Conservation Agriculture (CA) adoption by smallholder in Lake Alaotra area in Madagascar: from CA to agro-ecological practices.

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CA is implemented and partially adopted I Africa since 15 years. Many seem to have adopted partially CA through some agro-ecological practices as already observed in many countries of Africa (Corbeels et al, 2011). We will illustrate CA constraints to adoption with the case of Madagascar and in particular in the lake Alaotra area where CA has been promoted from 2003 to 2013 by the BV-lac project. In 2010, out of the 3000 project farmers, approximately 600 farmers had adopted CA "stricto sensu" in the long run on 410 ha (Penot, Fabre et al, 2011). The objective of the study is to identify CA cropping systems that have been adopted, transformed and eventually appropriated by farmers after project's completion in June 2013 on a 10 years basis. A survey has been implemented on 104 farmers (among them the 89 oldest CA adopters since 2003 and 25 CA "recent" adopters since 2009). This study is a continuation of a preliminary study implemented from 2003 to 2009 (Penot et Harisoa et al, 2011).

Rate of abandon

From the 88 oldest plots monitored since 2003: 36 % are not anymore under CA management but back to conventional practices (30 % in Northeast zone and 43 % in South East zone) with 50 % of the abandon in the year 2010/2011. The plots abandoned in majority (52 out of the 88 oldest plots) are those established in 2005 (among the oldest) (table 1) as it has been the first year of the project with a significant degree of implementation. The global abandon rate on all the sample of 104 farmers is 40 %.

Table 1: Year of CA adoption and abandon for the oldest CA farmers

Year of CA adoption / Year of CA abandon	2002	2003	2004	2005	2006	2007	2008	Total
2008-2009			1	2				3
2009-2010		2	1	13		1		17
2010-2011	3	2	21	29	1		2	58
2011-2012		1		6			1	8
2012-2013				2		1		3
Total	**3**	**5**	**23**	**52**	**1**	**2**	**3**	**89**

On *tanety*, 45 % of the plots have been abandoned, 14 % turned to forage systems and 4 % to ICS. The table 2 displays CA cropping systems evolution with, i) disappearing of *Brachiaria* based systems, ii) limited development for *stylosanthes* based systems and iii) mainly adoption of rice//maize+ *dolichos* or leguminous such as cowpea, rice bean...(table 2). The same trends have been observed on the foot-slope of the *tanety*, with 33 % of plots abandoned on the *baiboho* and 69 % for *tanety* bottom plots, mainly in the Northeast zone. The reasons of abandon are multiple (see table 3).
The rate of abandonment on the oldest CA plots seems, at first glance, most important on *tanety* than *baiboho*). However, if we remove one farmer with a large cropped area on *tanety*, it becomes similar to that on *baiboho* (54%). A high rate of abandonment of CA techniques (39%) was observed among farmers considered as the 'heart of adopters" illustrating the classical post project trauma and showing the fragility of CA adoption. Most farmers that have abandoned had less than 5 years of CA experience at the point where they stopped, which confirms the hypothesis according to which a minimum 5 to 7 years of practice is required to adopt CA in the long run. The drop-out rate is much higher in the northeast zone (58%) than in the South (22%). This difference is probably due to the

difficulty of implementing CA on *tanety* which covers large areas in the north. It seems easier for local farmers to increase its CA surfaces on *baiboho* rather than on *tanety* in the southeast zone.

Table 2 : Evolution of CA main systems adoption in percentage of surveyed areas on *tanety*

Agricultural season / Large systems	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013
System under imported dead mulch	100%	34%	28%	9%							
System on herbicide			9%	11%							
Voluble legume in pure culture season		27%	3%	4%	1%	0%	2%	2%	3%	9%	3%
Maize + Voluble leguminous			49%	49%	35%	40%	24%	30%	10%	14%	13%
System on residues		33%	3%	6%	33%	19%	29%	28%	21%	13%	16%
Brachiaria based system		7%	8%	17%	15%	2%	1%	1%			
Stylosanthes based system				1%	2%	13%	14%	11%	4%	2%	5%
Upland rice + Voluble leguminous											0%
Forage system : non CA system				4%	13%	27%	19%	15%	14%	14%	14%
ICS									5%	4%	4%
Conventional system							12%	14%	43%	44%	45%
Total studied surface (ha)	**0,54**	**0,90**	**6,75**	**23,25**	**23,25**	**23,25**	**23,25**	**23,25**	**23,25**	**23,25**	**23,25**

