Smallholders diversifying tree crops in Africa :
private sector initiatives and public policies

Comparative experiences of four cocoa producing countries in Africa.
Côte d'Ivoire, Cameroon, Ghana, Nigeria.

Methodological use of the Farming System Modelling software " Olympe " : risks asssement, market uncertainties and treecrop farmers' diversification

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1 Introduction : a tool for modelling.

Detailed Knowledge on local farming systems and farmers' strategies in various situations such as pioneer zones, rehabilitation areas or traditional tree-crop belts) may contribute to build better and more adapted alternatives, solutions and proposals to help farmers to make the right decision at the right time concerning their future investment. CIRAD has developed (with INRA[1] and IAMM) a software called " Olympe " that enable the modelling of farming systems [Penot, 2003 #1151]. There is also a module that permit the analysis at the level of farms groups. Positive or negative externalities can be integrated as well therefore enabling an approach taking into account C sequestration from tree crops of pollution effects.

The use of "Olympe", a farming system modelling tool is aimed to improve farmers' understanding of their own situation, of their socio-economic context as well as to provide orientations for agricultural and development policies for institutions or donors. Olympe can be used in a variety of situations and through various methodological approaches: comparison of cropping systems, farming system economics and resources management ("farming advices"[2]), prospective analysis, regional approach and even as a "role game". A recent seminar on the methological uses of Olympe has shown a wide variety of possibilities that we are going to present in this paper in order to enhance further analysis of present studies and data [Penot, 2003 #1170].

Why modelling farming systems ?? a model has two main roles: a figurative role of representation of systems (the functioning) and a demonstrative role (possibilities and strategies). Combining these two lead to an explaining model wich function is to represent particular phenomas deriving from general phenomenas (management, acountancy…) according to local conditions that characterise farming systems. [NOuvel, 2002 #1156]. The understanding of farming systems as a "productive system" and the logic behind technical choices recall the systemic approach [Badouin, 1985 #978].

2 General objectives of Olympe

Olympe is base on a systemic analysis of farming systems.
The overall objectives of using Olympe are the following :

- to identify smallholders' constraints and opportunities in a rapidly changing environment for the adoption of new cropping systems or even any other organisational innovation.
- To understand farmers' strategies and their capacity for innovation.

[1] INRA = Institut National de la Recheche Agronomique, IAMM = Institut Agronomique Montpellier Mediterranée.
[2] "Conseil de gestion" in french.

- To assess their ability to adapt to changing economy, prices crisis and technological change.
- To provide a tool to understand the farmers' decision making.
- To replace farming systems information in the social and economical context (through a regional approach).
- To do prospective analysis and build scenarios according to climatic risks, major climatic events such as "el nino years" and commodity prices volatility.

It is possible to build several scenarios according to changing prices, climatic events or various types of risks. It is also possible to calculate impact at the regional level on various groups of farms (according to a typology). Building scenarios allows such a prospective analysis and 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 level of representativness. For instance, a network of selected representative farms can therefore be monitored for several years with two main objectives : first, to diagnose constraints and opportunities and, second, to measure impacts due to technical change.

One of the main output of such approach is to assess impact of technical alternatives or choices at the farming systems level, on the economic point of view as well as on the environmental point of view. Olympe is feed with data from adapted farming systems surveys and will provide key information in terms of diagnosis and, further on, in term of prospective analysis.

3 The global problematic of diversification for treecrops smallholders

The sustainability of agriculture is becoming a major concern. The main questions concerning "ecological sustainability" are linked to the problem of degraded environment and fragile soils and thus fertility, biodiversity, and protection of watersheds. Several cropping systems offer potential solutions to these problems: agroforestry practices, permanent vegetal cover cropping systems, etc. Crop diversification and rapid technical change characterise the evolution of existing farming systems. The history of these innovations and innovation processes are key elements to analyse and understand and thus be in a position to make viable recommendations for development.

The notion of "economic sustainability", places emphasis on the profitability of specific technical choices: (margins analysis, income generation, return on labour and capital as a function of a specific activity, analysis of constraints-opportunities, etc.) from the point of view of farming systems, at the regional level, and the "community level" where there are serious constraints with respect to land availability, and to access to capital and information. Analysis of farming systems and knowledge about smallholders' strategies in the different contexts are thus key elements that should also be taken into account.

