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Risk assessment through farming systems modeling to improve farmers' decision making processes in a world of uncertainty.

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Summary

Risk assessment through farming systems modeling to improve farmers' decision making processes in a world of uncertainty.

Rubber farmers in Indonesia have shown a high degree of adaptability to the multiple crises that have occurred since 1997: an economic crisis linked with very low international commodity prices, a political crisis (Suharto's fall, 1998), ecological crises ("El Nino" and huge fires) as well as a social crisis due to new political and social rights. Uncertainty in both the economic sphere (price volatility) and in ecology (climatic factors) led farmers to adapt new strategies oriented toward diversification, while at the same time profiting from existing opportunities. Long term investment in perennial crops (rubber, oil palm etc.) combined with short term strategies (off-farm activities etc) are enabling farmers to come to terms with the rapidly changing political, social and economic environment. Alternatives with a high degree of economic and ecological sustainability are preferred. Among these, complex agroforestry systems with considerable environmental benefits still play an important role. Taking the right decision at the right time is now a challenge for farmers. Modeling farming systems using "Olympe"software, a tool developed by INRA/CIRAD/IAMM to assess the impact of the volatility of prices or climatic events on incomes enables identification of thresholds and potential scenarios. It helps to understand the factors that trigger processes of both technical and organizational innovation as well as the impact of global contexts on farmers' decision making processes, and in particular, the effect of globalization, state disengagement and policies of decentralization.

Key words: Indonesia, rubber, diversification; farming systems modeling, risk assessment, farmers' strategies.

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Introduction

The factors that determine technical change as well as discriminators taken into account for sustainable development in tropical rural areas need to be related to each specific context. Important issues such as the effect of decentralization, globalization and its effects on prices, as well as on local economies and public policies, environmental issues such as biodiversity, and ecological sustainability, are impossible to circumvent.

Perennial crops particularly in wet tropical areas[i] are subject to very significant and sometimes very rapid changes in plantation/re-plantation strategies in pioneer and post-pioneer areas, and these changes characterize farmers' strategies through phases of investment, capital building, capital conservation, re-investment and possibly intensification or diversification or both (Ruf, 2002). The recent coffee boom in Vietnam is a perfect example of such rapid dynamics.

The impact these strategies have on land control, land-use dynamics, i.e. agreement on the definition of new types of "territories" between stakeholders, as well as on 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 organizational innovation (farmers' organizations, access to credit, etc.) are key elements to understanding and qualifying change.

Most perennial crops (cocoa, rubber, coffee etc.) are now facing a post-boom crisis with a long term trend characterized by a decrease in prices. Commodity prices are subject to volatility with marked variations over time. In many countries, political changes have also resulted in new decentralization policies (indirectly linked with democratization in some countries) that can result in new ways of local governance (and sometimes in increased corruption). The major economic trend is towards globalization accompanied by a general decrease in prices for most agricultural commodities. Most farmers have enjoyed direct links to markets over a relatively long period of time (absence of the commodity boards in Asia while these are often encountered in Africa), in particular in the case of cocoa, coffee, rubber, oil palm and coconut.

In Indonesia, rubber based agroforestry (also called "jungle rubber") and its evolution has been one of the most significant aspects of colonization and development since its introduction in 1910 (Gouyon, 1995). During the move from slash and burn agriculture to rubber farming, and more recently during diversification with rubber and/or oil palm, social changes have accompanied specifically technical and more general rural changes. How can we understand, provide support for, and if necessary, accompany these social changes? Emphasis should be placed on the history of the innovation processes within the context of the change from pioneer fronts to increasingly stable post-pioneer areas. The problems of coherence between social demand (including the process of innovation and technical change), the role of the state, i.e. the relationship between the State and farmers, and between production and the market, need to be investigated (Penot, 2003).

To ensure the adoption and appropriation of locally adapted technology by smallholders is efficient, further research is required using socio-economic tools to understand innovation processes and technical change in general. Negotiation between stakeholders and a better understanding of the relations between the State and farmers is essential to improve the effectiveness of future projects and development actions. The objective of this paper is to present one of these tools: a farming systems modeling tool called "Olympe", and to show how its use can help explain the economic impact of technical choices, and subsequently to analyse the resulting social changes. The case study concerns rubber smallholders in the outer islands in Indonesia.

1 From technical change to social change.

Historically, fluctuations in local rubber price affected neither the farmers' interest in, nor desire to own rubber plantations. The market for rubber is directly linked with that of tyres (70 % of consumption), and therefore to air and land transportation. The transport sector has been constantly expanding and the result has been a permanent increase in demand, rubber being a very strategic product. Basically farmers considered rubber as a "refuge ", a valuable, flexible and sustainable crop, even when prices are low, as was the case in the period from 1997 to 2002. Indonesia is the second world producer of natural rubber after Thailand, and most rubber plantations correspond to the extensive agro-forestry system called "jungle rubber" (85 % of the total area under smallholdings which covers an area of 2.5 million hectares) and provides income for more than 10 million people in this commodity sector. Since the beginning of the 20th century, rubber has gradually been integrated into traditional shifting cultivation systems and has become the main source of income (around 80 % of local farms income up to 1998). Since the beginning of the 1990s and in particular since the crisis in 1997 (Penot, 2001), a combination of political, economic and social events has encouraged both changes in farming systems, which were traditionally focused on rubber, and in land-use (Geissler, 1999).

The wide range of stakeholders involved (farmers, Private Estates, projects, Government plantations etc.), each with their own development projects and objectives, created fertile conditions for innovation. The variety of behaviors led us to try and identify the reasons for the choices made by producers, as well as the factors and issues that explain the differences in behavior, and finally to analyze the production "strategies" themselves. This methodological approach is relevant because it excludes all typological and methodological preconceptions. It enables the identification of groups of farmers with similar behaviors and/or strategies irrespective of the system of constraints they have to face. Representative farming systems have been modeled in order to identify past evolution as well as to test hypotheses and identify possible future changes through prospective analysis.