The reasons of CA abandon

They are multiples and very often due to socio-economic factors. Most farmers either monitored by the project have adapted original CA systems into ICS/Innovative cropping systems where 1 or 2 of the CA principles have been adopted but not the complete package, developing therefore some agro-ecological practices.

Table 3: reasons of abandon of CA

Social reasons		Economic reasons		Technical reasons		Environmental reasons		Other reasons	
Technician's absence	23%	Superposition of activities	10%	Increase of time requirement	17%	Drought	20%	Simply the benefits of the DMS	3%
Zebus grazing not controlled	23%	Increase of expenses	33%	Lack of experience	7%	Insects	23%	Retirement	3%
Bushfire	3%	Crops incompatible with CA	3%	Poor covercrops seeds availability	10%	Soil compaction	3%	Health (refusal of use of phytosanitary products for CA	3%
Conflict with the project	13%	Absence of assistance and bank credits at the end of the project	23%	Difficulties to get phytosanitary products	3%				
Poor labour force availability	10%	Poor economic performances	3%	Difficulties to control the cover	7%				
Absence of assistance and credits at the end of the project	23%	Other reasons	7%	Poor control of weed	7%				

We observed a shift of recommended associated crop to productive crops in CA systems. 85 % replace *dolichos* by cowpeas and rice for economic return. Vetch is replaced by legume crops to generate a real income (Table 4). The pros and cons of cover-crops or associated crops evolution in CA systems are displayed on table 4.

The SWOT analysis (table 5) provide the evidence that CA adoption is not mainly based on mastering the technique, whatever its degreed of complexity, but involves social and economical constraints.

Table 4: Reasons of CA adoption or abandon concerning cover or associated crops

Couverture	Reasons of adoption	Reasons of abandon
Vetch	Grows and covers quickly, keeps well moisture	Does not grow in drought conditions
Stylosanthes	Grows well and good root effect	Hard to kill (80 to 100 mandays/ha), required a fallow year (2 years cycle)
Dolichos	Grows even in dryness	No economic value as not eaten
voluble leguminous	Easy destruction, economic value of the crop	Insufficient or very poor mulch
Dead mulch	No need to buy seeds, decomposes rapidly and can be used as fertilizer	Transport cost (if not producing on-site coverage)

Table 5: SWOT analysis

Strengths	Weaknesses	Opportunities	Threatens
Yields' increase	Expenses increase (inputs, labour, cover transport cost if used of dead mulch)	Partnership dissemination project (eg: ABACO)	Farmers individualism
Improvement of soil structure, fertility and moisture	Pests increase (including rats)	Spontaneous spread between CA-producers and non-CA	Lack of organisation between the producers Supply problems for seeds and inputs (poor availability)
Reduction of labor requirement : no-tillage and reduced weeding	Increase of labor requirement for planting (and cover transport if used of dead mulch or to destroy *stylosanthes*)	Better integration with other agricultural activities	Non-transmission of AC techniques to other generation

Benefits and drawback/constraints of CA systems

The 2 next figures n° 2 and 3 displays observed benefits and main drawback or constraints to CA adoption.