As sustainable development is on the way to becoming the new “priority objective”, the rehabilitation of previously intensively managed agricultural or degraded land also merits consideration[3].

Perennial crops in particular are subject to very significative and sometimes very rapid changes in plantation/re-plantation strategies in pioneer and post-pioneer areas, and these changes characterise farmers‘ strategies through phases of investment, capital building, capital conservation, re-investment and eventually intensification or diversification or both...

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 organisation, access to credit, etc.) are key elements to understanding and qualifying change.

Most perennial crops (cocoa, rubber, coffee …) are now facing a post-boom crisis. Commodity prices are subject to volatility with large variations in time. Political changes have also resulted in new decentralisation policies in most countries (indirectly linked with democratisation in some countries) that can/may introduce new ways of local governance. The major economic trend is towards globalisation accompanied by a general decrease in prices for most agricultural commodities. Concurrently, most farmers enjoyed direct links to markets over a relatively long period of time (absence of the commodity boards in Asia when it is often encountered in Africa), in particular in the case of coca, coffee, rubber, oil palm and coconut.

Therefore emphasis should also be placed on the history of innovation processes in the context of the change from pioneer fronts to increasingly stable post-pioneer areas. To ensure the adoption and appropriation of technology by smallholders is efficient, further research is required on innovation processes and technical change in general using socio-economic tools. Negotiations between stakeholders and a better knowledge of the relations between the State and farmers is essential to improve the effectiveness of future projects and development actions.

A programme of social back-up for the implementation of new technologies (either endogenous or exogenous technical change as well as organisational innovations) and economic analysis of technical choices and potential decision-making tools[4].

The main objective of topic-oriented research centred on the analysis of decision-making processes at different levels (farms, community, projects, regional or national

[3] With respect to the latter, two different types of areas seem to be important: ecologically degraded areas such as *Imperata cylindrica* grasslands, which cover 25 millions ha in SEA, and former mining areas that require rehabilitation in Southeast Asia for instance).

[4] Such tools enable prospective analysis to build scenarios of decision-making processes on production or price changes (including the climatic risks) to improve the effectiveness of development policies.

policies makers) would thus be to provide socio-economic information to policy makers to improve the decision-making process in agricultural development.

The process 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 themes (biodiversity, sustainability) are impossible to circumvent.

The problems of coherence between social demand (including the process of innovation and technical change), the role of the state (the relationship between the State and farmers, between production and market) need to be investigated.

This type of approach is applicable at several different levels, i.e. a small area, a big catchment area, a watershed, or an agrarian region, by taking into account the different levels of intervention (production systems, experimentation of farming systems and commodity systems, and so on).

One expected output would be the clear identification of the conditions required to ensure future projects are more viable at the decision-making level.
A further output would be to ensure the scientific valorisation of this collaborative work: namely :

i) to anticipate problems (e.g. recurring negative phases of booms, drops in fertility /productivity due to over-exploitation, negative externalities, etc.)
ii) ii) to propose alternatives (technical pathways or new organisational innovations, etc.) and
iii) iii) to provide better support for technical choices made by decision makers with respect to agricultural policy.

The main aim of this document is to describe a possible global approach using a modelling tool including the identification of gaps and opportunities to promote actions and projects or the implementation of policies that answer the needs of sustainable development, as well as those of local stakeholders, developers and researchers.

There is obviously also an overall objective, which is the "operational viability" of ongoing and future actions and scientific valorisation to be implemented in teams in the framework of project for scientific collaboration centred on the main topics listed above. As Jeff Sayer and Bruce Cambell[5] point out *"cutting-edge agricultural technology is still needed but it has to be set <u>in</u> local contexts and be applied in ways that recognize the special conditions of poor farmers*" (which is generally the case in pioneer areas).

[5] In "Improving livelihood and natural resources management in sub-Saharan Africa, annex 3 Insight – research to integrate productivity enhancement, environmental protection and human development. WWL and CIFOR.

Research questions could be directed towards a scientific and strategic plan around the question of the re-internalisation of costs of deforestation and of environmental pollution as a function of systems selected or recommended initially for pioneers, and then, with time, for post pioneer contextes, plus on costs of growth.

