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Abstract

Direct sowing mulch-based cropping systems (DMC) have been disseminated in Madagascar since ten years. They meet environmental conservation, income generation and poverty alleviation objectives, especially in zones under the constraints of strong population growth, land scarcity, environmental and resources degradation, and unsustainable traditional farming systems The Lake Alaotra region, has seen substantial DMC dissemination in recent years through a local development project BV-LAC,. The approach taken by the project is intended to combine DMC dissemination with socio-territorial actions such as land certification, access to credit, marketing of agricultural products, input supplies, assistance for livestock production and pastures management. The project takes into account the complexity of local agrarian systems as well as farmers' diversity. Several farms categories were thus identified in a typology using the following main differentiation criteria: rice self-sufficiency, size of the farm, access to the different units of the physical environment, crop diversification, and off-farm activities. The implementation of a "farming system reference monitoring network", associated with farming system modelling with the software « OLYMPE », enable to assess the economic impact of a technical choice for the different types of farms. Prospective analysis is done in order to identify the best bet alternatives and assess riks through climatic events or prices volatility. There are no categories that are completely "resistant" to DMC systems, but the degree of adoption can vary depending on i) the type of advantages or the response to a particular constraint and ii) the ability to implement these new technologies: integration with livestock, securing income on upland beside irrigated areas, relation between risk rating and investment capacity, access to markets…. By taking these different elements into consideration, it's possible to improve significantly the dissemination efficiency.

Media Summary

The dissemination of DMC technologies in the Lake Alaotra region in Madagascar is facilitated by its interaction with a project witch develops actions at a socio-territorial scale.

Key words

Madagascar, environment, conservation agriculture, catchments, DMC technologies, socio-economy, farming system approach, adoption

Résumé

Les techniques de systèmes de semis direct sur couverture végétale (SCV) sont diffusées depuis une dizaine d'années à Madagascar. Ils répondent à des objectifs de préservation de l'environnement, de création de revenus et de réduction de la pauvreté, en particulier dans des zones contraintes par la forte croissance démographique, la saturation des espaces habituels de production, la dégradation des milieux et des ressources et le risque de non durabilité des systèmes agricoles traditionnels.

La région du Lac Alaotra, située à 250 km au Nord de la capitale Antananarivo, a connu ces dernières années un important niveau de diffusion des techniques SCV. Avec 100 000 ha de plaines cultivées, elle est considérée comme l'une des principales zones rizicoles du pays et qualifiée de « grenier à riz » malgache. Malgré sa richesse relative, la région est menacée par plusieurs facteurs : la saturation des rizières de plaine et l'impossibilité de les étendre, la stagnation des rendements rizicoles, une forte érosion imprimée dans le paysage (7000 km^2 de bassins versants), la difficulté des acteurs locaux à maîtriser leur développement. Aujourd'hui, l'exploitation des collines et des zones de plaines exondées n'est plus considérée comme un phénomène émergeant ou marginal, les revenus procurés par les cultures pluviales sont devenus importants et parfois vitales pour de nombreux agriculteurs. C'est dans ce contexte que le projet « mise en valeur et protection des Bassins Versants du « Lac Alaotra » (BV/Lac) a démarré en 2003. L'un des volets de ce projet, confié notamment au bureau d'études BRL-Madagascar, vise à vulgariser les techniques SCV auprès des paysans des bassins versants.

L'encadrement technique assuré en 2008 concerne environ 1000 exploitants agricoles et une superficie globale de 600 ha. L'analyse des premiers résultats technico-économiques obtenus met en évidence une augmentation significative de la valorisation de la journée de travail au fil des années de pratiques des SCV : amélioration des rendements et baisse progressive des charges de production (temps de travaux, meilleure valorisation des fumures appliquées…). La démarche développée par le projet vise à associer la diffusion des techniques SCV à des actions à dimension socio territoriales : accès au foncier et au crédit bancaire, commercialisation des produits agricoles, approvisionnement en intrants, appui à l'élevage et à la gestion des pâturages. Le projet cherche par ailleurs à prendre en compte la complexité du système agraire et la diversité des agriculteurs qui le compose. Une étude conduite sur 107 exploitations agricoles en 2007 a notamment permis d'affiner les connaissances des opérateurs de diffusion sur le fonctionnement des systèmes de production rencontrés dans la région et donc d'accroître la pertinence des propositions techniques. Six catégories d'exploitations ont ainsi été identifiées, avec pour principaux critères de différentiation : l'autosuffisance en riz, la taille de l'exploitation, l'accès aux différentes unités de milieu physique, la diversification des productions et les activités extra agricoles. Ces différents types d'exploitations n'ont pas les mêmes moyens, objectifs et ne sont pas soumis aux mêmes systèmes de contraintes. Il n'existe pas à priori de catégories complètement réfractaires aux systèmes SCV mais le niveau d'adoption peut varier suivant (1) l'intérêt que chacun trouve dans les systèmes proposés (2) et la capacité à mettre en oeuvre ces nouvelles technologies: intégration avec l'élevage, sécurisation des revenus en dehors des périmètres irrigués, mise en relation « côte risque/capacités d'investissements », accès aux marchés. La prise en considération de ces différents éléments permet d'ores et déjà d'améliorer l'efficacité de la diffusion.

Determinants of DMC technologies adoption among smallholders in the Lake Alaotra area, Madagascar

1. Introduction

In Madagascar, land scarcity and stagnation of the productivity in irrigated areas, led to increasing cultivation of the hills ("*tanetys*"). However, erosion and runoff can induce the degradation of these fragile soils and cause damage to infrastructure and crop production downstream. The development of technical solutions preserving the environment, well adapted to the various agro-socio-economic contexts, economically viable and easily applicable, represents a key challenge for the country. The "Direct sowing mulch-based cropping systems" (DMC) can take up this challenge.
The purpose of this communication is twofold: (1) demonstrate the benefits of these techniques in terms of economic profitability and identify the determinants of a significant level of diffusion, (2) highlight a strategic approach that promotes the development of such techniques in the Lake Alaotra area. This approach is designed both to enhance the socio-economic environment of the farms (access to land and bank credit, marketing of agricultural products, input supplies) and the technical capital, and to better adapt the technical offer by taking better into account the farm needs and constraints: implementation of a "farming system reference monitoring network" (FSRMN) and notion of "decision support system" (DSS).

2. Innovation mechanisms in agriculture

The "farming system" approach was introduced in 2006 into development projects of "watershed-irrigated perimeters" type, funded by AFD and particularly in the pilot project "*BV Lac Alaotra*" (*Penot 2008*). The approach emphasises a clear understanding of the farms structure, with a "constraint and opportunity" analysis for a better integration of technologies to develop (new technical schemes, *DMC or others*, organizational improvement for access to credit…). A farming strategies analysis is implemented based on an operational typology. The farming system approach differs from the classical "plot approach" aiming at increasing the number of adopters trough a better adequation between farms' contraints and technologies proposed by projects.
The decision support for both the final users of those technologies and the developers themselves, seems now to be a priority in a context of sustainable development. This approach does not systematically provides the optimal solution proposed by a model. It informs actors, negotiators and policy makers on the impact of technology adoption and the resilience of systems after a technical change by showing to them the consequences of a technical or organizational choice, The objective of such approach is to optimize the efforts of outreach by proposing for each type of farmers, adapted technologies and relevant services.
The main idea is to better understand the outgoing and ongoing processes of innovations, to acquire the knowledge, the "know-how" and appreciate the practices that come along and to find the most appropriated techniques and services for the producers according to their socio-economic situations and their strategic orientation towards technical change. Two tools were developed to support such an approach: self-evaluation sessions of API type (Acceleration of the Propagation of Innovations) (Penot, 2008), initially launched by Guy Belloncle and the "farming system reference monitoring network" (FSRMN).
The API method is a group session which consists in making the farmers who obtained the best yields, explain the technical schemes to other farmers who produced less, and thus to stimulate discussions on the practices, constraints and adaptations made in the pilot villages (on the basis of initial technical proposals). Through this approach, all the members of the organisations (without exception) talk about their experiences and subsequently, it becomes possible to define precisely the strategies that will come along, to improve or secure the yields within all the farmers network, for the following cropping season. The method is also called "meeting of assisted self-evaluation and self-assisted programming".
A "farming system reference monitoring network" is a group of farms, representative of the various agricultural situations, depending on i) morpho-pedological and climatic units, as well as ii) contrasted socio-economic contexts. Farms are surveyed and then monitored annually, in order to assess the impact of projects actions and ongoing development policies (on the land, legislation, access to services for agriculture, organization of the producers; innovation processes…) The objectives of a pluri-annual follow-up are the impact assessment, monitoring and evaluation, and technical and organisational decision support for the projects. It also allows prospective analysis (coupled with the software Olympe, INRA / CIRAD / IAMM,

