Conservation Agriculture in AFRICA: Analysing and Foreseeing its Impact - Comprehending its Adoption

Final case study report (D1.6)

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Submission date:

February 2013

CSA-SA project (Grant agreement n° 245347)
Seventh Framework Programme
KBBE –Biotechnology, Agriculture, Food
Impact and development of Conservation Agriculture in developing countries –Mandatory ICPC (African ACP)

CA2Africa seeks to assess and learn jointly from past and on-going Conservation Agriculture (CA) experiences under which conditions and to what extent does CA strengthen the socio-economic position of landholders in Africa. This will enable the identification of knowledge gaps for future research, development and promotion of CA. The project is carried out by a consortium of 10 partners, led by CIRAD, France

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Disclaimer:

"This publication has been funded under the CA2Africa CSA-SA project, EU 7th Framework Programme, Theme 2 -KBBE –Biotechnology, Agriculture, Food; Topic addressed Impact and development of Conservation Agriculture in developing countries –Mandatory ICPC (African ACP); Grant agreement n° 245347."

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General information

Task(s) and Activity code(s):
Related milestones:

Summary

This report provide a final analysis of final adoption of CA in 2 selected areas or Madagascar: Lake Alaotra area and Highland of Vakinankaratra.

The Alaotra Lake is a wide region. Thus, there are a lot of different types of farm depending on the location, the production activities, the size and many different situations … That explains why the dissemination and adoption of CA systems and ICS (Innovative Cropping Systems) hasn't reached the same level in all the different zones. But, in general, Alaotra farmers are not reluctant to CA adoption at the conditions that quality extension is available for technical support and monitoring for several years (3 to 5). It is just easier and faster when the proposed systems fit with the farmers' expectations. Here, the first challenge is to find a variety of systems that respond to the variety of situations to increase the assimilation process; but the actual important challenge is to integrate these systems sustainably into the farm production systems. Indeed, with the current restrictive national context (no agricultural politics, no incentive measures), it is crucial to create "perennial" production systems trough perennial process of innovation which is probably the most important challenge in the next future. CA does not extend spontaneously with surroundings farmers. It might be too early to effectively measure or record any trend in dissemination. However, a heart of knowledge, know-how and CA practices has been created with around 1000 farmers on 600/700 hectares of CA since 10 years .

The Vakinankaratra highland area suffers from major technical constraints linked with major socio-economic lead to a situation where CA does not provide a solution acceptable for local farmers. Three main factors are not in favor of C A with current systems : i) competition for biomass between CA cropping systems (mulch) and livestock feeding requirement, 2) Coldness of the dry season with unadapted cover or associated crops leading to insufficient mulch and iii) delay in growth of crops in CA systems The do observe a new situation an a new trend since 10 years with the recent boom on upland rice on *tanety* , opening a new field or research to suggest solutions for soil fertility maintenance with rice based cropping systems.

1 Introduction

The country has suffered economic troubles that currently continue with the last politic crisis; and smallholders are particularly affected. But most of disseminated crop management techniques are based on an intensification of the use of inputs. The cost of herbicide is prohibitive for farmers. This over-investment combined with the financial overinvestment related to the increase of labor needs (for some systems requiring a straw collection) make the systems become very risky (Beauval & Leval 2003). According to their low capacity of investment, small farmers would rather adopt an "extensive logic" that guarantees a short-term income than bet on the "productivity challenge" that they have no insurance to win and which is expensive (Freud 2005). Therefore, since 2008, low or zero input CA systems have been favored by local farmers.

1.1 The Alaotra lake region

The Alaotra lake region is located in the Toamasina province 250 km north from the capital city, Antananarivo. The Alaotra lake plain covers an area of 180,000 ha at an altitude of 750 m. It is surrounded by high ferralitic hills raised on a granite-gneissic platform. The basin formation is due to tectonic and erosive phenomena. The plain center is occupied by a 25,000 ha shallow lake (2 to 4 m depth). This Alaotra lake region is characterized by a humid tropical altitude climate with a mean annual temperature of 20°C. The climatic year is divided in 2 seasons: the rain season from November to March and the dry season. Mean annual rainfall reaches 1046 mm on the east shore of the lake. Currently, the Alaotra lake region is composed of almost 30,000 ha of IPF and 72,000 ha of PWC (MAEP 2004).

Despite yield saturation, irrigation channels non-maintenance and positive population growth, the region remains productive on a national scale. Indeed, it produced 300,000 tons of paddy rice in 2004 which represents 9% of the country production. Every year, about 80,000 tons of white rice is exported to Toamasina and the capital city. Thus, the Alaotra lake region is the main Antananarivo food supplier (MAEP 2004). At the Alaotra Lake region, three evaluations of socio-economic impacts were realized: the first one was realized by Beauval *et al.* in 2003 but wasn't validated by the BV/Lac project (); the second study was made by Freud in 2005 and the last study was conducted by Fabre in 2010. Both Beauval and Freud studies underline the lack of means to achieve properly the evaluation.

