining vital functions and control capabilities: in other words a resilient system providessustainability. The ability to resist to shocks while maintaining the bulk of its structure and its operation prevails while including the possibility of change, both in structure and functioning. This vision seems more practical for living systems or humans when determinism is much less predictable. Conway (1987), finally, defines sustainability as the ability of an agro-eco-system to maintain productivity when subject to major disruptive events, of any kind. It introduced the concept of resilience.

What are the connections between concepts and indicators? Viability is a current immediate status as sustainability is observed in the long term.

Vulnerability reflects the external pressures to which individuals are subjected. However, they are not deprived of any ability to respond, as outlined in the concept of resilience. To analyze the vulnerability is not only identify the overall risk for each individual household or in a place and at a given time, but also their responsiveness and resilience, that is to say the overall capacity reaction to implement all the options available to them to resist the negative effects of shock and recover. Indeed, although constrained by a wide variety of risks, individuals act on their environment and their living conditions through preventive and offensive strategies. The three factors used to study the vulnerability and resilience: i) The risk exposure / risk description, ii) the ability to withstand shocks and coping strategies and iii) the dynamic effect of shocks.

The risk is linked with action that leads to a specific set of possible outcomes whose value is known, each result being paired with a specific probability. The risk at the macro level, according to orthodox economic theory, is that of expected utility, strongly challenged in the 1990s. The risk at the micro and meso-economic level appears to be a major factor to consider; and resilience of production systems will be dependent on the ability to identify and manage risks of all kinds, especially the risk of crops, climate risks, economic risks (related to price volatility) and ecological risk often neglected in favor of an immediate return.The risk is as much important as prices in agricultural activity. If it seems clear that price volatility has only a very small influence on the overall level of production in a country, the impact at farm level can be much larger and jeopardize the reproduction of system when prices are too low or too volatile. The two most important identified risks remain i) the risk that climate plays on cultural practices linked with the level of intensification and ii) the economic risk (price volatility, speculation strategy ...).

4 Identification and use of indicators

The FSRMN is a network of 14reference farms in 2011 (starting from 48 in 2009). Prospective analysis from 2008 to 2010 lead to the selection of the most representative farms in order to simply the network and the scenarios. The objective of prospective analysis with scenarios is to understand, by all extension operators, the pro and cons of conservation agriculture (CA)technologies proposed by the projectBV-Lac (CA crop performance, intensification, credit etc...).Scenarios have been built to assess the impact of technical choices on the production system (labor, economic performance, capital required etc..) and the resilience of the new system (Cottet, 2010).The building of these scenarios involves two steps: i) the first step is to compare technologies adopted and ii) the second step is to generate climatic and economic hazards in order to test the consequences of farmers' technical choices on farm structure and resilience (Penot and Deheuvels, 2007).The risk of adoption and technical choices can be therefore assessed (Cauvy& Penot, 2009).Such analysis is implemented as a Decision Support System (DSS) at project level in order to explore with extensionists the recommendations domains.Olympe allows to calculate classical economicindicators, , that are also present in the list of indicators used by OAM (Bosc and Le Cotty, 2009):i) Gross Margin and Operating Expenses, ii) Net margin for agricultural activities (equivalent to net farm income); iii) Return to labor, iv) Ratio of intensification and return to capital, v) Total Net Income (net farm income + off-farm income), vi) Cash Balance (after all expenses including that of family) and vii) Debt ratio and proportion of off-farm income in total. We can therefore estimate the impact of any hazard (climatic, economic, social, familial, etc...) and predict the effects of any shock on a given new situation with technology adoption. Only economic indicators are presented in this short paper as many others are effectively available as well.

5 Hypotheses and results

Some hypotheses are tested: i) the different forms of organization for farming explain their level of viability, ii) diversification strategy can be multiple, iii) households available capital might condition their vulnerability and resilience, iv) households that cannot subscribe to formal insurance mechanisms use other forms of insurance to limit risks, v) households do not all have the ability to turn an income increase into rising living standards in the long run, vi) the degree of risk determines the investment farmers are willing to do in a given cropping system. Farmers' strategies depends on real risk assessment, vii) there is less interest in investing in a plot in sharecropping, viii) some factors may reduce the poverty and vulnerability of households, ix) a good nutritional status of family workers can increase the resilience and x) according to their level of risk aversion, some farmers prefer to make extensive agriculture rather than intensive ones with a potential better income.

An exampleto illustrate the approach

We take the example of a given farm that represents a traditional farming system of Lake Alaotra. Rotation is based on a three year rotation of peanut/cassava/fallow (reference rotation in figure 1). Land is rented for three years. Therefore,there is no investment on the land, no or few weeding and the farm seeks to maximize its returns. The farmer is interested in CA. Several possible farm trajectories according to CA technology adoption will be tested in order to identify the "best bet" alternative and the lower risk for change.