Penot, 2003) and comparison of potential and actual scenarios (according to climatic events or prices volatility).
These two tools combined provide a double collective learning. The API sessions on the one hand help to understand the details of farmers' decisions on the selection of components of cropping systems. It provides collective knowledge for organisations, sharing of knowledge and a relatively good measure (for the operators' database) of the differences between the initial message and the actual practices ("Gap" notion). Beside, the "farming system reference monitoring network" and its application with a prospective analysis involves technicians and engineers who carry out development work, in a collective learning process (multi-operators) for the identification of priorities, risk measurement and eventually the choose of the most promising techniques locally adapted.according to diversification and intensification stratégies.

3. Examples of other agronomic innovations popularized in Madagascar (SRI, SRA etc….)

Reduction of rural poverty and safety food in Madagascar remain strongly related to improvement of productivity in agricultural sector (land and work), which supposes that the farmers are ready to modify their practices, to even intensify them. But these changes are particularly difficult to implement. Madagascar is an academic case on the matter, mainly due to the nature of its farms: small size of the exploitations, weak integration on the markets, strategies of survival, minimum risk management, saving in resources, role of the communal exchanges, strong external dependence…
Recent studies highlight the complex and slow process of the innovation within the Malagasy country society (Gannon and Sandron, 2006). They reconstitute the process of diffusion of the simple transplanting of rice in line, which put nearly forty years to be adopted by 90% of the exploitations of the commune of Ampitafika on the Highlands. The process takes the well-known "S" shaped curve (slow progression of the adoption rate during the first years, acceleration then deceleration) for which the values of the slope (the speed of adoption) and the asymptote vary according to innovations and the various conditions of adoption (Ramasinjatovo, 2006). However, this apparent S shape innovation diffusion, in quantitative terms and considering as a whole, masks the complexity of the process of adoption itself, which mobilizes many mechanisms of social interaction and comprises multiple dimensions: space, economic and in terms of perception of the risk, social (Gastineau 2006).
The case of the intensive rice growing system (SRI) is a perfect illustration. This innovation showed all the characteristics of an ineluctable success story: designed locally with the farmers rather than by experts, slightly expensive in inputs in a subsistence economy, adapted to poor soils, promising in yield in a country with chronic rice deficit (Jenn-Treyer and Al, 2007). Several surveys explained the difficulties of diffusion of this technique in comparison with concurrent traditional methods: very accurate water control, high labour requirement (therefore expensive for the poorest families), significant cash flow requirement, technical complexity and need for support (Moser, 2002), as well as effect of social conformity related to the perception of the risk. The farmers evaluated the technical offer by putting it in perspective within the framework of the constraints to which they are confronted and of the goals which they pursue, and accepted it with difficulty.
However, some local experiments of diffusion show that there is a possibility of adapting SRI to its environment, to make it more plastic and evolutive, and thus widening its potential public even if not aiming at records of productivity, while making this technique easier to control, nearer to the socially conventional practices, and less demanding in work. These pragmatic attempts propose a modification with the margin in the farming ways to allow gradually a measured risk taking by rice growersin the process of security. It is the case of the technical diagrams suggested to the lake Alaotra and Manakara where the technicians help the farmers to arrange the system suggested in order to make it more compatible with their financial constraints: minimization of the seeds, lengthened duration in nursery, possibility of transplanting not only in line, variable density of the seedlings, manure being able to replace fertilizer, reduction of working time on certain tasks, numbers and mode of hoeing, management of the water swell…. In the two zones, there was inflection of the initial technical scheme of the SRI, already from the rice growers but also from the diffusers, to adapt to the financial constraints of farmers.
In addition, the diffusion of the technical innovations in Madagascar comes up against the brake of the economic environment not carrying these agricultures: failing availability and access reduced to the factors of production (land, capital through credit, labour…), to the public infrastructures and to services (roads, information on the prices…) and to the markets (of the products and the inputs). Thus the failure of the adoption of several technical innovations leads to the need of setting up public policies supporting the reduction of uncertainty related to the environment of the farms. Several recent initiatives show that the State

tends today to better accept its share of responsibility and directs its interventions towards the creation of favourable conditions for the functioning of various markets (Jenn-Treyer and Al, 2007).
Thus, in the Malagasy context, the inversion of minimization risk strategies suppose at the same time: sufficiently "acceptable" techniques (designed in interaction with the beneficiary, limited "technological jump"…), an iterative offer and a technical support showing sufficient flexibility to generate a process of training (necessarily slow) of the beneficiary and diffusers.

4. Principles and history of DMC technologies in Madagascar

Direct Seeding Mulch-Based cropping systems (DMC) rely on a few principals, comparable to a forest system: i) the soil is permanently covered, ii) plants with deep root system recycle the nutrients leached deep into the soil, iii) biological activity and biodiversity are very high and iv) plant nutrition is insured by a rapid turn-over of organic matter. To insure these functions, DMC systems proposed a change in paradigm, and rely on three main principals, trying to mimic a natural forest environment and to speed up the biological processes involved: i) The soil is not disturb (sowing is done with minimal soil disturbance), ii) It is permanently kept covered by a thick mulch, iii) Crop rotations and associations helps maintaining biodiversity.
DMC systems rely on a high biomass production for a rapid turn-over of nutrients and organic matter. This biomass is produced thanks to crop associations and/or rotations, use of cover crops/forages to maximize water utilization, especially during dry and/or cold seasons when biomass production is usually very limited.
Plants with strong and deep root system are used as "biological pumps" to recycle water and nutrients from deep horizons, soil characteristics are improved (increase in organic matter, biological diversity and activity, structure, porosity, etc.) in a sustainable way (reduction of erosion). Water use efficiency is largely increased through better porosity, reduction of run-off and evaporation, etc.
By suppressing land preparation (no need to plough, soil structure and weed control being insured by respectively root systems and biological activity, and mulch/cover crop), the labor costs are reduced which make this systems very attractive to farmers, all the more that increase in yield is rapid.
In Madagascar, DMC systems have been locally adapted by TAFA (a local NGO) and CIRAD for over 10 years in various agro-ecological and socio-economic environments: (1) High lands (>1200-1700 m), with sub-tropical climate and a cold season; (2) Medium altitude (700-1000 m) with a long dry season (>6 months) as in the Alaotra lake; (3) humid tropics (0-500 m, 2-3 m/year) rainfall and (4): semi-arid conditions (400-800 mm/year rainfall, over 7 months- long dry season). A large panel of systems adapted to the agro-ecological conditions (climate, various soil type from rich to poor or even abandoned land) is proposed in each region, to fit the local socio-economic conditions and to be able to propose solutions locally adapted at farm level.