Thus, within the same village, different strategic groups with different objectives with respect to innovation may co-exist (Trouillard, 2001). The current situation is characterized by an increase in land scarcity that is accelerated by the increase in private Estates for perennial and industrial plantations (oil palm *and Acacia mangium*). The subdivision of plots due to successive inheritance transactions accentuates the trend at the village level and underlines the increasing pressure on natural resources and land in the medium term. In addition, State disengagement implies a reduction in opportunities offered by development projects and in indirect subsidies allocated to agricultural activity. This situation increases the risk of the exodus of the poorest farmers to cities.

The concept of “strategy” is here understood as a means to implement a “project” with a view to the future i.e. the definition of a range of production targets and the mobilization of the means necessary for their implementation (Mollard 1993). The identification of farmers’ strategies enables the search for new markets, the identification of the conditions necessary for innovations to emerge, and the provision of support for innovation processes leading to new technologies or improved organization.

Smallholders developed diversification strategies while maintaining traditional practices such as agroforestry. The persistence of traditional practices demonstrates the attachment people have to traditions and social standards, and consequently to cohesion and social structure, at least at the community scale i.e. in the village. Indeed, the whole process of social organization is concerned with the maintenance of these practices, in particular the mobilization of labor. Farmers with an off-farm activity and/or multiple activities display changes in social behavior in the sense that work off the farm implies making concessions with respect to social standards and in particular the abandonment of the use of labor in the form of " *gotong-royong* " (collective help) due to lack of availability. This social rupture, together with the economic cost of such labor may also explain the progressive abandonment of *ladang* (upland rice based traditional shifting cultivation).

Diversification strategies are developed to obtain a more even distribution of income throughout the year, to profit from potential opportunities (or not to miss them, which is another way to look at it!), by being less dependant on a single commodity in a world of globalization, and to increase knowledge, and technical know-how in order to be in a better position to innovate. More recently, an increase in the sustainability of agricultural production in the medium or long term has also become a priority. In this respect, taking externalities into account may be important for both producers and the rest of the world (in the context of the application of the Kyoto agreement and the Clean Development Mechanism (CDM) for instance. Agroforestry practices[ii] that maintain biodiversity and soil fertility, in other words that transform the “forest rent” into an “agroforest rent” are included (Ruf, 1994).

The increase in the planting of oil palm through private Estates will probably continue for a while given potential land availability. Land and labor are still plentiful in Indonesia compared to its neighbors, Malaysia, for instance, and this allows room for smallholder development as well as for export crops. Later on, in the absence of state or other projects, the continued development of oil palm and rubber plantations will depend on farmers’ own initiatives, and the setting up of more Estates will require an increase in farmers’ organizations like the “*Kelompok Tani*” as well as access to micro-credits. However farmers’ organizations have been permitted since 1999, and political and economic grouping of farmers will occur in the very near future as a consequence of social change, probably “very significant social change”, triggered by new laws and rights (political freedom, decentralization, and so on.).

2 Modelling farming systems with Olympe software

Rationale for using a model

A model plays two main roles: a figurative role in representing the systems (the functioning of the system) and a demonstrative role (identifying possibilities and strategies). Combining these two roles results in an explanatory model whose function is to represent specific phenomena that derive from general phenomena (management, accounting, etc.) as a function of the local conditions that characterize the farming system concerned. (Nouvel, 2002). The understanding of 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. Research can be directed towards a scientific and strategic plan for the re-internalization of the cost of deforestation and of environmental pollution as a function of systems selected or recommended initially for pioneers, and then, with time, for post pioneer contexts, in addition to the costs of growth.

The historical dimension is very significant in this type of analysis even if economic commodity cycles can be very rapid. Rebuilding the past using a modeling tool and creating new scenarios for change though prospective analysis can be linked in order to improve the efficiency of research for development. Here the question arises 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 role of each stakeholder? What are the main externalities (positive and/or negative.)?

The impact of technical change should take into account the effect of sustainability on both farmers' livelihoods and on the environment. Successful diversification strategies require a certain number of conditions: capital or the availability of credit, technical options (innovations), information, markets, and finally farmers' organizations to improve marketing.

Concentrating on perennial commodity crops such as cocoa, rubber or oil palm 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 growth in different scenarios with the aim of providing a framework for the definition of agricultural policies. However perennial crops are long term investments with short term consequences, in particular during the immature and unproductive period that trigger choices (of crops) and decisions (planting or replanting).

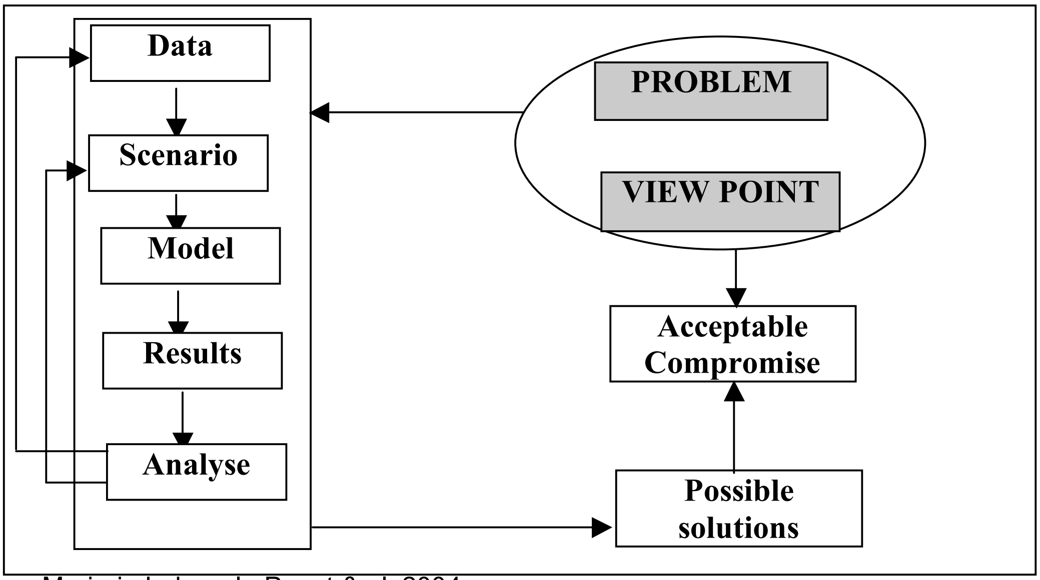
As contexts are important in the evolution of processes, the impact of globalization on smallholders and commodity systems as well as on their internal growth (logical internal development within a specific context) and the effects of decentralization policies also should be included in this analysis.