The historical dimension is very significant in this type of analysis even if economic commodity cycles can be very fast. So far, rebuilding the past with a modelling tool and create new scenarios of evolution though a prospective analysis can be linked in order to improve the efficiency of development oriented research. In fact this raises the question of the real cost of the growth of perennial crops under conditions of recurring booms : which type of growth concerns each commodity?
What is the rôle of each stakeholder? What are the main externalities (positive and/or negative.)?
Impact of technical change should take into account effect on sustainability on both farmers' livelihood and environment. Success in diversification strategies required a certain number of conditions : capital or credit availability, technical options (innovations), information, markets, farmers' organisations in order to improve marketing etc …

Concentrating on perennial commodity crops such as cocoa will serve to highlight current dynamics. Indirectly, the redistribution of growth among the different stakeholders of the perennial crops commodity system is a key in understanding dynamics and change not only to provide support for them but also to forecast them in different scenarios to provide a framework for the definition of agricultural policies.

As contexts are important in the evolution of processes, the impact of globalisation on smallholders and commodity systems as well as on their internal growth (logical internal development within a specific context) and the effects of decentralisation policies also should be included in this analysis.

4 Linkages between Olympe and other systems modelling

Preliminary experiences in Indonesia, Colombia… have been developed by the author and its team. The output of these previous research projects can be used as a starting point for a further and larger research. These outputs and the tools that can be used are the following :

- farming systems survey (FSS) with an operational methodology using Winstat software from CIRAD for instance, SPSS, or "sphynx" or any equivalent FSS software for data processing). Data from such survey will feed Olympe.
- Farming systems modelling using Olympe integrating data from previous or recent farming systems characterisation surveys. Additional information on costs, prices and labour requirements may be necessary.
- Regional approach and data spatial integration (using GIS/Geographical Information System with MAPINFO software). (A link between Olympe and SIG has been already developed by an Algerian student working on an irrigation scheme).
- Commodity systems analysis. Olympe might feed a commodity system modelling tool, at least for the production sector.

- Long term economic analysis of cropping system in order to compare productivity and return to labour (using incremental cost-benefit analysis). As Olympe can do prospective analysis on a 10 years basis (and more…), it might be necessary to use the net present value on the long haul (easily done on Excell as all Olympe data can be exporter on Excell).
- Others ?? In the very next future, data integration from plot level modelling software to Olympe might be developed using XML language.

Potentially, scenarios based on various alternatives of diversification and replantation can be simulated using the multi-agent system modelling (MAS). This modelling can be developed in order to integrate all actors decisions into the global analysis (a MsC training period study is scheduled in 2004 on that subject).

5 The use of Olympe : from farmers to developers…..

Tools for the comprehension of farming systems based on simulation and modelling such as the software "Olympe" (INRA/CIRAD) allow a comprehensive understanding of how a given farming system functions, as well as provide a tool to model prospective technical choices, price scenarios, and even ecological scenarios (for example taking into account the impact of El Nino in given years to test the robustness of technical choices and their adaptability in new conditions or environments).

Such tools based on the use of primary data collected during surveys for the characterisation of farming systems, are essential to provide decision-making tools to key stakeholders in terms of development, adaptive research, project orientations and so on, all projects which require serious negotiations between partners.

These tools could be used at different levels: the local community, regional, national or international, depending on the stakeholders and on the commodity involved. Emphasis would be on the farmer and on the other people directly involved in the farmers' environments, including the government (development policies at the national level). The Participatory approach and Action–Research are a basic methodology in the approach proposed by CIRAD partners.

These tools have been validated by experiments and activities in the field. In addition to the Participatory approach and on-farm experimentation, tools for decision-making aid such as SIG, System multi-agents (SMA) and farming system modelling (Olympe) allow possible answers to be identified to important agricultural questions.

6 Risks and hazard assessment through prospective analysis

Introduction

Most tree-crops farmers have developed a diversification strategy in front of markets uncertainties, prices volatility and climatic hazards. They may also have integrated local opportunities for particular crops (oil palm with private Estates providing development schemes for instance..). Therefore, the prospective analysis may provide visions for the future, potential or possible trajectories, an assessment of the

impact on a technical choice or several strategies, an assement of the robustness of farming systems according to commodity prices volatility as well as climatic risks, and eventually the definition of “thresholds” on risks, profitability and viable alternatives.
In this chapter, we will explore how Olympe can provide data on such hypotheses and how we can build scenarios that will later on discussed with farmer to validate the simulations.