Socio-economic aspects at the farm level

At the Alaotra Lake region, three evaluations of socio-economic impacts were realized: the first one was realized by Beauval *et al.* in 2003 but wasn't validated by the BV/Lac project (); the second study was made by Freud in 2005 and the last study was conducted by Fabre in 2010. Both Beauval and Freud studies underline the lack of means to achieve properly the evaluation.

It is hard to describe the on-farm socio-economic effects of CA systems with accuracy because a lot of different cases co-exist as well as most information is provided trough surveys with farmers. Indeed, with time, farmers develop their technical know-how. Thus, they appropriate the disseminated techniques and adapt them to their production strategy (Freud 2005). The study of specific cases has brought to light four profiles. In general, farm economic performances are improved but sustainability of these improvements is not guaranteed. A regional study has been run to confirm and deepen these first results by Fabre in 2010 and Macdowall in 2011 (Fabre 2010).

Adaptation and adoption of CA

As mentioned above, farmers usually adapt the CA systems to their needs, preferences and production strategy. The three CA principles are virtually never adopted together. The disseminated CA systems become Innovative Cropping Systems (ICS). There are three types of adopting farmers (Fabre 2010):

- Very dynamic: ICS tend to occupy 100% of the farm area. “Intensive” systems in terms of inputs and labor needs are prioritized (corn + legume or rice / vegetables on mulch). ICS represent more than 50% of total cultural income.
- Quite dynamic: ICS occupy 25% to 50% of total area and they are set up on “secondary” plots that don’t represent the heart of the farm activities. They are mostly extensive systems in terms of labor needs and inputs. The main source of agricultural income is rice cultivation but still, ICS represent considerable revenue.
- Opportunist: farmers bump into difficulties to cultivate ICS on wide surface. Thus they cultivate small surfaces that don’t represent a significant income. In such a way, they remain supervised by the project and can take part to training programs.

The Alaotra Lake is a wide region. Thus, there are a lot of different types of farm depending on the location, the production activities, the size… That explains why the dissemination and adoption of CA systems and ICS hasn’t reached the same level in all the different zones. But, in general, Alaotra farmers are not reluctant to CA adoption. It is just easier and faster when the proposed systems fit with the farmers’ expectations. Here, the first challenge is to find a variety of systems that respond to the variety of situations to increase the assimilation process; but the actual important challenge is to integrate these systems sustainably into the farm production systems. Indeed, with the current restrictive national context (no agricultural politics, no incentive measures), it is crucial to create “perennial” production systems.

1.2 Vakinankaratra region

The context

The Vakinankaratra region is located between 18°59’-20°03’ south and 46°17’-47°19’ east. It is mainly characterized by volcanic soils and a high-altitude tropical climate (over 1100m) with a mean annual rainfall of around 1000 mm/year and a mean temperature of 17°C (NANDIBINIAINA, 2008). This climatic condition is convenient for dairy farming and forage production. However, temperature drop-off during dry season leads to a significant decrease of biomass production, mostly between June and August (KASPRZYK, 2008). The climatic year is divided into 3 distinct seasons: i) November to March: the rain season with a mean temperature of 19.4°C, ii) May to September: the dry season with a mean temperature of 14.2°C. During this season, temperature can drop off to 0°C and iii) April and October: the intermediate season with a mean temperature of 17.8°C. The are selected as a case study for CA2AFRICA concerns the “highlands” of Vakinankaratra (The eastern part called “Middle west”, with an altitude between 800-1100 m. is not concerned).

Heart of the “Dairy triangle”, the Vakinankaratra is the main dairy production zone of Madagascar. The early set up of food industries (STAR brewery, TIKO dairy and KOBAMA flour mill) has turned this region into a central agricultural and agro-industrial area. Thus, farm production is oriented toward cereals, fruits, vegetables and dairy production. More than 80% of Madagascar dairy production is provided by this region (DUBA, 2010). A population density is very high with in addition a population growth dramatically high in the region (2.4% per year) and mean farmable area is estimated around 0.8ha per farm in 2005. With this growth, available farmable lands keep on decreasing year by year. These lands are either paddy fields and irrigated crops or rain field crops on hillsides. The population pressure leads to a complete saturation of paddy fields that increases more and more the agricultural land use of hills, already saturated as well in most areas. Added to the current political and consequent economical crisis, population income becomes truly low when off farm opportunities significantly decreases as well as global employement in main towns.