5. The Alaotra lake: lessons for extension

5.1. A project at the size of local constraints in the Alaotra lake

The Lake Alaotra region, located 250 km north of the capital Antananarivo, has seen substantial dissemination of DMC techniques in recent years. With 100,000 ha of cultivated lowland plains, it is considered to be one of the main rice growing zones in the country and is known as the Madagascar "rice granary". Despite its relative richness, the region is threatened by several factors: saturation of the lowland rice fields and the impossibility of extending them, stagnating rice yields, a landscape marked by heavy erosion (7,000 km^2 of watersheds), difficulty for local stakeholders to take control of their development. Today, upland rainfed cropping is no longer considered as an emerging or marginal phenomenon. The income from upland cultivation has become considerable and sometimes vital for many farmers. It is in this context that the project "BV Lake Alaotra" (financed by the "Agence Française de Développement") was launched in 2003.
The Project aims at several objectives: (1) improving the income of local populations, (2) avoiding natural resources degradation in order to secure important irrigation infrastructure on the lower side of the watersheds and (3) strengthening the capacity of farmers' organisations and local municipalities to become responsible for their own development.
This project is a real size prototype of the approach promoted by the government in its national program "watershed-irrigated perimeters". One component of this project, entrusted in particular to the society "BRL-Madagascar", is intended to extend DMC techniques among farmers at watershed level.

5.2. DMC techniques extended in Alaotra

The context

The Alaotra lake plain in itself , located 750 m above mean sea level, counts 30 000 ha located in large scale perimeters with irrigation means, and 72 000 ha of traditional paddy fields, without water control. This plain is surrounded by a set of hills and steep mountains streaked with small valleys. The climate is a tropical climate of moderate altitude, with long dry season (7-9 months-long).

The main constraints of this region are water resources and the strong erosion on watershed which creates huge problems of floods and sanding up.

In paddy fields without water control, unreliable rainfalls at the beginning of the rainy season do not allow farmers to grow rice at a favourable time. Unable to predict the transplanting date, it is difficult to prepare the nursery as it should be and transplanted plants are often very old. The length of the period during which paddy fields are submerged is unreliable and yields often are low, even when the crop was properly settled. As a consequence, farmers often broadcast rice seeds, playing a kind of lottery It should be mentioned that part of these paddy fields with too unreliable yields is no longer cultivated, since years.

Soils on the hillsides show very variable fertility levels, according to their geological origin, their place on the toposequence and their history of cultivation. The poorest soils in the region are located on the western shore of the lake. They are ferrallitic soils, leached, with high acidity, high aluminium and low organic matter contents. On the eastern shore, soils are richer, as originating from basaltic substratum (gneiss at amphiboles). The mains crops are upland rice, cassava, maize, groundnut and green bean. Declining yields and large erosion marks (at field level and at landscape level) are clear indicators that these traditional systems are not sustainable.

Technical offer

TAFA NGO started the first experiments on DMC in Alaotra Lake in 1998 (Charpentier 1999) Technical references on DMC were produced and made available to extension organisms (ANAE, BRL, VSF…) from 1999. Systems proposed to start DMC are based on farmers systems and their main crops. From the first year (often with ploughing as in the traditional systems), the aim is to increase considerably the total biomass production with addition of a cover crop, either associated to the main crop or as relay cropping A range of diversified cropping systems has been developed for hillsides, rainfed lowlands, and paddy fields with unreliable irrigation systems.

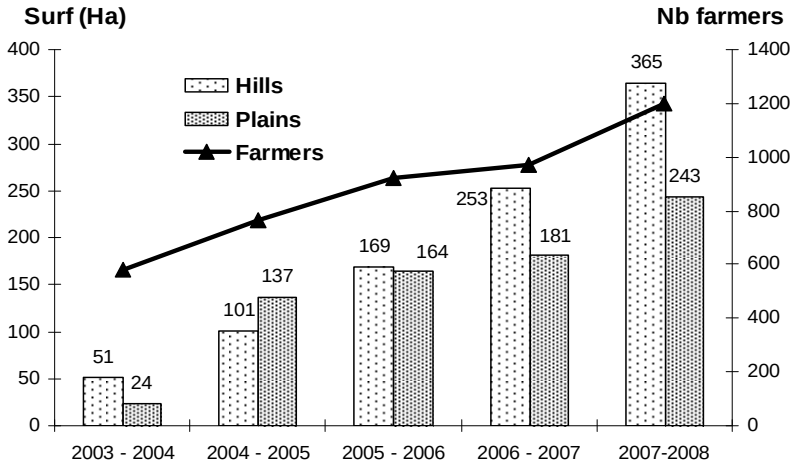
In paddy fields with unreliable irrigation, « polyaptitude » rice (SEBOTA varieties, with a high degree of polyvalence and the ability to grow either under rainfed or irrigated conditions) during the rainy season followed by a legume or vegetable during the dry season, provide good economic results.

On the hills, the technical offer is a function of the soil fertility. On rich soils, the most adopted cropping system is a rotation with Maize associated to a legume (*Dolichos lablab*, *Vigna umbellata*, *Vigna unguiculata*, *Stylosanthes guianensis*…) followed the next year by upland rice (eventually associated with *Cajanus cajan* and/or *Crotalaria sp.*). This system has the double advantage of being an excellent system to start DMC (high biomass production and soil structure improvement from the first year thanks to the association between maize and a legume) and to be economically very attractive to farmers. On poor soils, the association between Cassava and Brachiaria is being extended fast as it produces significantly higher yields than the traditional technique, while it also allows to increase forages production at farm scale and erosion control on steep slopes (Charpentier 2004). Low-demanding grain legumes such as bambara nuts or groundnuts can be cultivated in rotation with this association.

5.3. First results obtained regarding DMC extension

The surface cultivated in DMC under BRL supervision (one of the BV-lac project development operator) has steadily increased every year. In 2008, around 1200 farmers applied DMC systems on a total of 608 ha (Fig.1) (BRL, 2008). The increase in areas cultivated under DMC per farmer also insures a greater impact on farm benefit (Chabierski and *al*, 2005).

Fig. 1: Evolution of the extension (BRL, 2008)



The assessment of the main DMC cropping systems that have been extended, based on a technical and economical monitoring of fields supervised by BRL shows an increase with time in the valorization of the labour. With DMC practice, yield is increasing from year to year while charges are decreasing (no ploughing, decreasing weed pressure, increasing valorisation of manure etc.). As seeding is done very early, from the first rains, the production can be commercialized very early, at a time where prices are high (in march-april, during the hunger gap) (Fig.2).

The use of the BRL plot database helps in the precise evaluation of the abandon rate within the farmers' network. This rate was high at the beginning of the project but it now tends to decrease: It ranged from 40 % in 2005 to 27% in 2008. The training, the simplification of the cropping systems and a qualitative approach at territorial and farming systems scale justify this positive evolution. The main factors mentioned (Fig.4), are in ascending order: the technical control of crop management sequence, the levels of investment (notion of risk, in relation to the farms' type), the land access and the work organization at farm scale.