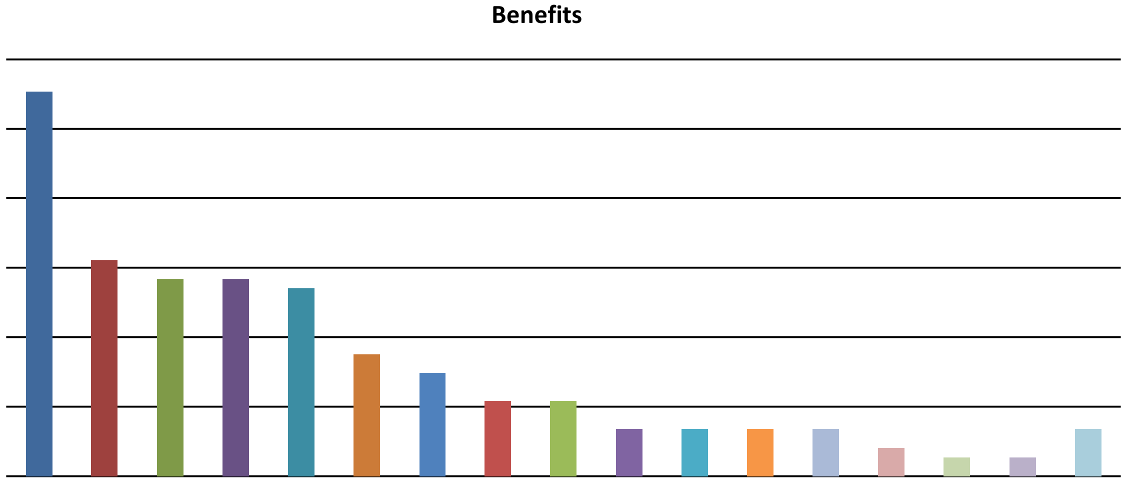

Figure 2: Benefits after CA adoption mentioned by farmers

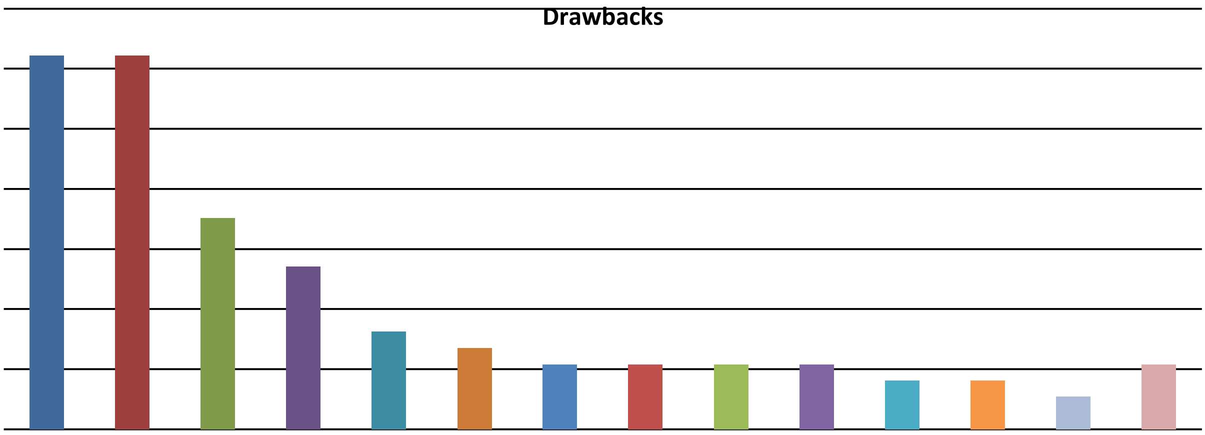

Figure 3: Main constraints to CA adoption mentioned by farmers

Thus out of this sample on the "heart of CA adoption" there is a maximum of 52% of producers with real benefits with these techniques in the long run as 8 % of current adopters might abandon due to lack of technician (and 40 % abandon). The main constraints to CA adoption are economic (60%) and social (57%) mainly. The absence of technicians at the end of the project had a deep impact: livestock uncontrolled grazing came back, motivation and willingness dropped as aid from technicians is considered as crucial for most farmers. Facing such a situation indicates what is the real understanding, perception and motivation of farmers when back to autonomy without any technical assistance.