Thus fallow periods are disappearing in traditional cropping systems and farmers diminish the use of manure. Subsequently, soils fertility decreases. Plus, traditional tillage techniques increase the erosion phenomenon. That is directly related to low lands silting-up which participates to the farmable land loss. These 2 agro-ecological constraints have a direct influence on smallholders’ standards of living.

Financed by the AFD[1], BVPI-SEHP project has been set up since 2006. It covers 4 regions including the region of Vakinankaratra. The main project challenge is to develop and enhance the management of watersheds, considering them as a coherent geomorphologic entity, low lands and high lands gathered (RAKOTONDRAMANANA et al., 2010).

Work related to CA in the BVPI-SEHP project

The first CA trials are set up by the non-governmental organization (NGO) TAFA[2] in 1991 (Randrianarison 2007). Its main action is to develop CA systems adapted to the region on agro-environmental and socio-economic aspects. To reach that objective, experimental stations are set up in 5 sites (Andranomanelatra, Ibity, Antsampanimahazo, Sambaina, and Betafo). However, the dissemination process is not actually launched. Indeed, on-farm trials are run in the village of Antsapanimahazo with the participation of several farmers (10 farmers in 1998; 23 in 2007) but because of a lack of technical support and human resources, the pilot-project has no real impact on CA adoption in the region. The first steps of dissemination start in 1998 with several organizations gathered into the GSDM in 2000 but it actually begins in 2006 with the BVPI-SEHP project which gives the means to achieve the objective.

Since the beginning of the BVPI-SEHP project, training programs have been built for agricultural advisors to be able to broadcast high-quality information about agro-ecological techniques (BRL 2010). These are dual-purpose programs. It is first made to deepen agriculture technical experts' knowledge already working on the field and it is also made to train new technical experts. One of the keys for a successful diffusion of CA techniques is a deep understanding of the "terroir" (physical and social environment related to the dynamism of an area). The GSDM has demanded to integrate this point into the diffusion strategy. Thus, since 2006 every technical expert has been asked to adopt a "terroir" approach including a diagnosis as soon as he supervises a new zone. The first year, it had been difficult because this tool had been set up during crop installation (October 2006). That hadn't given enough time for technical experts to deeply understand their environment. In general, they had to wait until mid 2006-2007 and even 2007-2008 to realize their "terroir" diagnosis. It seems to work out well because this last year, given advice seems to be based more and more on field reality.

[1] AFD: Agence Française de Développement (French Agency for Development)

[2] TAFA : Tany sy Fampandrosoana (Land and Development)

In 2008/2009, the Vakinankaratra area covered with CA crops on hillsides represented 270 ha for 500 farmers (103 ha in Y_0[3], 131 ha in Y_1, 33 ha in Y_2 and 3.4 ha in Y_3)[4] (Rakotondramanana et al. 2010). Among this total area, crops associated either with oats or with brachiaria represented 74 ha; the rest being pure crops (mainly forage). Included in these 74 ha, three-crops-association represented 42 ha. In this case, the third crop follows the first two-crops-association in the 2nd cycle. This type of association/succession cropping system can be very beneficial for biomass production if forage exports are limited. But we understand here that farmers favor these cropping systems for their forage productions.

Recommended CA practices and technologies

In the Vakinankaratra region, several CA cropping systems has been identified to fit with the different agronomic units because of their interesting characteristics. Though, the diffusion of these technologies is quite new and the economic evaluation of these systems has to be deepened. The use of biomass as forage or as a mulch is an important trade-off that depends on milk market price, which continuously fluctuates. Consequently, the optimal time required to improve a field soil (closely related to the mulch quantity) depends on market conditions. It can be quickly improved when market prices are low. On the contrary, it can be slower when market prices are high. Indeed, in this last case the mulch regeneration becomes less paying on a short-term. Thus, proposal and diffusion of CA cropping systems have to take in account the livestock requirements and performances. Because of the important pressure on farmable land use in the region, the easiest diffusion approach is to “add” cover plants to the farmer already existing systems. In such a way, total biomass production is increased and as much biomass as possible can be returned to the soil. The following systems are proposed by the GSDM and disseminated by BVPI-SEHP project (Rakotondramanana et al. 2010):

- ***Cassava + brachiaria*[5] *on poor hillsides soils:*** Introducing brachiaria into cassava fields is a good mean to produce perennial forage with minimum costs and a powerful capacity of soil restructuration. After several years, the cultivation of another type of crop becomes possible because of the soil improvement. This is only feasible if the forage exportations out of the field have been rationally managed (i.e. the exported biomass has to be replaced by fertilizers to counterbalance the loss). Depending on the brachiaria species, the cultivation of another crop is more or less hard to do without herbicides.

[3] Y_0=first year of DMC with tillage; Y_1, Y_2,… = Second, third, … year of DMC

[4] According to the operators, some mistakes have been done in the database analysis. Figures should be lower than announced.