- **1stsimulation: 1**hectare oftraditional crops is replaced by a classical two years base rotation of mais+dolic//rice CA system ("classic" in red on the figure)
- **2ndsimulation : 1**hectare oftraditional crops is replaced by a two years base rotation of mais associated with cowpeas+dolic//rice CA system ("optimal" in green on the figure)

Figure 1 : Farm balance without and with AC technology(SCV in french)

SCV = CA

The first simulation create stability with far more stable cash balances after 10 years. The increasing cumulated cash balance improvesfarmers' investment capabilities. The second simulation increases the global effect and the net income. Such trajectory was considered by farmers as the most adapted and optimal to their situation before 2008 (before the doubling of input prices).

3rdsimulation :increase of a shock on fertilizer price

The majority of extension operators have promoted the second pattern from 2003 to 2008 (in blue). However from 2008, following the doubling of fertilizer prices, farmers moved to a low input CA system and eliminated fertilizers (from both classic CA and optimal CA systems).

Figure 2 : Impact of 50% fertilizer price increase on farm balance

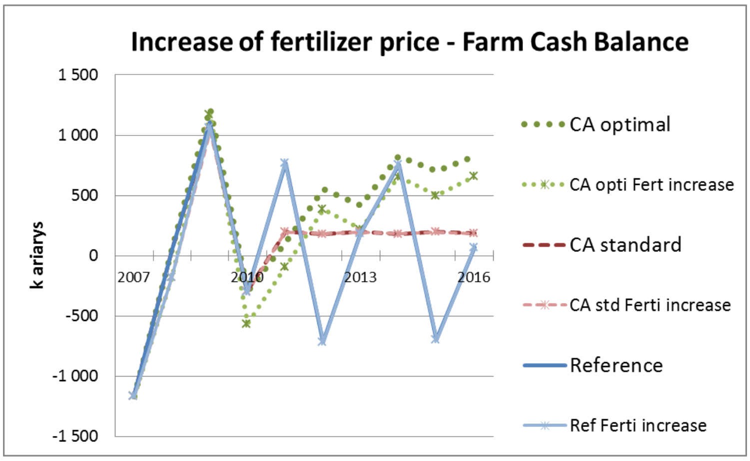
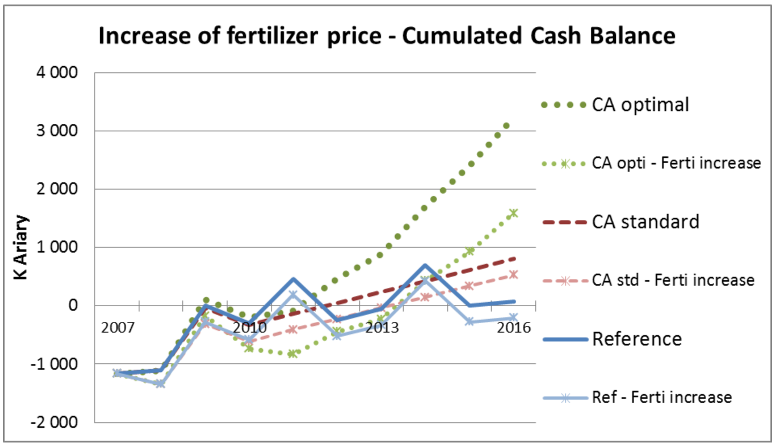


Figure 2 displays the impact of the shock due to an increase in fertilizer prices of 50%. Despite that, the "intensification" trajectory (so called optimal) remains the most interesting. The optimal CA system is in fact more resilient than the classical CA one. Thesescenarios results are challenging the "extensive" strategies effectively chosen by farmers since 2008 as risk is considered as far more increased with fertilizers (in particular if credit is required). Farmers'choices, however, can be justified by fear of credit failure and interruption of fertilizers availability (a realty in 2001). They return to a CA low input cropping pattern.

Figure 3 : Impact of 50 % fertilizer price increase on cumulated farm balance



The simulation of the decline of in rice prices by 40% give the best results also for the second CA.

- **4thsimulation: combination of shocks on fertilizer prices and rice prices**: it is again the second CA system that obtains the best results.

The choice of the CA maize/cowpea/dolic – rice system allows a higher cash balance and provides more resiliency to the farm. However it is considered as more risky by most farms which seem theoricallyantinomic. In fact the risk is considered socially as not acceptable whatever economic performance. It emphasizes that risk on farmers' point of view is probably over emphasized as long as the technology has not proven its efficiency which takes a minimum of 5 years with CA. Farmers'behavior may appear as not rationale in the long run but most farmers still have a short term strategy. After 5 years of CA adoption, a better knowledge and results (yield stability etc …) modify their perception of CA.