Presentation of the software "Olympe"

CIRAD, INRA[iii] and IAMM in close collaboration have developed a software called " Olympe " that enables the modeling of farming systems (Penot, 2003). There is also a module that permits analysis at the level of groups of farms. Positive or negative externalities can also be integrated enabling an approach taking into account C sequestration from tree crops, the effects of pollution or any positive or negative externalities resulting from agricultural production.

The aim of "Olympe" as a farming systems modeling tool is to improve farmers' understanding of their own situation, and 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 with various methodological approaches: comparison of cropping systems, farming systems, economics, resource management, farming counseling**,** prospective analysis, in a regional approach and even as a "role play". A recent seminar on the methodological uses of Olympe brought to light a wide range of possible applications to enhance further analysis of present studies and data that will be discussed in this paper (Penot, 2003). Figure 1 shows the overall approach behind the use of Olympe for farming systems modeling.

Figure 1. Overview of the use of Olympe software.



Source: Marjorie Lebars In Penot & al, 2004.

This illustration shows the most widely used function of Olympe, with characterization, fine description and analysis of economic mechanisms at the farm scale that produce income. Olympe enables the integration of the overall environment (including its history) in a true socio-economic analysis of the farm, irrespective of its size or whether or not it is a family farm. The impact of farming and off farm activities on the farm's immediate environment can be economically assessed through quantifiable positive or negative "externalities". A pragmatic and realistic use of the results of the analysis would be farming counseling using adaptable and refutable data. Such data should be validated by farmers in "feedback meetings". Coupled with the socio-economic analysis of decision-making processes (linked with innovation processes), this process leads to the identification of farmers' strategies and pathways.

Coupled with the analysis of constraints and opportunities seen in a social and environmental perspective, it is possible to economically quantify decisions of a technical nature. The economic analysis (budget, margins, incomes, cost-benefits) linked with non economic factors and in particular with social factors enables the use of Olympe as a tool for dialogue, often for representation purposes (in the majority of cases) but sometimes to raise awareness among stakeholders though negotiation.

With Olympe, farming systems are defined according to a typology that may change as a result of the prospective analysis. Scenarios have to be defined according to real potential using historical records and data on prices. Previous local agrarian history can help to identify possible scenarios. Validation is obtained through presentation and discussion of the results with the farmers concerned.

Olympe as a prospective tool to assess the resilience of systems in the face of hazards.
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 hazard allows the definition of scenarios where the resilience of a given farming system can be quantified. Some examples are given below. The "revealing character" of using a farming system modeling approach leads to enhanced sensitivity by stakeholders to problems that are not initially apparent. In this case, its use is very close to that of role plays. Resilience, mutation and resistances can be explored through a prospective analysis that assesses the impact of risks and hazards. The logical framework is presented in figure 2.

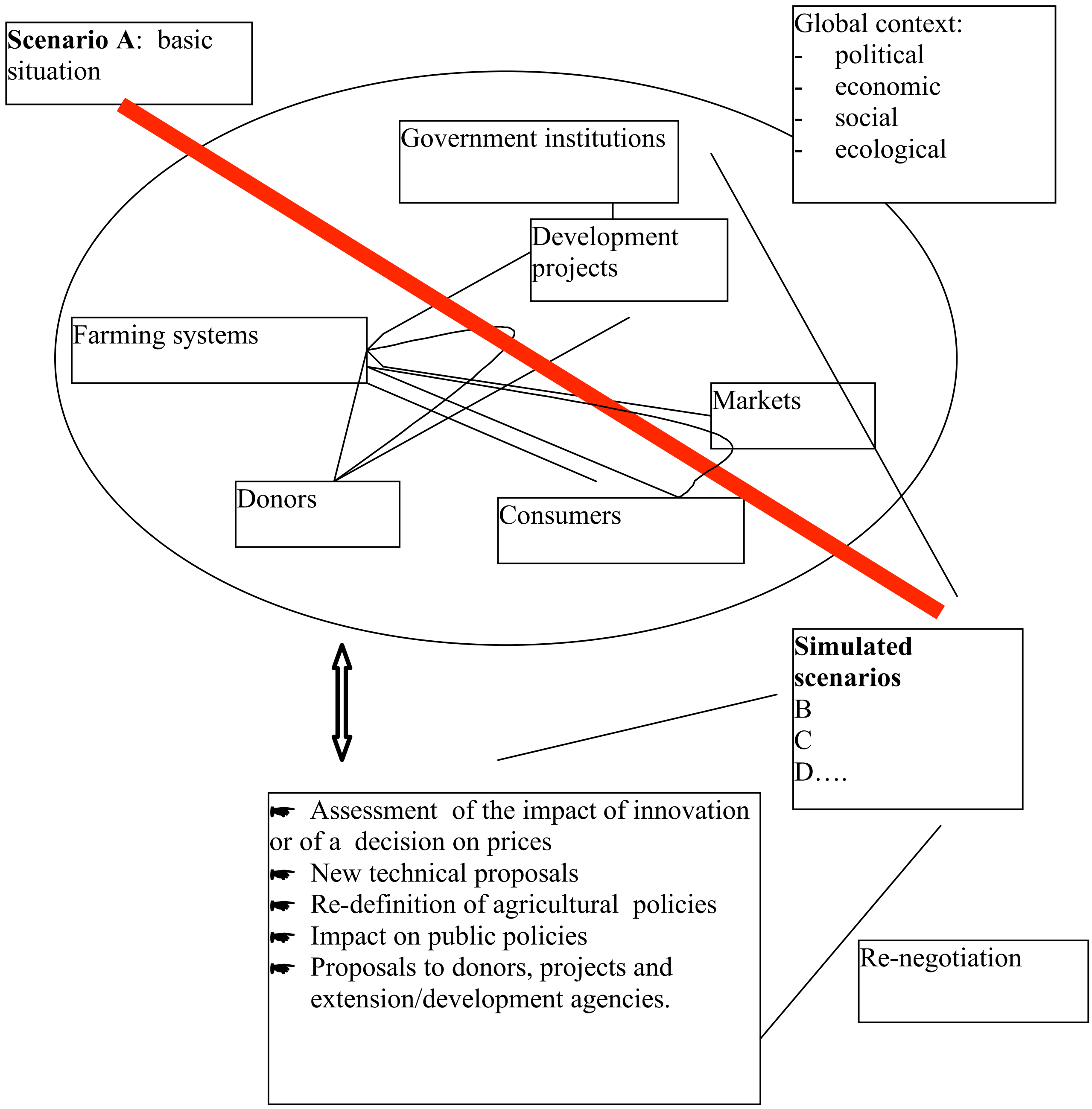
The use of the "risk and hazard" module means prices (inputs-outputs) and types of production can be modified with two possibilities for implementation: 1/ the definition of a "trend" (annual fluctuations over a period of 10 years) or 2/ the definition of a "scenario" (the definition of "bad" or "good" prices or levels of production and application of this predefined data in the 10 year period of the simulation). Using this powerful tool, the Indonesian 1997-2002 crisis was re-created for rubber farmers for instance) including high price volatility of export commodities, an increase in the price of rice and of agricultural inputs as well as fluctuations in currency. Farmers were literally lost in a "mad dance of prices" as they themselves described the period. Uncertainty had never been higher; as a result, making strategic choices such as planting perennials (rubber and oil palm) with a long-term return versus coming to terms with immediate emergencies (income stabilization and food sufficiency) was very difficult for most farmers. Short term strategies such as temporary off-farm activities in the vicinity (in oil palm plantations, Estates or gold mines) were implemented. Now farmers who are used to the long term perspective of perennial crops with a life span of 20 (oil palm) to 40 years (rubber) are expressing the need for a tool that can help them define the most suitable trajectories with the minimum of risks in such a world of uncertainty.