[5] +=crops association with a seeding either at the same time or staggered; /=intra-annual succession; A+[B/C+D]=A and B are associated, when B is harvested, C and D are seeded in association into A.

- ***Corn + [Common bean / Potatoes + Oats] on rich volcanic hillsides soil:*** Adding oats to the traditional *Corn + [Common bean / Potatoes]* system increases biomass production, produces winter high-quality forage, protects the field against weeds (allelopathic power of oats) and considerably reduces field labor (no more tillage). Potatoes are grown every 2 or 3 years to avoid diseases and to minimize operational costs (tuber-to-plant and fertilizers prices are high). The following crop uses the important fertilization provided to Potatoes (e.g. rice).
- ***Rice / vicia or forage radish on paddy field:*** The Rice / vicia system provides an important quantity of nitrogen, controls bugs populations and reduces field labor (no tillage and easier weeding). The fractional use of vicia biomass as forage is a major advantage to make up for the lack of forage in dairy farms on winter. Forage radish growing is also a good mean to produce a huge biomass quantity and subsequently to protect against pests. But this is only interesting on hillsides to prevent from white grubs.

Adaptation and adoption of CA

Actual adopted CA systems - Accounts given by BVPI extension operators

A meeting has been organized gathering the operators working on the supervised zone to answer the question: “Among the 3 recommended CA systems (§ 3.), which systems are actually disseminated?” and the response is unanimous: None of these systems is disseminated as CA system. They are all adapted or not adopted because of several reasons:

- Before the BVPI-SEHP project, the lack of forage was already a main issue. In this context, biomass produced by “cassava + brachiaria” system is exclusively used as forage and this export is not compensated by fertilizers in order not to increase operational costs. Thus, the installation of the following crop needs tillage because of a nonsufficient soil restructuration. Plus, cassava cycle lasts 18 months. The system is not productive enough to be a priority in farms with a mean area of 0.6 ha.
- Oats seeds are very expensive. Thus, farmers abandon CA crop management as soon as subsidies are suppressed. “Oats” system is only suitable for zones with access to water on dry season and oats is used as forage.
- “Rice / vicia” system is adapted as a “green manure” system because tillage is needed because of an important white grub pressure.

Reasons of no adoption

Since the first introduction of CA systems in the Vakinankaratra region (1991), farmers do not seem to have been convinced for several reasons. Indeed, the number of farmers that have adopted CA system remains very low and the dissemination work along the year has revealed a certain number of non-adoption factors (Randrianarison 2007):

- Farmers' low capacity of investment: CA systems are considered by farmers as intensive systems because they usually need a certain quantity of chemical inputs, specific equipments and seeds.
- Land security: Because of the important investments that have to be made, farmers don't want to take that risk if they are not owner of the land they cultivate but it is unfortunately often the case (tenant farming or state-owned land)
- Lack of farmer's awareness: surveys have shown that a lot of farmers have doubts or different perceptions on these new technologies because they don't get sufficient information about CA systems.
- A reluctant first phase: The difficulties of the installation phase are very demotivating for farmers (high production costs, technique instability).
- Trade-off between CA systems and animal rearing: as long as the dairy production is more lucrative than mulching systems, biomass is exported for animals.
- Social constraints: for farmers that have adopted CA systems longer than 5 years, there are not much technical or economic abandonment reasons. The social reasons of abandonment cannot be all listed (conflicts among farmer organization members, bereavement, divorce…).

More information was provided after Maiike survey in 2010.

2 CA adoption in highlands of Vakinankaratra : an example of failure

Introduction

In the Vakinankaratra region, several CA cropping systems has been identified to fit with the different agronomic units because of their interesting characteristics. Though, the diffusion of these technologies is quite new and the economic evaluation of these systems has to be deepened. The use of biomass as forage or as a mulch is an important trade-off that depends on milk market price which continuously fluctuates. Consequently, the optimal required time to improve a field soil (closely related to the mulch quantity) depends on market conditions. It can be quickly improved when market prices are low. On the contrary, it can be slower when market prices are high.

Indeed, in this last case the mulch regeneration becomes less paying on a short-term. Thus, proposal and diffusion of CA cropping systems have to take in account the "livestock requirement" and performances. Because of the important pressure on farmable land use in the region, the easiest diffusion approach is to "add" cover plants to the farmer already existing systems. In such way, total biomass production is increased and as much biomass as possible can be returned to the soil

The main results on CA adoption

Several studies have been done on CA adoption since historical introduction or CA in the area in 1995 with the NGO TAFA. In 2006, RAZAFIMANDIMBY Andriatiana Jean William released a thesis on CA adoption contraints in Antsapanimahazo, Ampandrotrarana et d'Ivory (Vakinakaratra) showing severe constraints to preliminary CA tentative of adoption according to a survey of 73 local farms. In 2008, Narilala Randrianarison study the diagnosis of the same area using a cohort method to understand CA abandon in Antsapanimahazo. They all lead to the non adoption and inadequation of CA to local conditions

Maiike Hartog implement a survey for CA2AFRICA in 2010, as a Master thesis Land Degradation and Development Group submitted in partial fulfillment of the degree of Master of Science in International Land and Water Management at Wageningen University, the Netherlands named " Constraints and opportunities for the implementation of Conservation Agriculture in the highlands of Vakinankaratra.