First of all, the set of data have to be well defined. Farming systems are created in Olympe according to a typology that may evoluate and change through the prospective analysis. The scenarios have to be defined according to real potential possibilities . Historical records and prices data, agrarian history can help to identify the scenarios.

The prospective analysis can be used for the following purposes ;

- to test the impact of commodity or inputs prices volatility
- to test the robustness of technical choices in the short, mid and long term
- to assess the impact of stratégies or logics on farming systems structure and income
- to assess the impact of climatic events and reduce risks
- to define financial or economical threshold beyond which profitability is too low or risks too high,
- to measure capital and credit requirement to change trajectories through a move to adoption of new cropping systems or re-arranging farming system’s structure.
- measure inputs and outputs flows
- assess impact of any decision on profitability, return to labour and return to investment

From a farmer’s perspective, the objective is clearly to assess potentialities, risks and identify potential interesting farms trajectories through the domain of possibilities. From a developer’s perspective, a better knowledge of economic impact of decisions help to define a better farm counselling and measure the potential impact of extension and recommendations. For the researcher, it helps to define for both farmers and developers a common perspective on development, risks and impact of agricultural policies and markets.

These objectives are included in the general farmers objectives when diversification occurs :
- income securing (a guarantee for a minimum revenue and not a income decrease) and eventually improvement.
- limitation of risks :
  - climatic risks on production (food security, assure self-sufficiency, other cash crops…) and
  - economic hazards (commodity prices).
- To get a better distribution of income throughout the year (typically from cocoa with 2 incomes periods to rubber with weekly income)
- to profit from potential opportunities (or not to miss it, wich is another way to look as it !).
- being less dependant of a unique commodity in a world of globalisation.
- To build a property (patrimony)

- To valorise land that were not previously cropped.
- to increase knowledge, technical information in order to be in a bettre position to innovate.
- more recently : increase the sustainabilty of agricultural production in the mid or long term. To that respect , taking in to account externalities can become important for both producers and the rest of the world (within the application of the Kyoto agreement and the Clean Development Mechanism (CDM) for instance. Agroforestry practices that maintain biodiversity and soil fertility, basically that maintains the “forest rent” into an “agroforest rent” are included [Ruf, 1994 #857].

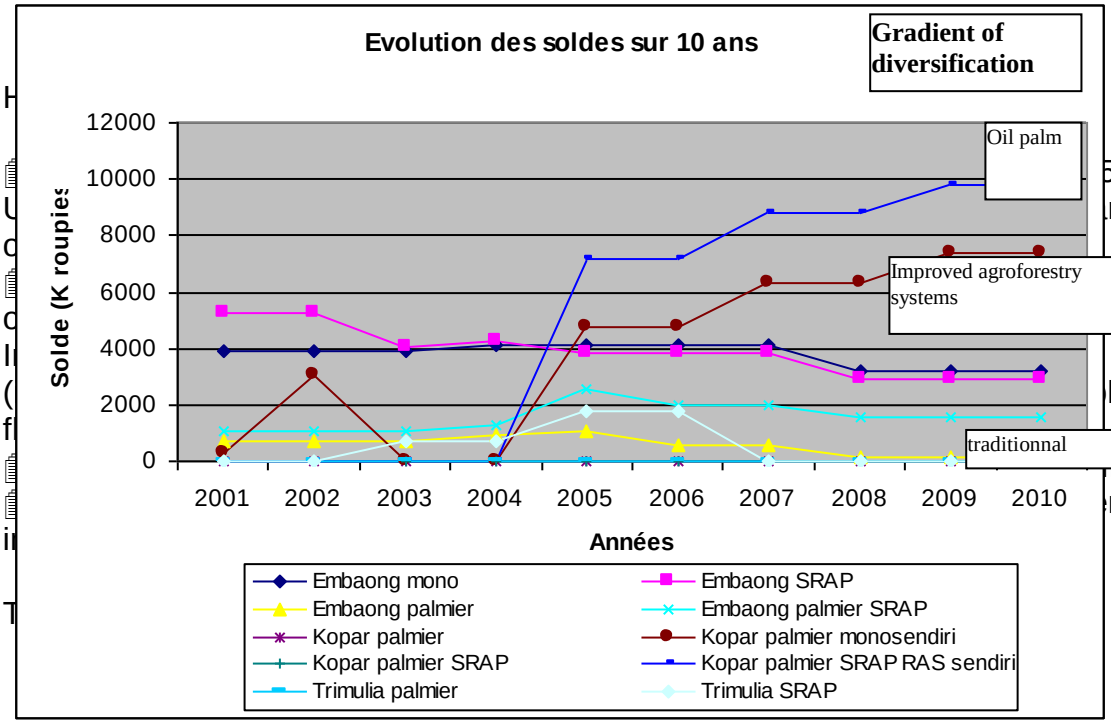
This strategy and prospective analysis is part of the overall framework suggested by the team to compare diversification situations :