Fig. 2: Relation between labour productivity and the number of years of DMC practices (BRL, 2007)

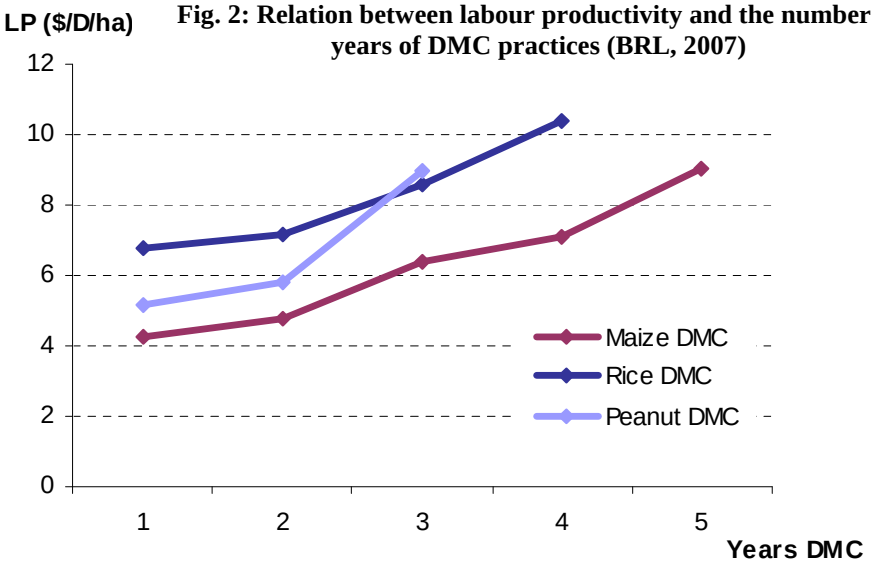


Fig.3: Evolution of rice and maize price in the lake Alaotra area (PENOT, 2008)

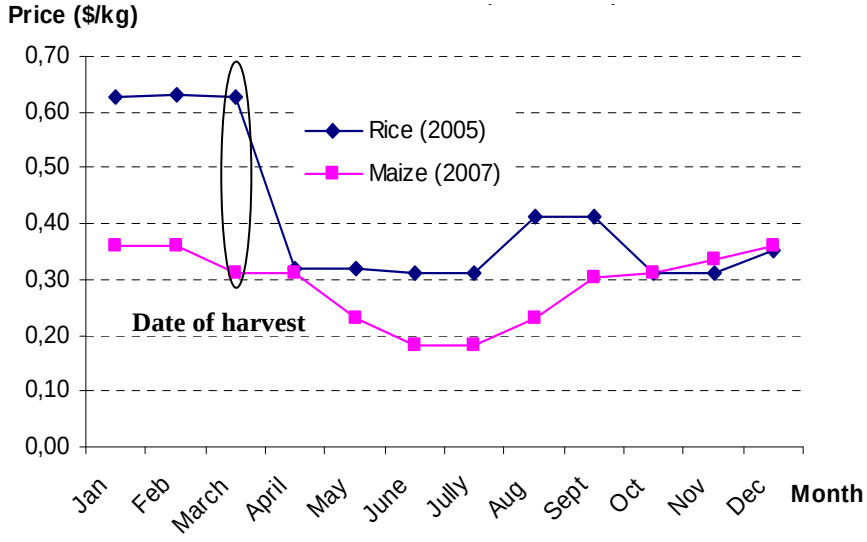
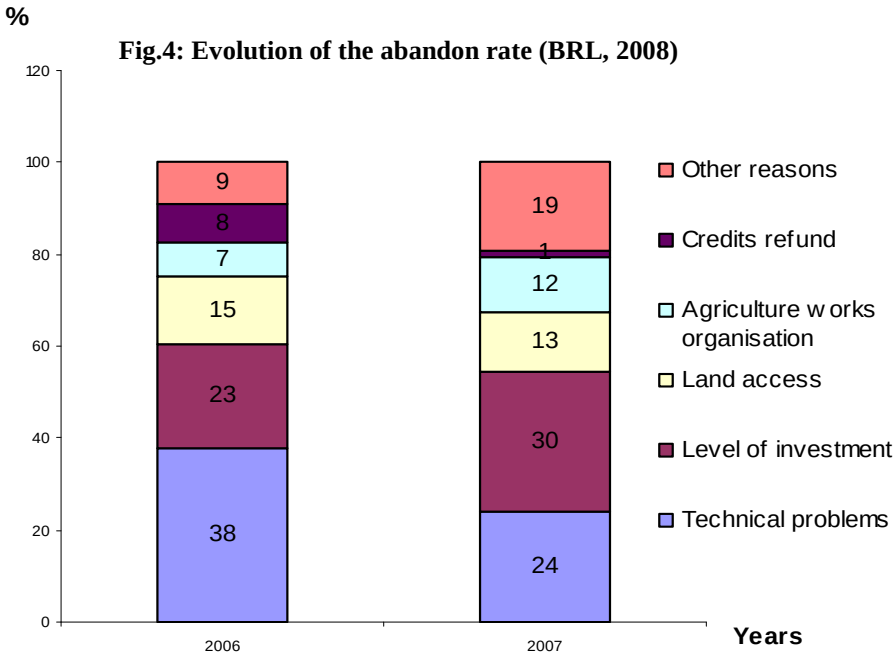


Fig.4: Evolution of the abandon rate (BRL, 2008)

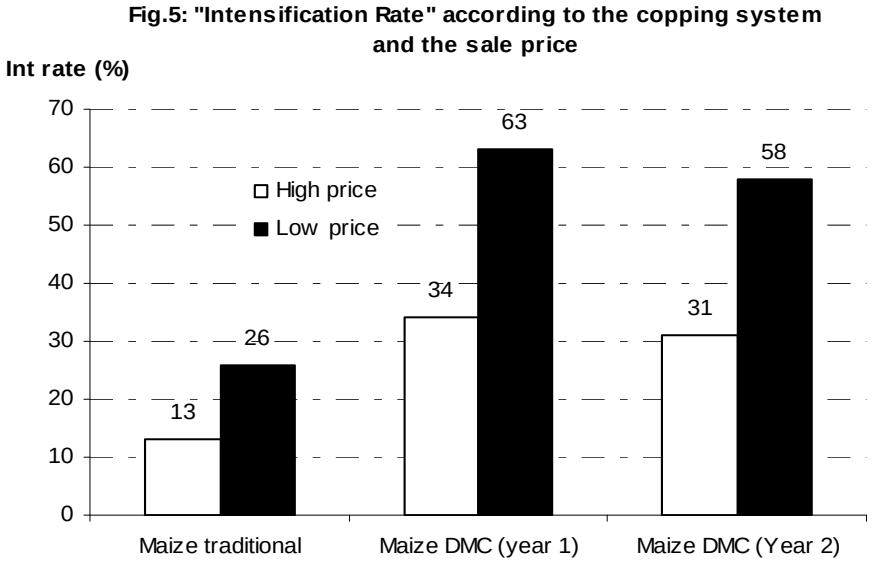


Farmers sometimes face difficulties in carrying out technically DMC technologies. The adoption of DMC technologies is considered as a « mini-revolution » of the mentalities, a reversal of the agro-techniques fundamentals of the farmers' practices. A good understanding of these new approaches and a good technical level is essential. The non-respect of the technical recommendations or the inadequacies of the proposed systems could harm the subsequent dissemination.

The important climatic variability observed in the region (subsequent years of dryness, devastating storms…) can inhibit the capacity of some farmers to invest in the rainy crops, especially the modest ones. The more prevalent DMC systems require a mean level of investment of 200 $/ha, witch represent an intensification ratio significantly superior than the traditional systems (Fig. 5).

Fig.5 : « Intensification Rate » according to cropping system and sale price (Penot, Domas, 2008

Cropping systems: (1)" Maize traditional": Maize on ploughing; (2) Maize DMC: "Maize + Dolicos lablab" / "Maize + Dolicos lablab".