The idea of CA does not raise high expectations with regard to production. This is mainly due to a lack of confidence in a no-tillage system; *´labour toujours´* seems to be the device in the studied zones. People who applied CA mention this low production level as the main economic disadvantage. Farmers without experience with CA are more inclined to decide on the basis of subsidised inputs they can get through the project. The social threshold they need to take to get involved in the project is their weakest link towards CA. This shows that the local context involves more than 'just' climatic circumstances and financial possibilities. Changing an agricultural practice requires strong support systems that provide inputs and equipment (Corbeels *et al.*, 2011), and above all a social environment that incites and stimulates this change. Elaborating on the notion of change - the meaning of this concept depends highly on a person's circumstances. For a farmer in Fitakimerina a change in crop rotation has much more influence on the income of the family and issues like food security. So, one of the reasons why farmers are 'hesitant' to apply CA practices, could be that they simply have no choice. Several of the families we encountered during the survey had no capital to invest in whatever better system. While they are the ones that can use innovation of agricultural practices, they are caught in the poverty-trap and do not have any power to choose. 'Development' in this sense means that they themselves create a way to raise their production or income.

The project BVPI SE/HP has recently started the introduction of CA practices at the study locations. The CA systems that are currently used by farmers who are part of the project:

Fitakimerina	**Iandratsay**
Beans + Oats	
Maize + Beans +Oats (Iandratsay: + Potato)	
Beans + Brachiaria	Potato +oats
Cassava + Brachiaria	Potato + Wheat
Pois de terre+Brachiaria	Potato +Vetch (low part)
Pluvial/non-irrigated Rice + Crotalaire	Ray-grass + Vetch
Soja + Brachiaria	Barley + Vetch
Soja + Crotalaire	Beans + Vetch (mainly C2/C3)
Brachiaria/Oats pure	Wheat + Vetch

Table 1

- In the zone of Fitakimerina, the dissemination of CA practices has not been successful until now. Since the beginning of the project, the cover crops have been removed from the fields; often not with a direct purpose for fodder but to sell the crop residues or exchange it for fertilizers. This happens because the farmers cannot afford chemical fertilizers and also do not own enough cattle. Farmers also prioritize the rice paddies above the *tanety*. According to BVPI SE/HP reporting, adoption of CA practices cannot be expected in this zone (Raharison & Andrianaivolala, 2009).
- In Iandratsay, the pressure on crop residues is also high. The stalks of the maize are for example used as firewood. But there is a potential for systems that improve the 3-cropping system that is practiced on the *tanety*. In this rotation, oats can be added to provide extra biomass. It will be explained in the next paragraph (Raharison & Andrianaivolala, 2009).

Overall, CA has not been adopted in Vakinankaratra due a very high level of technical and socio-economical constraints.

Which selected latest CA systems could be eventually used and disseminated ?

In 2011/12 Hanitriniaina Rrazafimahatratra E Penot and C Mc Dowall and did implement a modeling of potential promising CA and comparison with current situation (farm with no CA) integrating recent results from research (SCRID). This suggests that there might be potentially some possibilities of further CA development if some conditions change. New rotations with crops have been tested through modeling according to results from on station experimentation
:

Crop rotations suggested per location

Location	A0 year 0	A1 year 1	A2 year 2
Fitakimerina	Rice + crotalaria	Crotalaria alone	rice + crotalarae
Fitakimerina	Rice	Maïze + crotalaria	Rice
Ikobona	Rice	Maïz + Common Bean → Oat	Rice
Iandratsay	Maïze + Common Bean / Potato + at	Maïze + Common Bean / Wheat + Vetsch	Maïze + Common Bean / Potato + Oat

Table 2

The main results of modeling have been presented in details in the CA2AFRICA D 3.1 modeling report. CA potentially may increases farm net income of 45 % with 0.20ha of CA and 50 % with an area of 0.28ha compared to non CA farm. There is still a scope for further on farm experimentation on such systems.

The main constraints to CA adoption in the highlands

The main technical reasons are the following

1 Growth delay of rice in CA system

- delay in soil biological activity and plant growth : soils remains cold due to the mulch, if mulch is existing (in experimental conditions with soybean maize and Maize Bracharia) (Julie 2012) if a graminae is present in the rotation : delay in rice production (not seen with maize).
- Rice is a plant more difficult to associate with others compared to maize for instance
- Phenomena of “nitrogen deficiency due to mulch” due to Bracharia in the system.