In the face of market uncertainties, price volatility and climatic hazards, most farmers eventually developed a diversification strategy to overcome risks and to profit from opportunities. They may also have integrated local opportunities offered by particular crops (oil palm for instance, with private Estates providing development schemes for smallholders). Prospective analysis can thus provide a view of the future, potential or possible trajectories, an assessment of the impact of a technical choice or of several different strategies, an assessment of the robustness of farming systems with respect to the volatility of commodity prices as well as climatic risks, and possibly the definition of "thresholds" for risks, profitability and viable alternatives.

Prospective analysis is very useful to test the impact of volatility of prices for commodities or inputs, to test the robustness of technical choices and to assess the impact of key decision on the structure of the farming systems. It enables a detailed analysis of income generation, the assessment of the impact of climatic events, of reducing risk factors as well as financial or economic thresholds beyond which profitability is too low or risks too high. Capital and credit requirement to change trajectories through a move towards the adoption of new cropping systems or re-arranging the structure of the farming system can be tested. Flows of inputs and outputs and the impact of any decision on profitability, return to labor and return to investment can be assessed.

From a farmer's perspective, the objective is clearly to assess potential risks and to identify potentially profitable farming pathways among the range of possibilities in order to secure income. From a developer's perspective, a better knowledge of the economic impact of decisions helps define better farm counseling and also measures the potential impact of extension and recommendations. From the perspective of the researcher, this knowledge will help define a common perspective for farmers and developers on development, on risks and on the impact of agricultural policies and markets.

Figure 2. Definition of prospective scenarios:

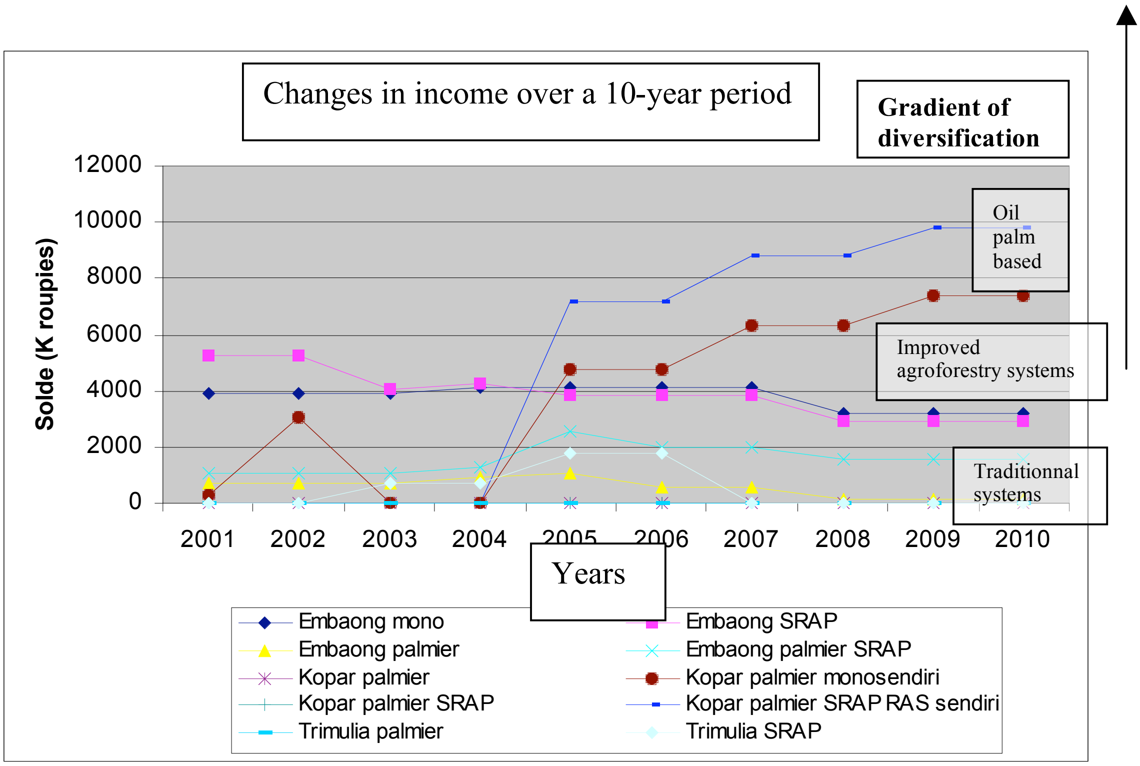


Source: E Penot.