The land tenure is one of the principles determinants of farmers' strategies at cropping system scale and represents a major challenge in Madagascar. Some tenure such as share cropping or land renting, remain an important barrier to DMC adoption, limiting therefore a sustainable smallholder development. In the *Lac Alaotra* area, landlords are reluctant to rent their plots for several years, fearing to lose their land ownership in the long term. Still, a strong competition appears every year between the implementation of irrigated rice and rainfed crops. Rice remains the cornerstone of household production and thus the agricultural operations in irrigated perimeter, with a good water control, constitute a priority in the farming management.

The follow up of the abandonment help to estimate the appropriateness of the cropping systems introduced to the local context and to adjust both the technical offer and the socio-economic measures (training, land security, organization of the farmers…). Extensionist were not able at the beginning of the project to tackle with farming systems complexity and various strategies. This sometimes resulted in unsuitable technical recommendations: intensive and poorly diversified system to porr farmers leading to a risk of credit no reimbursment, "integration agriculture-livestock" topics poorly developed, land factor not clearly understood…Although these principles are now widely accepted, it is good to recall that taking into account farmers' practices, strategies, objectives and constraints are fundamental in a process of agricultural extension. Farmers should not be regarded as an homogenous set as they do not have the same means, and do not necessarily produce in the same social and economical conditions. Improving locally the knowledge on farmers' reality made it possible to improve the relevancy of the technical proposals and as a consequence, the efficiency of extension.

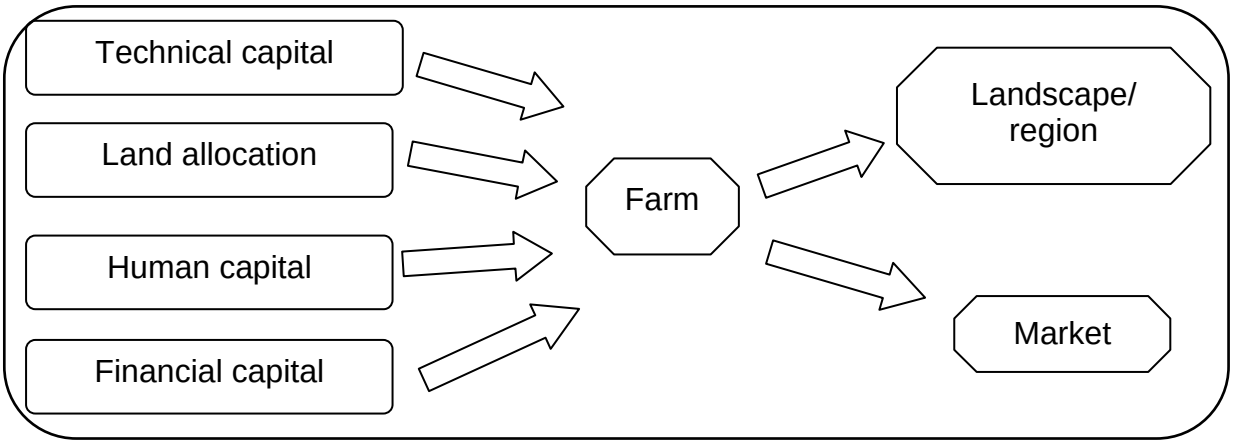
5.4. A holistic approach placing the farm at the centre of project strategies

5.4.1 The improvement of the socio-economic context

The strategy of the project is based on the idea that the degree of adoption doesn't only depend on the expected advantages but also on the ability to implement these new technologies (Fig. 6). Based on this principle, the actions developed within the pilot villages consists in i) training the farmers at mastering diverse "DMC scenarios", on their lands, using crops of their choice, and ii) in contributing to the

organisation of the villages communities: access to credit, marketing of the productions, inputs supply, agricultural equipment, seeds productions, cuttings, breeding grounds of shrub species for hedgerows.
In 2007 for instance, 100 farmers organisations (included more than 600 individuals) worked with BVLAC project, the amount of the bank credits contacted (for input costs) was around 150 000 USD and 450 land certificates were delivered to DMC adopters. Cover crops had also been implemented at territorial scale by several village communities, in order to control erosion and increase significantly the forage availability for the cattle raisers. But the real impact of these activities at a regional scale is conditioned by the level of involvement of the local stakeholders, the private sector notably. In that matter, the private sector susceptible to buy agricultural products ("URCOOPA" from Reunion island, "Taureau ailé" from France…), to sale chemical inputs (FIAVAMA, SEPCM etc…) or to rent their equipment (AGRO-BP-CONSEIL) had been regularly informed of the projects activities. The private sector should have a marked impact on the dissemination and adoption of these new cropping practices since they are in regular contact with farmers.

Fig. 6: a holistic approach for a sustainable development



5.4.2 Refinement of the technical offer

The diagnosis
A regional farm typology, obtained from a survey on a sample of 107 farms made in 2007 made it possible to identify 6 farm types, based on: rice self-sufficiency, farm size, access to the different land units, products diversification and off-farm activities (Table 1).

Table 1: farming systems typology (S. Nave, C. Durand, 2007)

TYPES	Total area	Rice self sufficiency	Livestock production	Off farm activities
A	TA>9ha (RI>5ha / UPL> 4 ha)	[S / C]	Cattle	No
B	TA>7ha (RL>5ha / 2<UPL<3 ha)	[S / C]	Cattle	No
C	TA<5ha (RI/RL=2ha / UPL< 3ha)	[S]	Cattle, pig, poultry, duck	Commerce, handicrafts
D	TA<3,5ha (RL=1,5 ha / UPL<2ha)	[S]	Pig, poultry, duck	Commerce, farm worker
E	TA<1,5 ha (RI/RL<0,5ha / UPL< 1 ha)	[NS]	Poultry	Farm worker
F	TA<1,5 ha (RL=1 h / UPL< 0,5 ha)	[NS]	Poultry	Fishing

RI : Ricefield surfaces ; UPL : Upland surfaces ; RL : Rainfed Lowland surfaces
S : rice self-sufficient ; NS : not rice self-sufficient ; C : rice commercialisation

Large rice growing farmers (A type)

These farmers are self-sufficient regarding rice production and can sell a large part of their production. They have large irrigated paddy fields (> 5ha) and upland fields (mainly on the hills). Farming is centered on rice cultivation and the hills are often partially cultivated, in an extensive way, with low labour-demanding crops (Cassava, groundnuts, etc.). These farmers have rather large cattle herds which represent their main labour force. Permanent workers are the couple, one child and very often a permanent employee, and they usually employ temporary manpower.

Rice growing farmers with unreliable yields (B type)

These farmers have large paddy field areas, with unreliable water control (> 3 ha) and upland fields (2 to 3 ha) which are rather intensively cultivated (upland rice, maize, vegetables, etc.). This "upland cropping " strategy allows to compensate the unreliability linked to the poor water control in the paddy fields. They are self-sufficient in rice (which represents 60 % of the farm incomes), except during the rare very bad climatic years. They have a high number of cattle. Crops diversity demands a good organization of cropping calendars at farm scale and they have to hire temporary manpower

Farmers self-sufficient in rice, cultivating on the hills (C type)

These farms produce enough rice to cover the family needs. The farming system in not entirely centred on rice production and is very diversified: upland crops (groundnuts, maize, cassava, legumes, vegetables during the dry season and fruit trees) and animal raising (chicken, ducks, gooses and pigs). These farmers have 1 to 3 ha of paddy fields (with good or unreliable water control) and 1 to 3 ha of upland fields. Some of these farmers also chose to have off-farm activities, but are not selling their labour force to other farmers. They often employ temporary manpower, especially during labour picks. Upland crops provide . 80 % of the total net agricultural income.