- Rice roots grows more rapidly with tillage

2 Coldness :

We observe a real difficulty to produce biomass in counter season and to keep it dur to coldness during 2 to 3 months.

3 Competition biomass mulch/animal feeding

There is effectively in this area, called "the dairy triangle" a very strong competition for the use of biomass between livestock requirements and mulch for CA croppig systems.

4 Complexity of current CA cropping system

Existing and suggested CA cropping systems are effectively relatively complex to implement with respect to specific agronomic requirements but local people are quite used to complex cropping systems with up to 4 associated or successive plants a year.

5 Difficulty to control weeds compared to tillage

CA systems implies a full control of weeds regarding their complexity and it is even more complex to control if linked with dry seeding technique for instance or rice : it has been proved that to control weeds need an almost perfect 100 % covering mulch (K Naudin, 2011).

The main social and economic reasons are the following :

1 Small cropping area with priority to food security

Farms have a very small cropped area, between 0.4 and 0.6 ha in average. Therefore modifying rotation to include CA is a potential risk for food security: there is in fact no possibilty to do unproductive fallow or period/plot with no production

2 Global farmers'priority to upland rice

Farmers always give priority to rice, whatsoever , in particular since several years to upland rice with even rice on rice rotation pattern. We observe a double phenomena : increase of upland rice area in general and new rice /rice rotation on upland that will lead very rapidly to fertility problems as rice is a relatively exigent crop in terms of soils fertility.

It is therefore a real difficulty to suggest CA complete rotation that could be compatible to farmers's objectives or priorities.

Conclusion

New CA cropping possibilities from SCRID do exists : i) Systems maize with crotalaria seems to be prominsing; no need of herbicids to control weeds and crotalaria cannot be used as forage. Crotalaria has a negative effect on white grubs. And ii) Mais + crotalaria, + cajanus and Eleusine finger millet //rice in year 1 (A1): technically could be feasible work BUT does not fit farmers global strategies.

But still these systems are not yet adopted as BVPI-SEHP, the main local development project ended in October 2012. The only CA Systems rice // maize + common bean/ oat currently used by less than 30 farmers in BVPI development project is even not stable: oat does not generally provide sufficient biomass for mulch. Rice being the priority crop : TAFA has proposed in the past maize and legumes based CA cropping systems : maize with Desmodium, common beans with Kikuyu (*Pennisetum clandestinum*) : but no adoption has been observed as most systems were without rice, rice being farmers' priority. Rice is i) the stapple food that contributes mainly to self sufficiency and ii) sales of rice are valuable as rice price is high compated to maize for instance.

Priority is given as well to livestock and dairy production as soon as farmers can afford it. Therefore, competition for biomass remains one of the most powerful constraints. Dairy production is the main potential output for farmers who have sufficient land to feed their animals.

The second global trend is the explosion of upland rice cropping. Such trend will lead very rapidly to a real problem or soil fertility management by farmers: how to maintain upland rice in systems with such conditions?

Farmers will have to take in to account both on erosion and fertility management. That will required:

- Introduction of plants to regenerate fertility , compatible with local demand, probably linked with CA systems
- Integration with livestock : better efficiency of manure (currently the only fertilizer used by farmers as mineral fertilizers are not anymore used since 2008). .

Farmers that have never tried to implement CA, are often under informed about the system. Witnessing other people abandon CA is also a reason to stay away from it. In cases where people have tried CA but abandoned it after some time, the organization of the dissemination turned out to be problematic.

Credit can only be obtained when one is a member of a farmer's association (*association d'agriculteurs*). There is a lot of critique on these organizations. Complaints are about the delivery of inputs and material, that is often late.

(Randrianarison et al., 2007). TAFA offers no assurance if the harvest is lost, which can happen through natural causes. Razafimandimby (2007:32) concludes that the credit system should become less rigid, to enable more farmers to profit from it.

In conclusion

The Vakinankaratra highland area suffers from major technical constraints linked with major socio-economic lead to a situation where CA does not provide a solution acceptable for local farmers. The do observe a new situation with the recent boom on upland rice on *tanety* , opening a new field or research to propose solutions for soil fertility maintenance with rice based cropping systems.