6 Conclusion

Many agricultural projects have been implemented in the Lake Alaotra area since the 1960's, creating a real innovation process, in farmers' strategies and a real changes in agriculture. With the BV-Lac project assessment frame, it seems important to integrate farms that are not supervised by the project in order to assess real impact of any changes and to take into account the typology as farm types and associated strategies are quite different in term of risk and technology adoption. The basic data of the FSRMN, built from the initial 2007 agrarian farming systems diagnosis, should be seen as a tool to obtain information on vulnerability and resilience through the establishment of different scenarios, to understand the effects of different technology adoption and different types of shockson the performances and strategies of farmers. This is complementary to the analysis of other available databases, especially the ROR (Rural Observatories Network), which focus more on livelihood (Andrianirina et al, 2011).

Bibiographie

Andrianirina N. (2011), Benoit-Cattin M. David-Benz H..Trappes de pauvreté et trajectoires de livelihood des ménagesruraux à Madagascar. 5èmes Journées de recherches en sciences socialesles 8 et 9 décembre 2011, Montpellier, France, 12 p.

- Bar Marie. (2011). Indicateurs de vulnérabilité, résilience, durabilité et viabilité des systèmes d'activité au Lac Alaotra, Madagascar. CENTRE D'ETUDES ET DE RECHERCHES SUR LE DEVELOPPEMENT INTERNATIONAL. (UMR CNRS 6587). UNIVERSITE D'AUVERGNE. Mémoire Master 2 « Analyse de projet ». 121 p. Projet OAM. 2011.

Bosc P M., Le Cotty T., (document collectif), (2009), Définitions de la performance. La viabilité des différentes formes d'organisation de la production, Note méthodologique, document de travail, CIRAD. 21p.

Bruntland commission report (1987). Our Common Future.Oxford UniversityPress, London, 1987.

Cauvy S., Penot E., (2009), Mise au point des scénarios en analyse prospective et des simulations sur les exploitations agricoles du réseau de fermes de référence, Document de travail n°43, BV-Lac, 28p.

Conway Gordon R (1987).The properties of agroecosystems.Agricultural Systems. Volume 24, Issue 2, 1987, Pages 95–117.

Cottet Lionel et Penot Eric (2010). Mise au point des scénarios d'analyse prospective développés sur les réseaux de fermes de référence (RFR) au sein du Projet BV Lac Alaotra : modélisation et préparation des recommandations techniques et plans de campagne PTA pour 2010. Rapport BV-lac. 2010. 101 p.

David-Benz H., Benoit-Cattin M., Ramboarison R., (2010) Evaluation du Réseau des Observatoires Ruraux à Madagascar.45 p.
Durand C. Nave S. (2007). Les paysans de l'Alaotra, entre rizières et*tanety*. Étude desdynamiques agraires et des stratégies paysannes dans un contexte de pression foncière, Lac Alaotra, Madagascar.IRC/ESAT 123 p.
Garin P., Penot E. (2011). Charrue et variétés de riz. Maîtrise sociale des savoir-faire techniques au Lac Alaotra, Madagascar .Revue d'anthropologie des connaissances, 5 (3) : 573-598. [20120109]. http://www.cairn.info/revue-anthropologie-des-connaissances-2011-3
Gunderson, and CS Holling, editors (2002).Panarchy: Understanding Transformations in Human and Natural Systems. Island Press, Washington, DC. 2002.
Lallau B., (2011), La résilience, moyen et fin d'un développement durable ? Éthique et économique/Ethics and Economics, 8 (1).
Loyat J., (2008), La viabilité de systèmes adaptatifs complexes, Observatoire des agricultures du monde, Document de travail.
Landais Etienne (1998). Agriculture durable : les fondements d'un nouveau contrat social ? Le Courrier de l'environnement n°33, avril 1998. 18 p.
Penot Eric (2012). Exploitations agricoles, stratégies paysannes et politiques publiques. Les apports du modèle Olympe sous la direction de Éric Penot. Editions Quae, Versailles. Collection « Update Sciences &Technology. Janvier 2012.350 p.
Penot E., Deheuvels O. (2007) Modélisation économique des exploitations agricoles, modélisation, simulation et aide à la décision avec le logiciel Olympe, L'Harmattan, Paris. 180 p.
Penot E., (2008). Mise en place du réseau de fermes de références avec les opérateurs du projet. Document de travail du PROJET BV-LAC N° 4. 32 p.
Winograd (2006).M. « Sustainability and vulnerability indicators for decision making : Assess the two side of the same coin » Colloque « Usages des indicateurs de développement durables ». Montpellier, 3-4 avril, 2006 Montpellier. 21p.