Farmers not self-sufficient in rice and diversifying their productions (D type)

These are rather small farms which viability can rely on one family member off-farm activities: manpower, handycrafts, trading. They usually have 1.5 ha of paddy field with unreliable water control and small upland fields (1 to 2 ha). The crops are diversified, over half of the profits coming from selling upland crops or animals (pigs, poultry). Most of these farmers do not sell rice although a few of them do it to purchase daily basic products (oil, soap, etc.), which leads them to eat cassava during the hunger gap. It should be mentioned that these farmers are found exclusively in villages of migrants and are innovating farmers. New agricultures following migration can indeed be opened to new technologies which they will apply without to much recognition as the intimacy with the cultivated plant, the environment and the technique will be poor (D. Rollin, 2000).

Farmers not self-sufficient in rice and farm workers (E type)

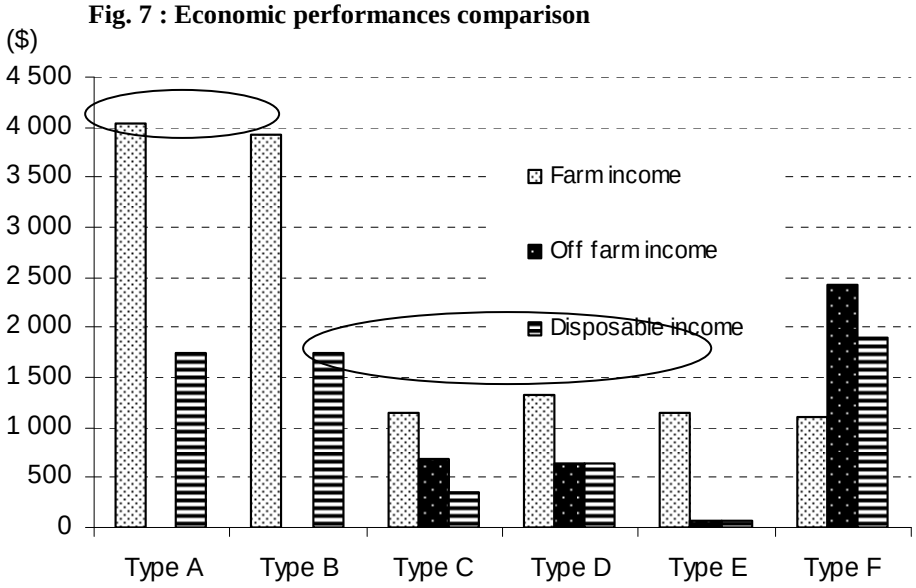
This type of farm has very limited land : less than 1 ha of paddy fields and less than 1 ha of upland fields. These farmers are often young (less than 30 years old), do not hire farm workers and sell their labour force to other farms. They do not own cattle and earn small incomes from poultry. They cultivate the hills intensively (cassava, upland rice, maize, etc.) for cash.

Fishermen having off-farm activity (F type)

These farmers benefit from their location near the lake to get significant incomes from fishery. Their area in paddy field is too small to make them self-sufficient in rice. They cultivate upland fields intensively, trying to get some cash from their products. Less than 30% of the total farm incomes come from agriculture.

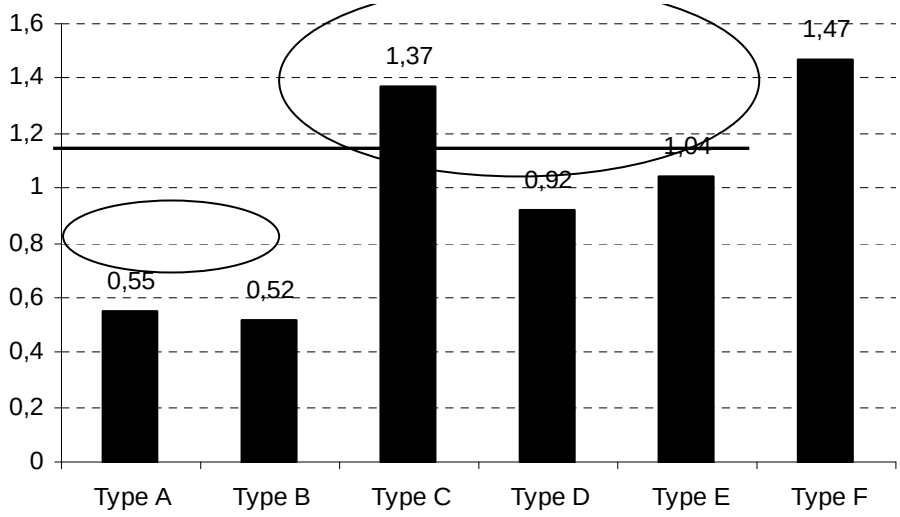
Figures 7 and 8 show respectively the various sources of income and the ratio "Familial expenses/agricultural income" for each of these farm types. A significant difference between two groups of farmers is highlighted: a first group is composed of A and B type, which have a net profit from agriculture three times higher than the second group, gathering farmers from C, D, E and F type. Farmers of this latest group have to rely on off-farm activities to insure their viability. This statement is confirmed by figure 7. It should be mentioned, however, that D type shows a ratio expenditure/agricultural incomes slightly higher than 1: diversification of products through animal raising (integrating crop production with pig feeding) allowing an important added-value.

Fig. 7 : Economic performances comparison



Source : Durand & Nave , 2007.

Fig. 8 : Ratio « Familial expenses / Agricol income »



Source : Durand & Nave , 2007.

These graphics indicates that several factors to be taken into account during extension work.
(1) A and B types have more financial means, allowing them to capitalize and invest for the improvement of their farming systems. Strategies developed by these two types, however, are very different: (1) A type farmers base their farming systems on a secured rice production (paddy fields with controlled irrigation system), with a large part of the production commercialized every year; (2) B type farmers have more variable results with rice, depending on climatic conditions, and upland crops allow them to buffer these hazard. These two types have large cattle herds and the long hunger gap (7 months-long dry season) reduces considerably the performances of the animals when they have to work in the fields.
(2) C, D and E types have a strategy of diversification, under important financial constraints. They are looking for systems more efficient and more reliable for marginal production areas (paddy field with poor water control, uplands, etc.) Incomes from off-farm activities, upland crops, pigs and poultry insure the economic viability of their farm. Their capacity to invest and take risks are globally much lower than A and B type.
(3) Farmers from F type get most of their incomes from fishery (69%) but are more and more interested in agriculture due on the one side to the increasing prices of agricultural products and on the other side to declining fisheries resources in the Lake. Their financial means are rather high.

Propensity of the different types to adopt DMC technologies and adaptation of the technical offer
By taking these different elements into consideration it is possible to improve dissemination efficiency.
The table 2 presents (1) the advantages found by each type in DMC techniques, and (2) the cropping systems that can be proposed in function of these different farm types.