3 A case study: rubber farmers in Indonesia

The cases presented here have been explored since 1997 in collaboration with several MSc students stationed in Indonesia. In summary, farmers' strategies are 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 of rubber), short term strategies based on off farm activities and diversification (integration of new crops such as oil palm, pepper) (Penot, 2003). Figure 3 shows changes in farmers' annual net income as a function of different diversification strategies (trajectories). Oil palm has an immature period of 3 years compared to 6 years for rubber and up to 10/15 for jungle rubber, and thus rapidly provided a significant income when rubber prices were low (1997-2002). Such a trend will be less significant if rubber prices recover after 2003. Only a few examples will be presented in this paper (a complete analysis has been done by Hébraud, 2003).

Figure 3: Changes in farmers' annual income (in X 1000 Rp) for 10 different types of farms with varying degrees of intensification (rubber) and diversification (oil palm).



An example of building scenarios as a function of the volatility of commodity prices

The hypothesis concerning hazards is based on the following main hypotheses:

✓ 1: Volatility of rubber and oil palm prices: rubber prices ranged from 0.5 to 2 US$/kg , i.e. 200% between 1995 and 1998, whereas oil palm was subject to variations of only 100 % in 2 years.

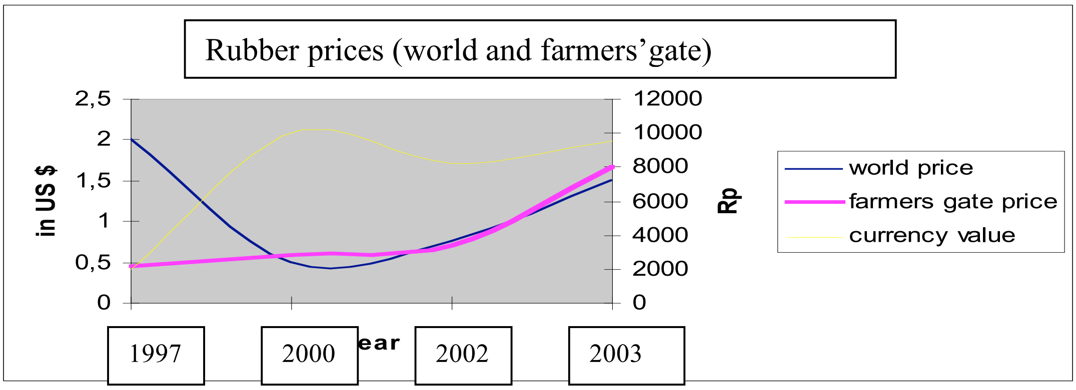
✓ 2: The effect of a commodity windfall, the result of a period of very good prices with an impact on household expenses, financial return and investment capabilities.

In this case, our hypothesis (based on a previous survey and observations) was that household improvement is the first priority (with an increase of 30 % in households expenses), and that subsequently the balance of available cash flow may be invested in tree crops.
✔ 3: The effect of climatic events, for instance, one or two El Nino years in a 10-year period: to measure risks and the robustness of technical choices and possibly the production system's global resilience (1997 and 2003 were El Nino years in Indonesia).

The objective was to assess the overall negative or positive effect on investment, re-plantation and diversification in various situations.

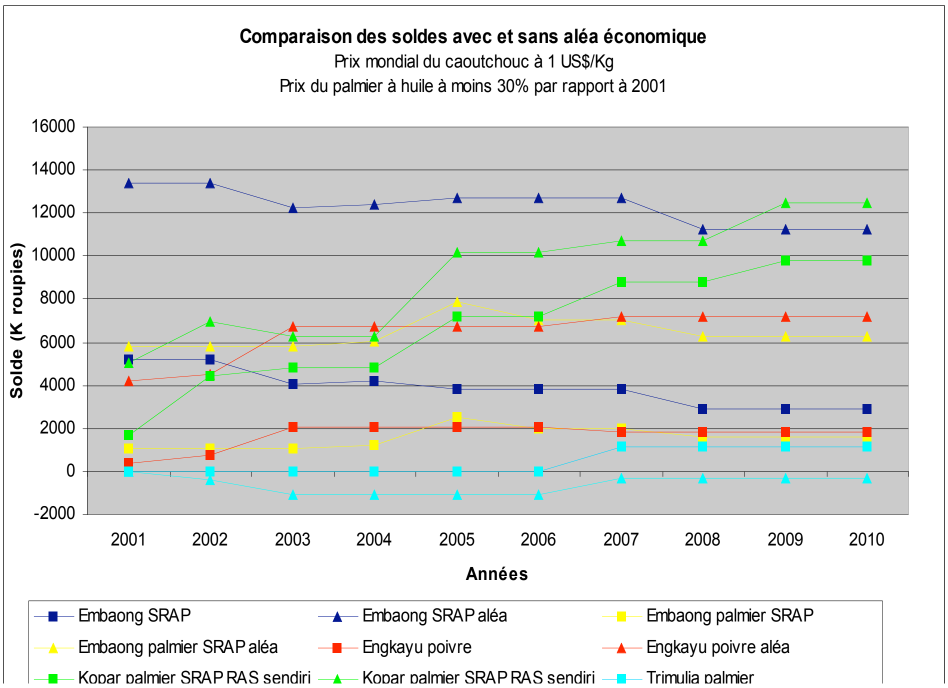
Case 1: rubber and oil palm price volatility: rubber prices ranged from 0.5 to 2 US$/kg (see figure 4)

Figure 4: rubber market and farmers' gate prices, currency value.