3 Lac Alaotra : an example of a relative success

The main results of modeling at farming system level an impact measurement have been presented in the Modeling report D3.1

Introduction

CA was introduced in the Lake Alaotra area in response to three major challenges: reducing poverty, feeding an increasing number of people, and reversing the degradation of the biophysical environment. The objective is more to develop a sustainable agriculture in opposition to traditional rainfed "mining" agriculture. The paradigm shift to CA is based on no tillage, combination of plants and rotation. However, the benefits of these systems vary according to their conditions of application. The ecological balance is sometimes mitigated by: the frequent use of pesticides and herbicides, the need to adapt crop technical pathways to local practices, the management of soil-animal competition for biomass, the constraints on small family farms and low capital (Serpentié, 2009). CA has been promoted in a context of a "slow pioneer front" (Penot, 2009) in order to develop a regular and sustainable production (Domas et al., 2009). CA systems require an investment more or less consequent according to level of intensification (mineral fertilizers, herbicides, insecticides, equipment…) (Bolliger, 2006). Such investments are often essential to deal with hazards (weeds, mulch failures, parasites...). The majority of current CA surfaces of Madagascar are at Lake Alaotra, facilitated by a long term dynamic history of innovations (Serpentié, 2009). In 2007 are identified in the Lake Alaotra area a farm typology and a "Farming System Reference Monitoring Network" (FSRMN),(Durand et al, 2008). The table 1 presents a synthesis of CA systems distributed according to the plot physical situation and soils.

Table 3: Opportunities for cultural pratices applicable according to the physical environments (Domas et al., 2009)

Soil type and physical situation	Intensification level	Cropping Systems
Tanety rich (Upland)	All levels	▪ Intensive, cereal based (rotation maïze + legumes // rice) ▪ Extensive, based on fodder plants (*Styloxanthes spp*)
Tanety poor (Upland)	Low	▪ Extensive, based on fodder plants (rice on a long fallow) ▪ Ground legumes on mulch
PWCRF (Poor Water Control Rice Field in lowland)	All levels	▪ Intensive, cereal based (rice // rice) ▪ Extensive, with covercrops in dry season
Baiboho (upland with access to water in dry season through soil capilarity)	High	▪ Intensive, cereal based (rotation maïze + legumes // rice) ▪ Intensive rice production with winter vegetables (rotation legumes // rice//vegetables CS) ▪ Rice-vetch //rice-vetch ▪ Intensive system with one year *Stylosanthes guianensis* fallow

Due to the low intensification of all non-CA systems (low inputs), the climate remains the main factor limiting yields beside soils. CA yields evolve according to the age of the plot in CA as CA systems are less sensitive to climate (buffer effect of the much prooven by yields evolution from the projet plot database). The criteria used to define cropping systems are as follows: tillage or no tillage, rotation, pseudo-rotation or monoculture, absence or presence of mulch *in situ* on the plot. The results of the survey show a wide diversity of situations (the figure 1). Most tillage cropping systems have a rotation (77% against 19% in monoculture). 50 % combine agronomic rotations and soil cover. The covers are mostly covers of dead mulch on *baiboho*.

Technical pathways with a monoculture or pseudo-rotation (two consecutive years with the same culture) are mostly in pure culture (no cover or combination of culture). In conclusion, farmers most often use the principle of rotation whether in tillage or no tillage. Based on these results, it is possible to define from the different combinations of practices what are the systems (conventional, ICS/(Improved Cropping Systems, CA) adopted by most farmers. The majority of surveyed plots are carried out spontaneously in hybrid systems : ICS (73 % of the plots): conventionnal systems with addition of some CA techniques. Conventional cropping systems have been therefore profoundly altered (contaminated) by development projects extension in Lake Aloatra. However, most farmers do not spontaneously adopt entirely CA systems “stricto sensu”.

The table 4 below shows the standard rotations or crop sequence established from different rotations observed during surveys in 2011.

Table 4: Synthesis of disseminated CA systems and standard innovative systems per toposequence and per year

Toposequence	CA practices recommed by the project	Farmer ICS (Fabre,2010)	Spontaneous ICS (Enquêtes 2011)	Conventionnal (enquêtes 2011)
Tanety	Maize+leg.//upland rice (VSE, ZNE) Maize+leg.//upland rice // Maize+leg. //Groundnut (VSE, ZNE)	Maize + leg // maize + leg (ZNE) Maize+leg.//upland rice // Groundnut (VSE, ZNE)	Maize//maize// Groundnut (ZNE) Maize//maize// Groundnut //cassava (VSE)	Groundnut Cassava Maize Beans Tobacco (ZNE)
Tanety *Slope bottom*	Maize+leg.//upland rice // Maize+leg. //groundnut (VSE, ZNE) Maize+leg.// upland rice (VSE, ZNE)	Maize + leg // upland rice // groundnut (VSE, ZNE)	Upland rice//maize// groundnut (ZNE) groundnut//cassava//beans (VSE)	
Baiboho	Upland rice+vetch – veg growing on mulch in dry season (VSE, ZNE)		Upland rice – veg growing on mulch in dry season (VSE, ZNE)	Upland rice – dry season veg. (VSE, ZNE)

This shows the strong innovative capacity of local farmers. This also shows that partial CA technologies do percolate through into cropping systems but generally not the entire CA technique as a whole.