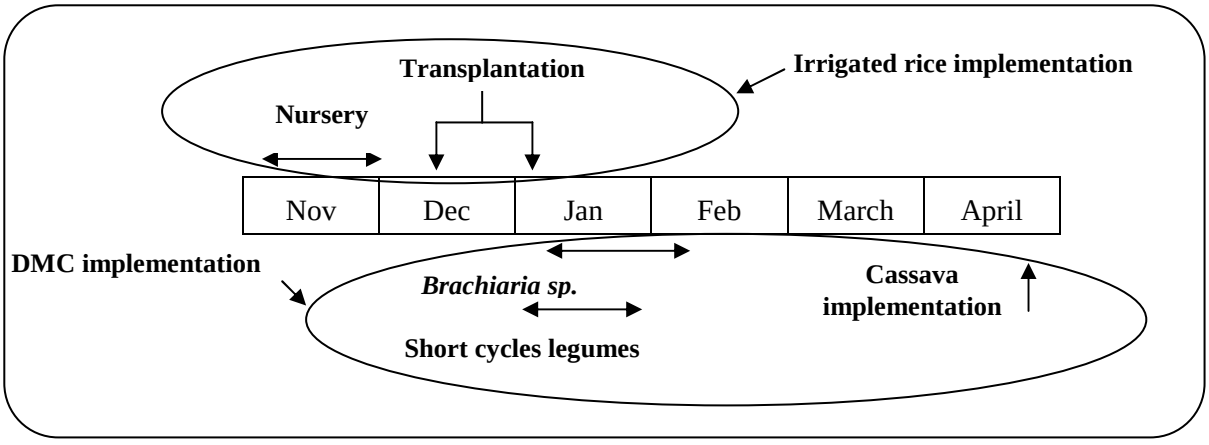
Table 2: Technical offer according to the farms categories

Type	Interests	Technical proposals
A (3)	Forage availability Diversified productions	Forage-based cropping systems / flexibility of the cultural calendar
B (1)	Securisation of the income provided by the rainfed lowland and the hills	All the cropping systems / integration of the medium and heavy mechanisation
C (1)	Securisation of the income on the hills Integration with livestock (cattle and pig)	Diversified rotational sequences / integration « agriculture-livestock » ; high level of intensification possible
D (1)	Securisation of the income on the hills Integration with livestock (pig, poultry)	Diversified rotational sequences / integration « agriculture-livestock » ; different levels of intensification following investment capacities
E (2)	Ploughing removal Improvement of the incomes	Cropping systems without chemical inputs
F (3)	Additional incomes Reconversion in agriculture	All cropping systems

(1) High propensity to adopt DMC techniques
(2) Interests but some constraints can restrain the adoption
(3) No interests and/or important adoption constraints

The rice producers (A) could be interested by DMC technologies to improve their forage resource and to diversify their productions but their farming systems are based on irrigated rice production and the rice,fields activities constitute a priority for them. Forage-based cropping systems with a flexible cultural calendar (sowing dates notably) will thus be proposed. These cropping systems could include Cassava or short cycle legumes in rotation with *Brachiaria sp.* (groundnut, cowpea or Voanzea). The implementation period of these DMC based cropping systems allow a rational labour force organisation at farm scale (Fig. 9).

Fig.9: adaptation of the DMC based cropping systems proposed (cultural calendar) at farm scale



The "Type B" farmers are really interested in DMC technologies to secure their productions on rainfed lowlands and on the hills. According to their investment capacities (cash flow after all expenses), all types of cropping systems can be proposed, including intensive rice or maize cultivation and the integration of intermediate or heavy mechanisation: two row Planters and sprayers for power tillers, no-till Planters for small-medium tractors etc… Their farms could constitute technologic showcases for all farmers of the area

and they could invest in equipment, witch would be rented to a network of small farmers. They could also focus at given places, significant levels of production, to help at merchandising the products.
DMC adoption presents a major interest for the farmers who belong to the types C and D. They are interested by DMC to secure their yields on the hills and to improve their livestock productions. Diversified rotational sequences integrating notably agriculture and livestock will thus be advised: cattle's fattening with forages like *Brachiaria sp.* and *Stylosanthes sp.* ; incorporation of *Mucuna sp.* in the feed rations of the pigs. The diversification of the sources of incomes allows these farmers to buffer efficiently climatic and economic hazard, frequently observed in the region. The level of intensification proposed will be modulated in function of the soil's categories but also the farm size ("risk management" notion of the cropping systems in relation with investment capacities). These farmers could use small mechanization like hand-jab planters, sowing wheels, sprayers for human traction etc…
Farms belonging to the type E are really poor; they may be potentially interested by DMC technologies for two main reasons: i) DMC allows the removal of ploughing which is an important constraint for this class of farms (high rental costs) and ii these systems could ensure an added income, essential for the long-term viability of the farm. This substantial improvement would allow these farmers to move towards the superior categories after several years of practices. Extensionists should however be very careful in the systems recommended because a majority of these farmers live in precarious conditions which prevent them from having a vision on the long term. It seems to be hardly possible to propose costly cropping systems, witch require consequent financial contribution and don't provide incomes during the first year. These farmers can't afford to leave their land fallow, making it difficult to establish sole regenerative of fertility (during two or three years). The "burn-beating" technique (Ecobuage in French) or Stylosanthes rotation based cropping systems which can be managed without chemical inputs, could be well adapted in this situation.
Type F fishermen often need additional incomes and some of them think about a retraining in agriculture, at a medium term. According to their investment capacities, all the cropping systems could potentially be adopted by these households, in function of their needs and objectives.

The use of the software « OLYMPE » (INRA/IAMM/CITAD, JM Attonaty), associated with this classical farming systems survey, will enable to i) test the economic impact of a technical choice (level of fertilization, integration with livestock…) for the different types of farms, ii) test the robustness (resilience) of a technical choice according to climatic or economical uncertainties, iii) assess risks and iv) do a prospective analysis according to climatic events or prices volatility.

6. Experience at national level: Conditions for extension of DMC systems

At national level in Madagascar, the same constraints to extension of DMC systems as in the Alaotra region are observed:

(1) Human resources availability is a necessary (but not sufficient) condition to extension. Without efficient extension teams, able to propose DMC systems locally adapted to actual farmers' needs, constraints and means, extension of DMC systems is not sustainable. This requires an important phase of capacity building prior to large scale extension. Extension staff should acquire knowledge (and know-how) on DMC systems, but also capacity to analyse local constraints, risks and opportunities at farm and village levels. It usually takes 3 years to build efficient extension teams.

(2) Socio economic environment is of high importance: unreliable land tenure, poor access to credit and agricultural inputs, poor marketing channels for instance can annihilate the benefits of DMC systems of high agronomic and economic interest.

Experiences in various socio-economic environments also shows that some situations may largely favor rapid extension of DMC systems as for instance when DMC systems can be proposed to overcome a major constraint to agriculture (like *Striga* infestation in the middle west), unreliable paddy field irrigation (Alaotra lake), open possibility to reclaim uncultivated land, or systems with very limited inputs (all zones).
Integration agriculture/livestock may be seen as a constraint (in case of very high cattle pressure on natural resources) or an advantage for extension of DMC systems (increase of forages production through DMC).
In all cases, the first 2-3 years of transition from conventional systems to DMC are crucial and require proper accompaniment of farmers by extension staff to help them to face new situations. After 3 years, extensionists support to farmers can be reduced.

7. Conclusion

The Lake Alaotra shows today the highest rate of dissemination of DMC technologies in the country. But besides the number of farmers or the global surface concerned, the decrease of the abandonment rate incite to be optimistic for the durability of DMC extension in the region, thanks to "farming system approach " adoption. Many reasons can explain this local evolution. First the results of a efficient Research and Development program witch allowed the creation of a large range of cropping systems adapted to various agro-ecological conditions and categories of farms. Then the important role of a local development project : its originality is to adopt a global and integrate approach, associating technical training and socio-eco-territorial actions: land access, access to credit, integration to market.