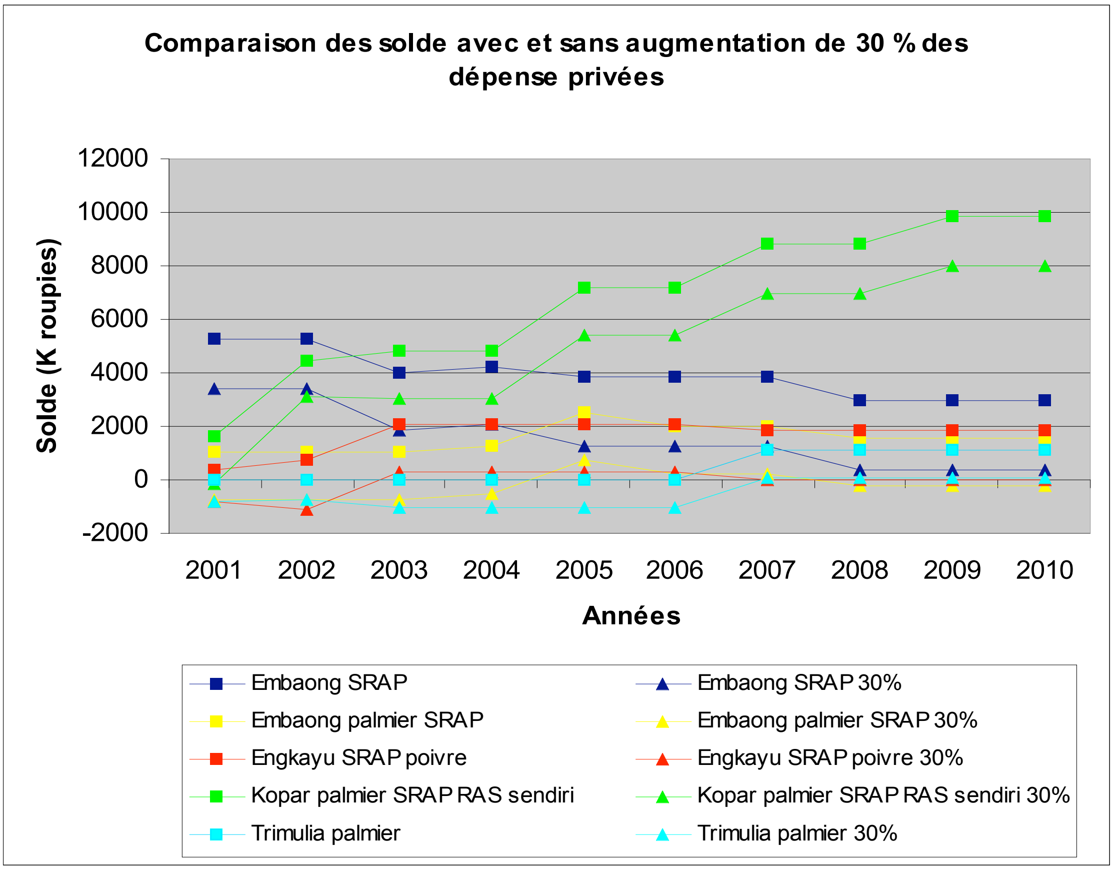
In this case rubber price volatility is very high. After a relatively short boom in prices in 1994/1996, prices fall as a result of the economic crisis in 1997-2001. Prices recover in 2003. Meantime the local currency (Rupiah) is subject to dramatic fluctuations. Figure 5 shows the effect of an oil palm price crisis (minus 30 %) when rubber prices stabilized at 1 US $, in order to see if oil palm diversification will lead to increased fragility. We compare annual income with (square) and without price hazards (triangle).

Figure 5. Changes in 10 farmers' incomes with average rubber prices (1 US $/kg, international market) and a 30 % decrease in oil palm prices



Case 2. Effect of a commodity windfall on household expenses with an increase of 30 % in households expenditure: balance of available cash flow invested in tree crops (see Figure 6)

Figure 6. Comparison of the same farmers' incomes with and without an increase of 30% in household



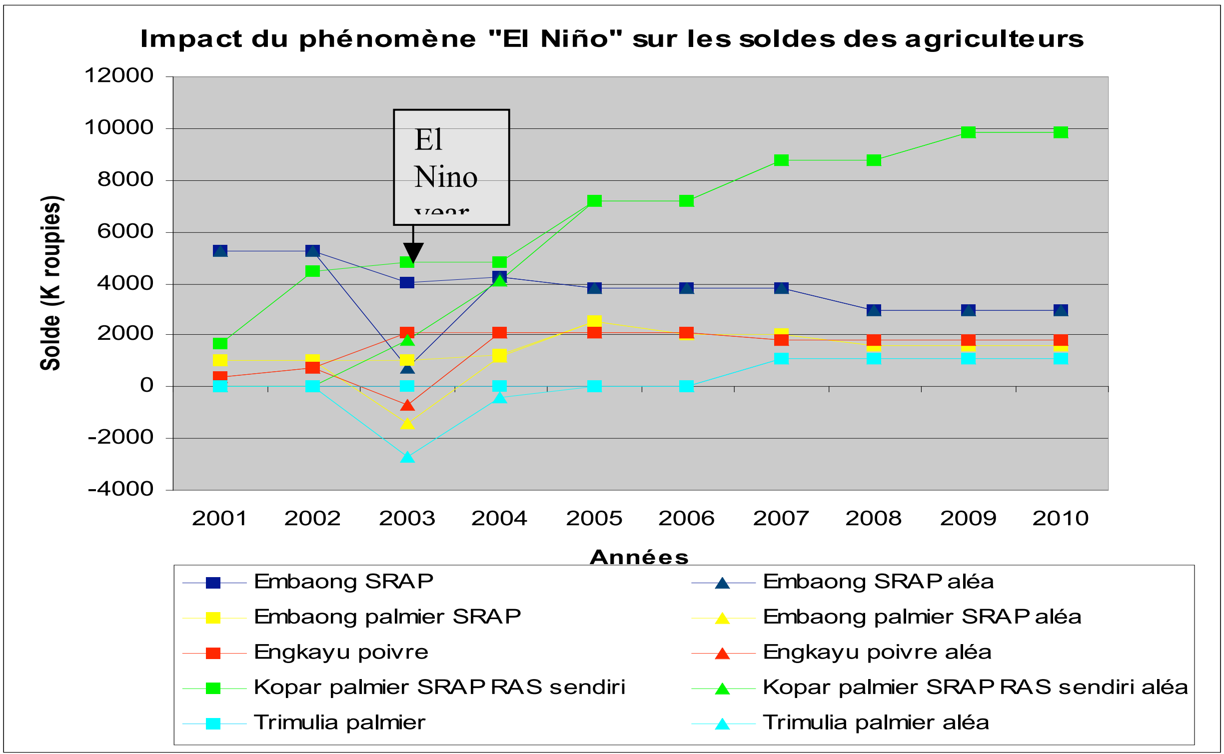
In this case, farming systems with limited land, such as those in transmigration areas (Trimulia) cannot afford such expenses. In other words, they are obliged to intensify. Farming systems with diversification (oil palm) without rubber intensification see their investment capacity decreased by an average of 50 % (Embaong, Engkayu). Farming systems with oil palm diversification and improved rubber (with rubber intensification) rapidly recover their investment capacity after the 6th year (Kopar).