CA systems evolution

A typology has been identified according to CA cropping area evolution (table 6). A behaviour typology according to CA adoption is presented in table 7 where 70 % are CA adopters in the mid run (10 years). The typology of situation shows that farms that have increased their CA areas in 2013 compared to 2006 are those with relatively few rice field and more *baiboho* and *tanety*. CA adoption is more sustainable on *baiboho* that have a better and less risky potential than *tanety*

Table 6: Types of situations of farms

Evolution of CA cropped areas since 2009	CA cropped area/total uplad farm area	CA cropped area/ total farm area	%	*Type of situation*
Increase	>100%	> 50 %	3%	***I1***
		< 50%	3%	***I2***
	100%	from 35% to 80%	8%	***I3***
	<100%	from 25% to 60%	7%	***I4***
		<25%	9%	***I5***
No evolution	>75%	<20%	4%	***II1***
	from 25% to 75%	<25%	3%	***II2***
	<25%	<20%	12%	***II3***
Decrease	>60%	100%	1%	***III1***
		<35%	7%	***III2***
	from 5% to 30%	<20%	7%	***III3***
	0%	0%	38%	***III4***

The typology of behavior established in 2013 (table 7) shows a particular anthropologic aspect for some farmers considered as "assisted" (30%) or with "low autonomy": the necessary link whith the technician (30%). The pure "technical approach", originally developed by the project, has sometimes been continued by technicians who did not wish to change their way of working. Meanwhile, 40% of producers, dynamic and autonomous, really benefited from years of learning as they were able to test and adapt CA techniques to meet their constraints. Adoption of various CA cropping systems differs as well according to that typology.

Table 7 : typology of behavior

1st criteria	2nd criteria	Type of behaviour	%
Mastery felt of the techniques	0 consequence with the project end	Full CA adopter	29 (40%)
	Regrets "project time " (counselling) without direct impact on CA surfaces	CA adopter	22 (30%)
	Regrets of current no supervision with direct impact on CA surfaces	Fragile CA adopter (H1)	16 (22%)
Non-mastery of the techniques	Need a permanent support to maintain CA	Non autonomous adopter (H2)	6 (8%)

Discussion

On *tanety* like on *baiboho*, farmers have innovated by adapting CA cropping systems with the objective to increase or secure incomes, either by adding a second crop on the crop cycle, or by replacing in the rotation and in the crop association a more profitable crop (called ICS). These new ICS systems are also developed in order to cut expenditures and/or decrease painfulness of agricultural work (eg continuous system cassava + *stylosanthes* on *tanety*). The part of "unstable or opportunistic" rotations fell sharply on *tanety* compared to the previous similar study of 2009 by Raharisoa B. On *baiboho*, most cropping systems "in transition" have greatly reduced with a clear stabilization of cropping systems over time. Moreover, the strategies used by farmers in the choice of cropping systems and cover-crops plant service are eventually more intensified with the addition of crops with high added value (eg introduction of peanut in rotation, marginalization of cassava). Such evolution may jeopardize the real technical and environmental sustainability with for instance a negative effect on the mulch, in favor of economic results, which are immediately perceptible by farmers
Innovation processes and time-shift has been analyzed: the first period focus on CA techniques learning (5 to 7 years to acquire know-how). The second period is based on farmers own experimentation to adapt CA systems to their own constraints (2/4 years). The last period focus on appropriation and final modification of cropping systems partially from CA to ICS where some agro-ecological practices are maintained. Such results confirm that innovation time is not project time (Penot et al, 2014).

Conclusion

CA adoption is still very difficult for most farmers due to systems complexity and socio-economic reasons. If CA "stricto sensu" has a very limited adoption and extension, agro-ecological practices have been widely adopted on a large scale. A typology of behavior for CA adopters shows that 40 % of farmers are "autonomous" and long term CA adopters, 30 % are CA adopters still requiring technical support for psychological reasons and 30 % are "assisted" farmers which will never maintain CA systems without technical support. If CA in itself is difficult to adopt on a sustainable way, most farmers do adapt CA systems and develop agro-écological practices and ICS through partial adoption.

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