A good understanding of the local practices also helped extensionists to be more efficient in choosing their technical advices according to the type of farmers. It is not necessary to understand all an agrarian context to identify the axes of a relevant work, and initial diagnostic is not necessarily long, the "optimal degree of knowledge" has to be found out. The elements currently available in the project make it possible to formulate adequate solutions to various categories of farms encountered. Significant efforts have also been realized to better link the selected cropping systems, the cultural calendars, the periods of commercialization (in relation with the evolution of the prices), the real amount of credit needed and the ability to refund, even in the situation of low productivity or during the dried years. The executives of the project didn't identified categories totally refractory to the adoption, but the propensity to adopt can vary depending on the interest found by each farm in the proposed system and the ability to implement these new technologies. If some farms categories have a vital need to find sustainable alternative to cultivate the hills, for others this is not a priority and the technicians must be aware of it. The implementation of a "farm monitoring network" covering the variability of the farming systems encountered in the region, already allows to improve the approach developed in the pilot villages. Field officers feel thus more responsible and see their outputs valorised, while people in charge now have tools which enable them to well assess the impact of their actions on the technical change, on the incomes and on the evolution of farming systems. The vision of the use of the various "agricultural services" (outreach, credit, supplies, marketing) had been changed and its importance is now clearly recognized by all the project's partners.

The experience from the *Lac Alaotra* is demonstrating that the conjunction of an efficient technical offer adapted to the constraints and to the needs of farmers, and the existence of a favourable socio-economic environment, allows a significant dissemination of DMC technologies, even in a smallholder's context.

References

Chabierski S., Dabat M.-H., Grandjean P., Ravalitera A., Andriamalala H. (2005). *Une approche socio-éco-territoriale en appui à la diffusion des techniques agro-écologiques au Lac Alaotra, Madagascar*, IIIe World Congress on Conservation Agriculture: *Linking Production, Livelihoods and Conservation*, Nairobi, Kenya, 3rd to 7th October, 8p.

Chabierski S., Andriamalala H. (2007). « *La Diffusion des techniques de semis direct sur couverture végétale, Rapport de synthèse (2006-2007)* » - BRL, projet BVLAC, juin 2007, 20 p.

Charpentier H, Andriantsilavo M, Andriamandraivonona H, Razanamparany C (1999). *Projet d'appui à la diffusion de l'agro-écologie à Madagascar, rapport de campagne 1998-1999, Madagascar*, CIRAD/TAFA/AFD, 204 p.

Charpentier H, Andriantsilavo M, Andriamandraivonona H, Razanamparany C (2004). *Projet d'appui à la diffusion de l'agro-écologie à Madagascar, rapport de campagne 2002-2003, Madagascar*, CIRAD/TAFA/AFD, 72 p.

Domas R., Andriamalala H. (2008). « *La Diffusion des techniques de semis direct sur couverture végétale, Rapport de campagne (2007-2008)* » - BRL, projet BVLAC, juin 2008.

Durand C., Nave S. (2007). « Etude des dynamiques agraires et des stratégies paysannes dans un contexte de pression foncière, lac Aloatra » - Mémoire SUP-AGRO-IRC, CIRAD, Madagascar, sept 2007, 160 p.

Chauveau J.-P., Cormier-Salem M.-C., Mollard E. (1999). *L'innovation en agriculture, Questions de méthodes et terrains d'observation*, IRD Editions, à travers champs, 362p.

Gannon F. et Sandron F. (2006). « Diffusion d'une innovation avec révision des croyances individuelles », *Travaux et documents du programme de recherche « Dynamique démographique et développement durable dans les Hautes Terres malgaches »*, n°10, IRD, Antananarivo, 26p.

Gastineau P. (2006). « Adoption de l'innovation et modèle à seuils », *Travaux et documents du programme de recherche « Dynamique démographique et développement durable dans les Hautes Terres malgaches »*, n°11, IRD, Antananarivo, 21p.

GSDM (2004). *Stratégie du GSDM pour la mise au point, la formation et la diffusion des techniques agro-écologiques à Madagascar, Madagascar*. GSDM, 28 p.

Husson O, Rakotondramana, Séguy L. (2004). *Le semis direct sur couverture végétale permanente, enjeux et potentiel pour une agriculture durable à Madagascar* – CIRAD/GSDM, Madagascar, 8p.

Jenn-Treyer O., Dabat M.-H., Grandjean P. (2007). Une deuxième chance pour le système de riziculture intensive à Madagascar ? La recherche d'un compromis entre gain de productivité et investissement en facteur de production, Colloque international *La pauvreté rurale à Madagascar : caractéristiques, dynamiques et politiques publiques*, Antananarivo, 15-17 Novembre, 27p.

Kasprsyck M. (2008). *Analyse des pratiques d'élevage dans la zone de Betafo, Vakinankaratra*. Mémoire Supagro/Elevage Montpellier, 2008.

Moser C.M. (2002). "Les limites du système de riziculture intensif et les leçons apprises pour la promotion des technologies agricoles à Madagascar ». *Cahier d'études et de recherches en économie et sciences sociales* n°4, FOFIFA, Antananarivo.

Narilala Randrianarison. « *Diagnostic agraire et mise au point d'une méthodologie de suivi et d'analyse des succès et abandons des systemes a base de semis direct sous couverture végétale (scv) : cas du fokontany d'antsapanimahazo – Madagagascar »*. Diplôme de master professionnel en sciences économiques. Montpellier i/Tafa/Cirad, octobre 2007.

Oustry M. (2007). « *Analyse des causes de non remboursement des crédits au Lac Alaotra. Impact sur l'accès au crédit et sur le fonctionnement des ACCS* ». ESAT 1. SUPAGRO/IRC, Décembre 2007

Penot, E. (2003). Le logiciel « OLYMPE »un outil de simulation et de modélisation du fonctionnement de l'exploitation agricole. Séminaire SHS, CIRAD, Septembre 2003, Montpellier.

Penot E., 2006. « *Lier l'utilisation du crédit aux itinéraires techniques et à leurs résultats technico-économiques : gestion du risque dans une perspective d'autonomisation à cour terme* » - Rapport de mission, Ambatondrazaka, CIRAD, décembre 2006, 32 p.

Penot E, Dèze Ratsimba, J.AndriaTsitohaina, Randriamanalina JM (2008). Document méthodologique de travail n° 1 : *La Méthode API Accélération de la Propagation de l'innovation*. Analyse des processus d'innovation et d'auto-évaluation. Projet BV-lac/AFD.

Penot E. (2008). Document de travail du PROJET BV-LAC N° 4 : *Mise en place du réseau de fermes de références avec les opérateurs du projet*. Projet BV-lac/AFD.

Penot E (2008). Document méthodologique de travail n° 5. *Harmonisation des calculs économiques et correspondance avec le logiciel Olympe*. Projet BV-lac/AFD.

Randrianasolo Jery. « *Caractérisation technico-économique de l'exploitation agricole familaile associant élevage laitier et cultures avec plantes de couverture dans la région de Antsirabé* ». Faculté de droit et d'é»conomie. Ingenierie economique et financiere option analyse quantitative pour les organisations. Master II. Université de St Denis la Réunion. Octobre 2007.

Ramasinjatovo N. (2006) « Diffusion spatiale de l'innovation, Travaux et documents du programme de recherche *« Dynamique démographique et développement durable dans les Hautes Terres malgaches* », n°9, IRD, Antananarivo, 25p.

Rollin D. (2000). « *La diffusion des systèmes avec couverture végétale (SCV) : quelques réflexions à partir de l'expérience du Cirad* » - CIRAD, Montpellier, 11 p.

Séguy L (2007). *Rapport de mission à Madagascar du 21 mars au 12 avril 2007* – Document CIRAD, juin 2007, 194 p.

Terrier M. (2008). *Contraintes de mise en oeuvre et conventions de modélisation pour les réseaux de fermes de références : le cas du lac Alaotra*. Mémoire de césure, Supagro Montpellier, 2008.