Of course, such trends will differ if the balance of commodity prices between rubber and oil palm changes significantly. This figure shows one possible scenario that provides a reliable basis for further discussion/negotiation with stakeholders (farmers, development projects, extension, trader) Olympe enables all possibilities to be tested using price volatility of both outputs and inputs.

Case 3. Effect of climatic risk on annual net income over a period of 10 years.

Figure 7 shows the effect on income when an average El Nino year occurs in 2003 and how different types of farms recover differently depending on their degree of diversification. In this case, the impact of El Nino on yield is minus 30 % for annual crops, minus 10 % for rubber and oil palm with a secondary effect of minus 5 % in the second year for oil palm (as recorded or observed in Sumatra, Caliman, CIRAD, personal communication).

Figure 7: Impact of an El Nino year in 2003 on net annual income over a 10 year period. Eric you need to



So far, most farmers with perennials recover rapidly (as accumulated income over a 10-year period shows) compared to farmers who rely only on annual crops. Tree crops act like an income buffer. The overall resilience of farming systems based on perennials is relatively high.

4 Innovation triggering factors in a changing world.

After having integrated some improvement through either technical (cropping practices) or organizational (management, organization, trading practices..) innovations, there is always a period of stabilization, of "digestion of changes" that is most often associated with stagnation or inertia. Then a further change is triggered by the global change and new needs arise, and so on. Even if such a model could be relatively complex, it does not explain all the factors that trigger innovation, in particular social factors. Innovation being a social process, it is not only linked with agricultural production or the efficiency of production. Factors such as land control, land use patterns, a decrease in risk and more generally in resilience and family factors may play very important roles.

The factors that trigger change and consequently innovation are multiple, sometimes apparently contradictory but finally never autonomic. Beside the classical technical innovations that improve yield and return to labor, a series of other factors appears to be extremely relevant; robustness or a certain degree of resilience to risk, coherence between social and production systems, land regulation and access to land (mainly through land security), the relations between the State and farmers, the existence (or not) of empowered regulations and the "State of Law", access to markets, the degree of distortion of information between stakeholders, reciprocity and social regulations concerning "acts of production" depending on the ethnic group or on cultural factors (the influence of "traditions"..)

All innovative factors may contribute to sustainability, in the sense of minimizing risks, and consequently sustainability will be emphasized by producers. The more certain the factor, the higher the degree of sustainability.

Sustainability can also be explained at a different level. Ecological sustainability is usually measured through biodiversity or fertility. Economic sustainability is achieved when crop combinations are able to provide a stable and diversified source of long term income. Social sustainability may be provided by land tenure and land-use systems that are socially adapted to new economic and political environments. When traditional laws adapt rapidly to new contexts and the coherence between social and technical systems is maintained, the resilience of rural communities to external "aggression" (as it is commonly perceived by producers) seems to be more effective.

If innovation leads to widespread adoption of a single major cropping system such as jungle rubber by the majority of farmers, then there is no social differentiation. But when diversification processes engender different access to capital and information and many different possible pathways, then social differentiation will occur. Beside possible power plays within the community, potential conflicts about resources and in particular about land will follow. Traditional laws may temporarily play the role of a "safety net" but they will probably rapidly adapt to the new socio-economic context. Social changes will then be accelerated, as has been observed in Indonesian society since 1997..

Beside quantification and therefore possible comparison, the use of farming systems modeling leads to the identification of economic thrusts at the scale of the individual farmer and potential impact or adaptation at the collective scale. Olympe also has the ability to analyze groups of farms at the regional scale. The flux of inputs/outputs can be analyzed from a given situation in the past or present to one in the near future using different scenarios. The changes in the flux of capital, savings, investments, use of fertilizers, improved planting material and possibly an increase in production will provide the basis for more organization of farmers to control sales or purchases and to obtain better markets. Genuine endogenous farmers' organizations do not yet exist in Indonesia for tree crop farmers as it was forbidden until 1999 or more or less fully controlled by government agencies (the KUD, *Kooperativ Unit Desa* or Village cooperative for instance) or private companies (through marketing channels to a specific factory for rubber and oil palm).

So far, in the Indonesian case study, Olympe has been used to model and re-analyse changes in farming systems mainly though discussions between researchers, students and farmers. The next logical step would be to use Olympe databases and results (in particular from prospective analysis) to promote negotiations between stakeholders, government agencies, projects, Estates and farmers concerning land-use and the impact of diversification. If the impact of technical innovations is relatively easy to measure (and quantify), the impact of significant social change is more difficult to assess. A qualitative analysis including collective behaviors of communities and the impact of policies (on both political and development themes) is required.

5 Conclusion

The economic forecast of incomes, monthly treasury, labor availability per activity allow the evaluation of the viability of technical or organizational choices to define technical thresholds and possible scenarios for change. FSM enables the readjustment of an observed reality of an existing farm, and its future change (real and potential through prospective analysis) and impacts. This is why, Olympe is particularly well-adapted to monitor a network of farming systems of reference and to assess the impact of any potential technical or organizational innovation whether introduced or endogenous.

Farming systems modeling can be used as a prospective tool to build scenarios about potential farming pathways and to define agricultural policies, recommendations, the feasibility of recommendations as a function of local constraints, the assessment of different impacts and of the adequation between policies and the real situation of the farmers.

The main interest of modeling is that stakeholders can negotiate from a position of symetric information while in possession of the potential advantages and disadvantages of each decision for both individual farms and for the region as a whole. Coupled with a detailed analysis of history and social processes, social change can then be more satisfactorily analyzed in the context of technical change and innovation processes.

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Figure 1: the global methodological scheme using Olympe.