- definition of farmers’ objectives
- definition of sub-objectives for each main tree crop.
- identification of the determinants of diversification strategies leading to implementation
- identification of criteria and indicators of diversification
- the types of farmers that diversify.
- the lessons in terms of policy and agricultural development guidelines

The example of Indonesian rubber farmers diversifying with oil palm

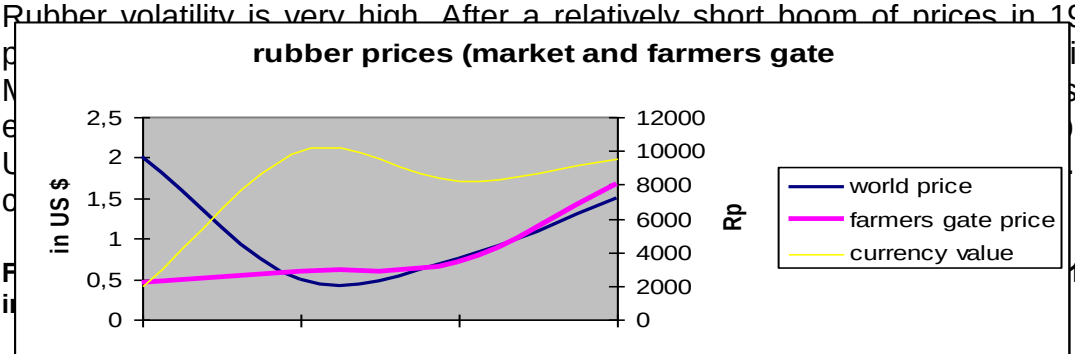
The cases that will be presented have been so far explored through the case of rubber farmers in Indonesia. Their strategy is based on both intensification of rubber systems (from traditional jungle rubber to monoculture of improved agroforestry systems, sustainability (development of improved agroforestry systems compared to monoculture for rubber), short term strategy based on off farm and diversification (integration of new crops such as oil palm, pepper…) [Penot, 2003 #1171].
Figure 1 shows farmers annual net income evolution according to various strategies of diversification. Oil palm provides rapidly a significant improvement when rubber prices were low (2002). Such trend would be far less significant when rubber prices recovers in 2003.

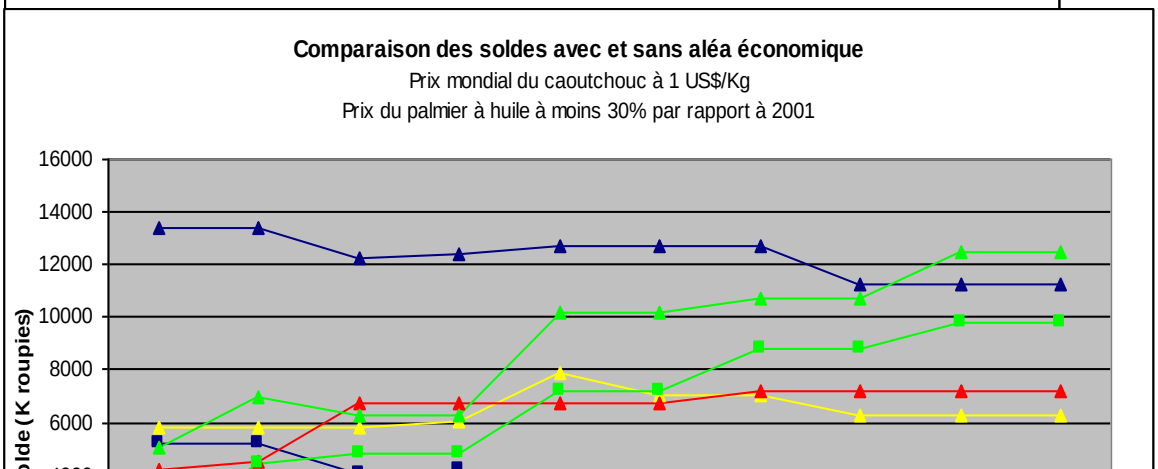
Figure 1 : Evolution of farmers income for 10 different types of farms with various levels of intensification (rubber) and diversification (oil palm).