In the short term the impact of CA is not very significant for farms already economically viable (A, B, C and D). It takes at least a decade before measuring the cumulative effects at the farm level; even if the results appears significant rapidly at the plot level. This “lengthy time” is what is required for farmers to learn and consolidate their knowledge and know-how on these systems. The purely quantitative economic gain from CA sustainable agriculture is not obvious for farmers. Some farmers might not understand the basic principles of CA but do adopt CA to keep a link with the project and receive technical advice. The important development of ICS shows that if CA as a whole is difficult to manage and diffuse: the partial elements of the techniques “percolates” very well in conventional systems that then evolve into ICS.

The continuum of systems from CA, ICS and conventional systems reflects the plasticity of local stratagies when existing techniques are modified to tackle farmer’s contraints. It is perhaps too early to judge the real economic and ecological sustainability of these innovative systems. This trend, however, allows us to hypothesize that innovation is a strong local process that might boost ecological intensification in the long run. Finally, the major obstacles to CA adoption seems to be the paradigm shift from a short-term to a long-term vision of agriculture. Given the economic and political instability of the country, few farmers take the risk of waiting 10 years to observe the effects of CA on their income.

The main conclusions on the Alaotra Lake area

The Alaotra lake area can be consider as a success in term of real CA systems adoption (CA systems "stricto sensu") : 410 hectares of CA systems with 600 farmers have been identified in 2010 : probably 600 to 700 hectares with 1 000 farmers in 2013.

If we carefully look at statistics in some other countries claiming 100 ,000 ha of CA (Zambia, Zimbabwe , Tunisia etc …) : most of what is declared as CA is not : most of them are "light or limited tillage systems " or systems which include 2 but not 3 of the main CA principles as described by FAO (2008).

In fact, Madagascar is probably one of the few if not the only country there CA systems "stricto sensu" (according to the 3 prinipales) have been effectively adopted by smallholders (we are talking of small family farms) at least significantly locally to create a "heart of knowledges " sufficiently developed to remain after the end of CA promoting projects and, potentially, might be used as key informant persons in the very next future for the co-innovation platforms (such as those currently developed). North Cameroon, Laos and Cambodia have probably as well some limited area with real CA systems (less than 1000 ha). But the lake Alaotra area see clearly a critical mass of farmers and a relatively locally significant area under CA to built up a sufficient and sustainable "heart" od CA adoption. This is the results of 14 years of Research presence and 10 years of Development efforts (with the projects BV(lac).

But the question is now: what next after the end of the current BV-lac project in may 2013?

We do observe a real technical demand from farmers on whatever type of practices or technological package that can provide production stability. Meanwhile, If CA systems have been effectively adopted, we do observe that they are not spontaneously adopted by non project surrounding farmers. In other words: NO CA outside development project which raise the question of CA diffusion when project ended up (according to 2012 Anais Teyssonier survey). One of the constraints to such no outside project diffusion could be: i) 5 years or learning process, ii) no immediate and visible results (results appears after several years).

Positive aspects are the following: i) a real basquet of technology: many CA available cropping systems with 5 families and over 130 cropping systems to cover many situations, ii) freedom of choice as farmers have never been constrained to a specific technique, iii) easy adoption and importation of covercrops , iv) real positive outputs after 5 years …v) a real expansion trend on upland when irrigated rice area is limited and saturated

With low input CA systems such as those adopted in Lake Alaotra, CA practices after 10 years improve the net annual agricultural income of farmers from 15/20 %. However this souls be seen as relatively low, qualitative advantages: a better global resilience, less risks in case of climatic variability, suppression of fallow and relevant crop rotations with a better global output on a 10 years time. Beside that, the same current CA cropping systems could lead to better yields if associated to ecological intensification with both manure and chemical fertilization.

Final conclusion

The first CA introduction has been historically made in Vakinankaratra, in the high lands, but too much existing constraints leave to no adoption. The highlands have extreme constraints when Lake Alaotra still has potential areas of development and far less severe constraints. CA success eventually linked with very specific situation. Therefore, it seems to be very difficult to extrapolate CA success to another region if not similar.

Many agricultural projects have been implemented in the Lake Alaotra area since the 1960's, creating a real innovation process, in farmers' strategies and a real changes in agriculture. But as "project time" is not that of "innovation time ", we need more time to assess global impact of CA adoption. History has shown to us that almost all technologies introduced by the Projet de Recherche Développement (PRD) in the 1980's (FOFIFA/CIRAD) have been eventually adopted 30 years after.

Can CA techniques follow such a trend in the long run ? History will tell us…. In 20 years !

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