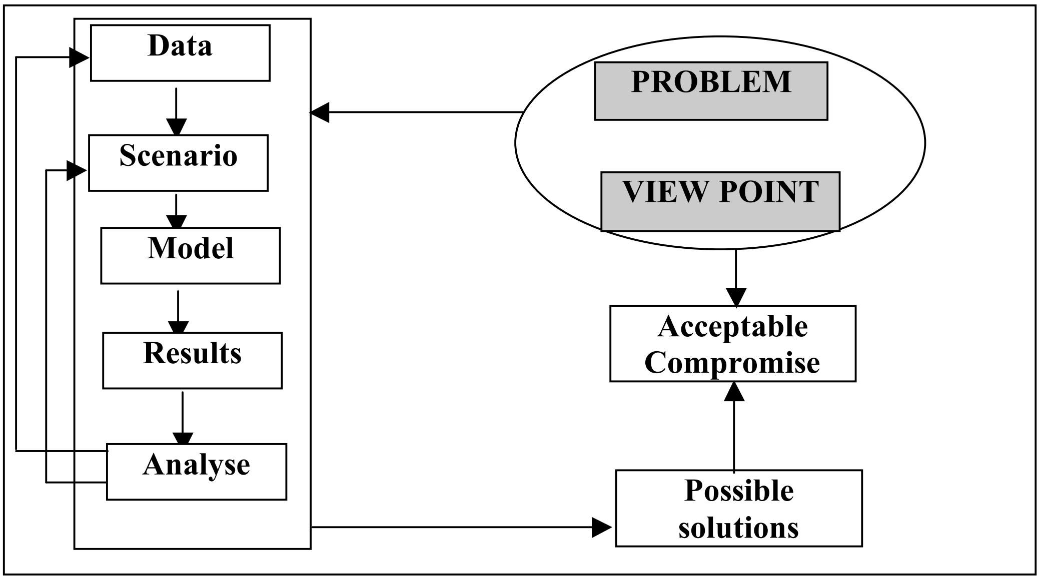
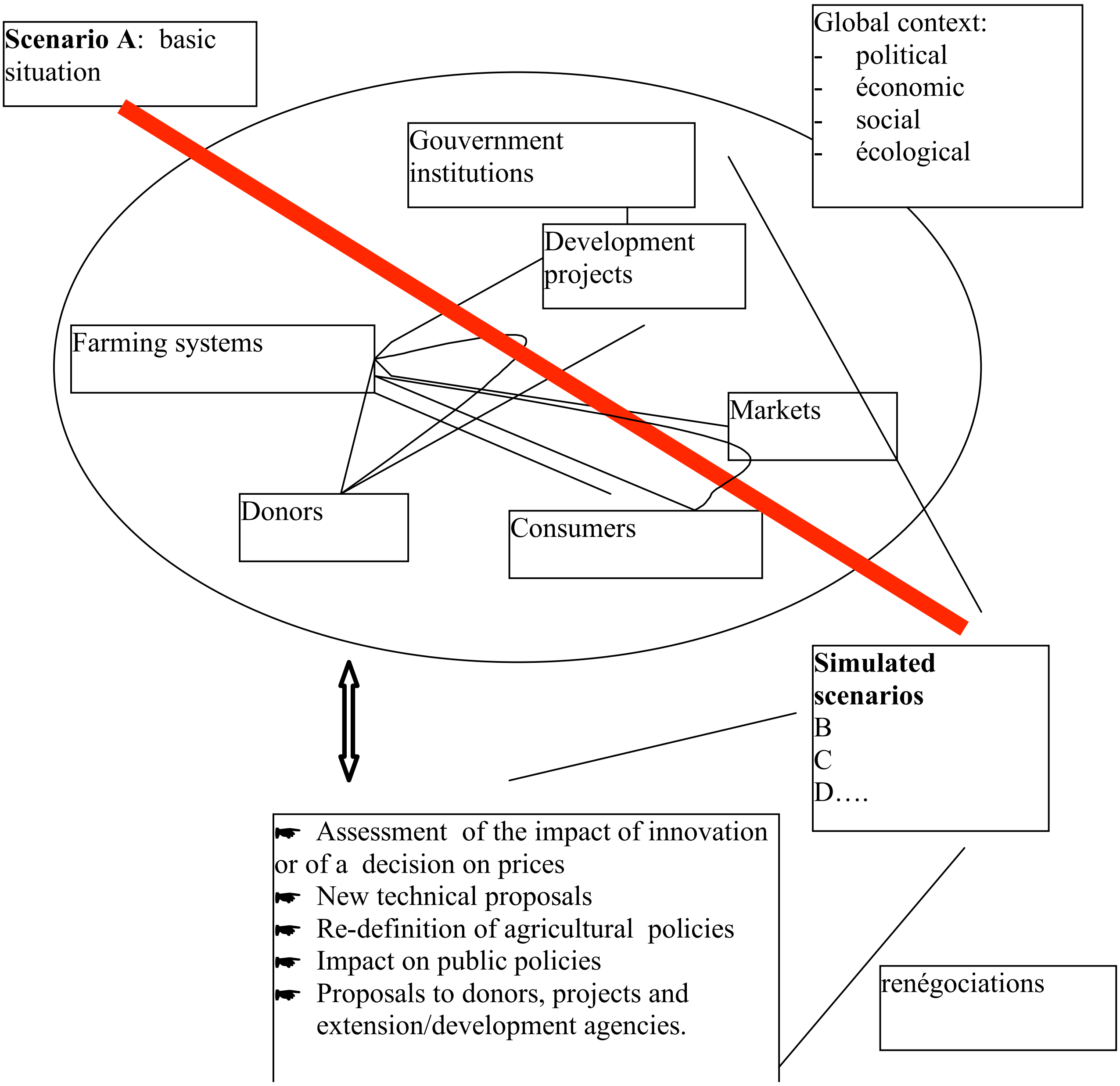


Figure 2. Definition of prospective scenarios:



End notes

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[i] Mainly speaking of coconut, cocoa, coffee, oil palm and rubber.
[ii] This refers to 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 of rubber), short term strategy based on off farm activities and diversification with integration of new crops such as oil palm, pepper etc. [Penot, 2003 #1171].
[iii] INRA = Institut National de la Recheche Agronomique, IAMM = Institut Agronomique Montpellier Mediterranée.