Case 1 : rubber and oil palm prices volatility : rubber prices moves between 0.5 and 2 US$/kg

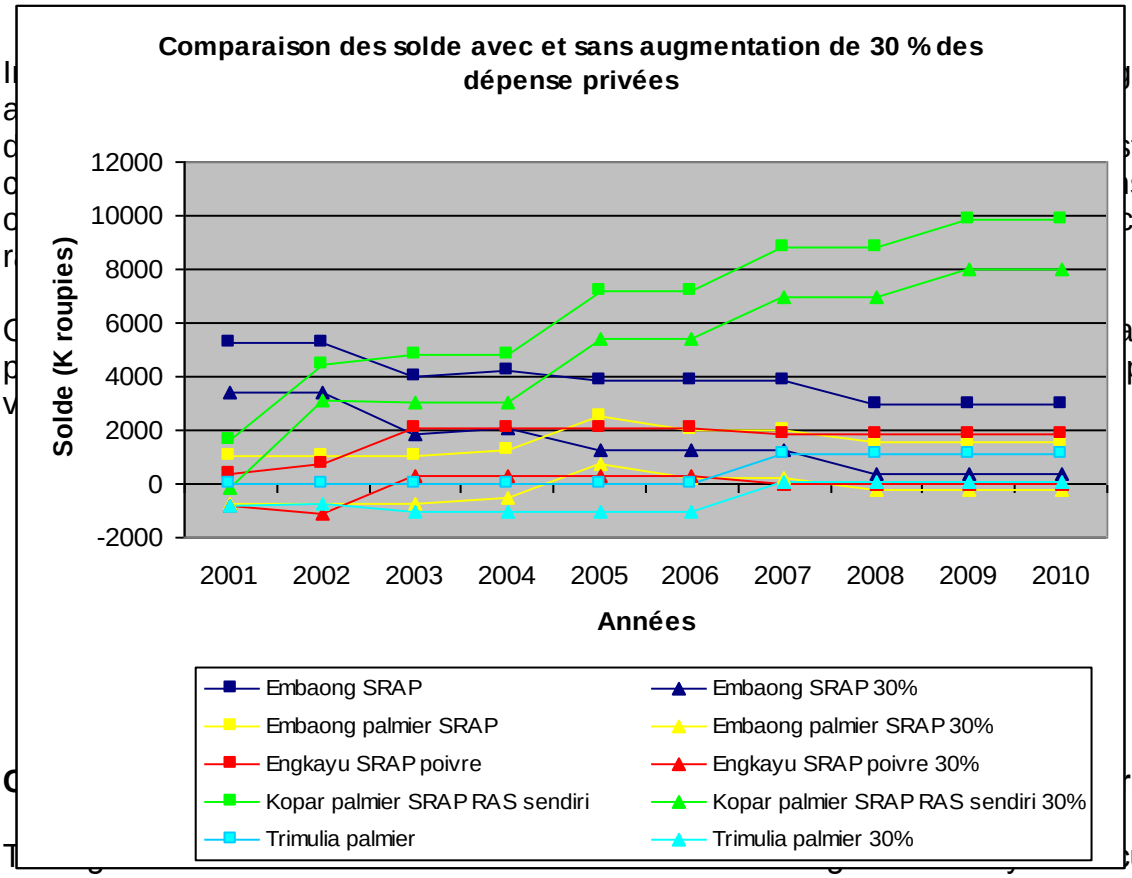
Figure 2 : rubber market and farmers' gate prices, currency value.





Case 2 : effect of commodity windfall on household expenses : increase of 30 % of households expenses : balance of available cash flow invested in tree crops.

Figure 4 : Comparison for the same farmers of such increase :



2003 and how types of farms recovers differently according to their level of diversification. In that case, impact of “El nino” on yield is minus 30 % on annual crops, minus 10 % on rubber and oil palm with a secondary effect of minus 5 % on the second year for oil palm (as recorded or observed in Sumatra).

Figure 5 : Impact of “el nino year “ in 2003 on net annual income on a 10 years period.

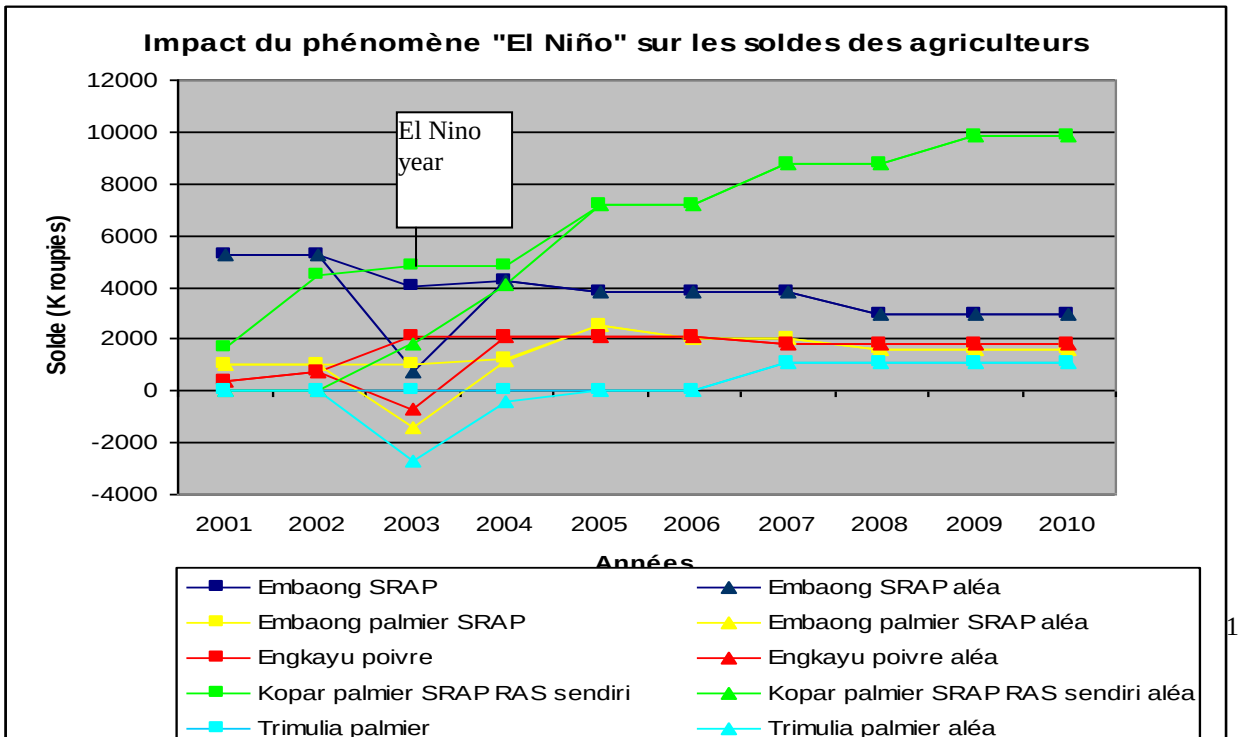
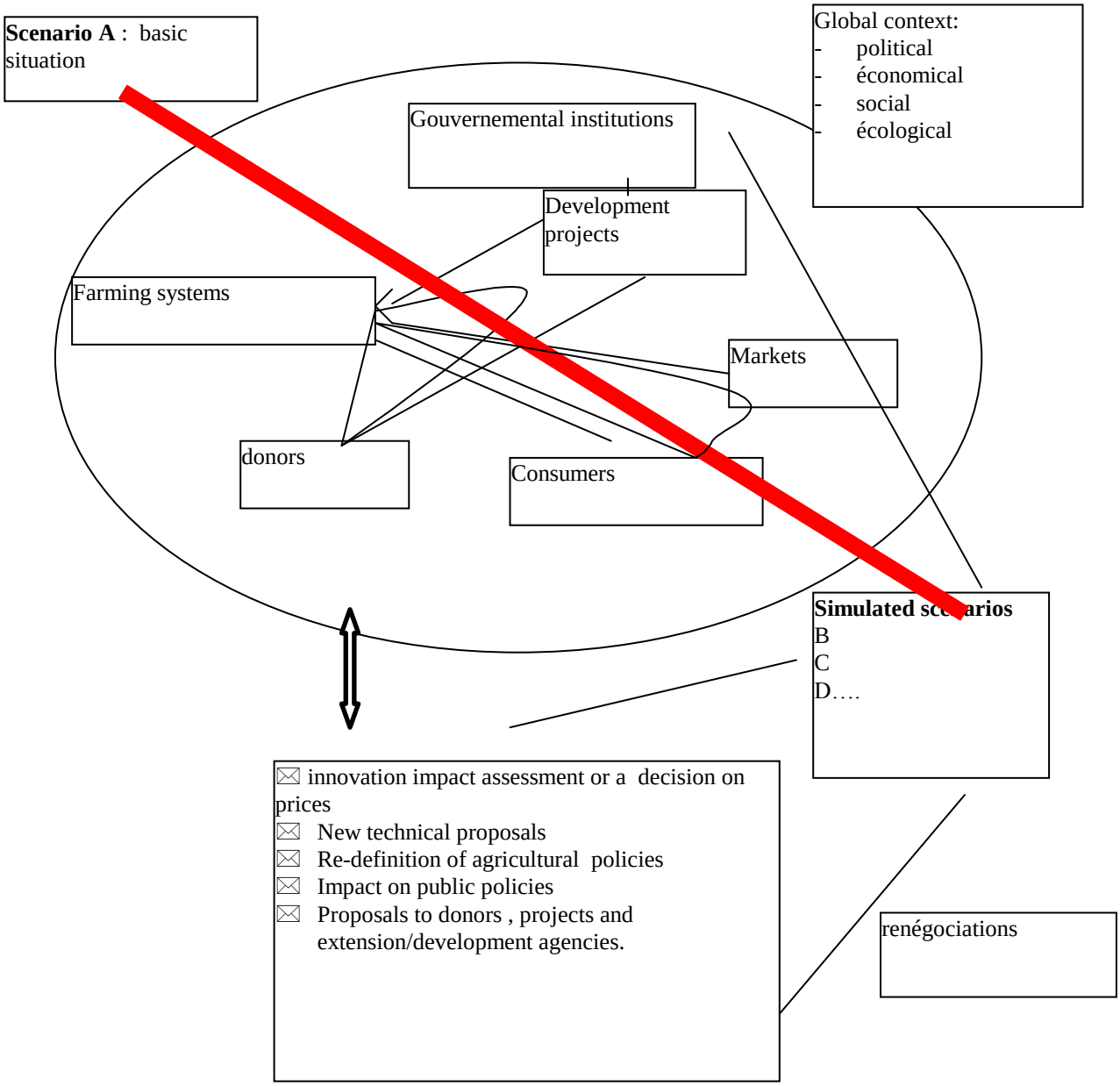


Figure 6 ; Definition of prospective scenarios :



7 Type of data required for farming systems modelling using Olympe

Olympe is based on a farming system characterisation using systemic approach. Therefore, all traditional information that qualify the structure and components of factors production of the farm are required. They are obtained through traditional survey. Beside that, as Olympe is focused on the origin of the different sources of incomes and provide an economic analysis, all information should be collected at least at 4 levels :

- cropping systems : crops are divided into annual crops, perennial crops (minimum 5 years) and multi-annual crops (typically banana, pine-apple and cassava, between 1 and 5 years cycle),
- livestock systems whatever type of animal…
- activities system (all activity that is not directly linked with agricultural or livestock production :; including transformation of primary products…

In these three systems, all cost of production, inputs and outputs and yields. Basically, all operational cost are considered her. If externalities can be quantified , they will be at that level. Labour requirement have also to be collected in order to calculate return to labour, a very important factor of decision for farmers.

- production system : the “farm level” with a 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 (incomes, including off farm, credits , loans ….), and expenses what so ever are integrated at that level. Family account and enterprise account can be separated but should be recorded.

All commodity prices should be collected , in particular taking into account the local variations as well as international historical series of prices that will enable to build potential scenarios.

8 conclusion

Modelling farming systems can be used (beside other uses) as a prospective tool to build scenarios about potential farms trajectories.
It might be used to the definition of :

- agricultural policies
- recommendations domains
- applicabilibity of recommendations according to local constraints
- measuring impacts
- addressing policies to farmers’ reality.

Bibiography