FACTORS INFLUENCING ADOPTION OF SWC MEASURES IN SOUTHERN MALI

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Abstract
This paper presents the results of an analysis of factors that influence adoption of SWC measures in Southern Mali. The SWC extension programme has been going on since 1986 and promoted erosion control measures and soil fertility measures. The 5 factors included in this analysis are: land pressure, cotton growing area, possession of ploughing equipment, possession of a donkey cart and farmer training in SWC. In 30 representative villages and 30 villages with high SWC adoption, 298 farmers where interviewed and 2-3 fields per farmer were visited. Correlation, regression and factor analysis led to the following conclusions:

1. Farmers in the high land pressure area adopt more soil fertility measures.
2. Farmers in the cotton growing area adopt less SWC measures.
3. Farmers with more ploughing equipment adopt more SWC measures.
4. Farmers with a donkey cart adopt more soil fertility measures.
5. Trained farmers adopt more erosion control measures

Key words: SWC adoption, erosion control, soil fertility management, agro ecological zone, farm equipment, SWC training.

Résumé
Cette communication présente les résultats de l'analyse des facteurs qui influencent l'adoption des mesures CES au Mali Sud. Le programme de vulgarisation est en cours depuis 1986 et incluait des mesures anti érosive et des mesures de gestion de fertilité. Les 5 facteurs inclus dans l'analyse sont : la pression sur la terre, la zone cotonnière, la possession d'équipement d'attelage, la possession de charrette et la formation paysanne en CES. Dans 30 villages représentatifs et 30 villages avec un niveau d'adoption élevé en CES, 298 paysans ont été enquêtés et 2-3 parcelles par paysan ont été visitées. L'analyse de corrélation, de régression et des facteurs a résulté en des conclusions suivantes :

1. Paysans dans la zone de forte pression sur la terre adoptent plus des mesures de gestion de la fertilité.
2. Paysans dans la zone cotonnière adoptent moins de mesures CES.
3. Paysans avec plus d'équipement d'attelage adoptent plus de mesures CES.
4. Paysans avec une charrette adoptent plus des mesures de gestion de la fertilité.
5. Paysans formés en CES adoptent plus de mesures anti érosives.

Mots clés : Adoption CES, mesures anti érosives, gestion de la fertilité, zone agro écologique, équipement agricole, formation CES.

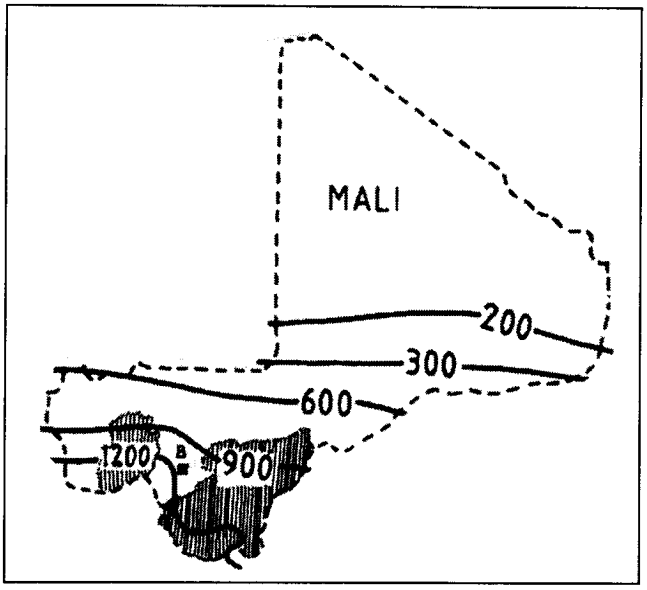
1. Introduction

After 20 years of soil and water conservation (SWC) activities in southern Mali, an evaluation study is currently being undertaken to estimate the impact of the SWC programme on adoption, crop yields and agricultural sustainability in order to make recommendations on policies and to develop a monitoring and evaluation system for SWC programmes. This paper analyses factors influencing the adoption of SWC measures in southern Mali.

Research area

The SWC programme covers most of cotton growing zones in Southern Mali, about 125.000 km2 with 3 million people forming 160.000 farm families in 5000 villages.

Figure 1. Rainfall isohyets, mm/year
(after Breman, 1991). Gray area : CMDT zone



Two agro-ecological zones can be distinguished: the south-west, with average rainfall of about 1200 mm and the north-east with only 700 mm (Figure 1). Due to the presence of tsetse fly in the humid south west in the past, which nowadays remains a problem for cattle, population density varies from 18 in the newly reclaimed south-west to 37 in the old cotton growing north-eastern zone[1]. Soils are mainly loamy sand, in the north-east formed on fragile sandstone resulting in very gentle slopes (cultivated fields 0-2%), in the south-west formed on schist and granites resulting in somewhat steeper slopes (cultivated fields 0-5%) (Hijkoop, 1989).

In the south-west, rotational fallowing is still common: for each hectare of cultivated land more than 2 hectares of fallow land are available. About 60% of the farm families have at least one plough and 2 oxen and 45% have a donkey cart. The cultivated area per person is 0.41 ha.

In the north-east, agriculture has become permanent: for each hectare of cultivated land, less than 1 ha of fallow land is still available . 83% of the farm families have at least one plough and 2 oxen and 68% have a donkey cart. The cultivated area per person is 0.75 ha (Schrader et al, 1996; CMDT, 2000).

The mayor crops in both zones are cotton (30%), sorghum (27%), millet (15%), maize (14%) and groundnuts (5%) (CMDT, 2000). Cotton, receiving fertiliser, is the main cash crop, grown in rotation with staple food crops that benefit from the residual fertiliser effects. Due to decreased rainfall during the last decades, the most northern villages had to give up cotton growing.

Nutrient balances in the CMDT zone have been estimated as negative (Van der Pol, 1992), especially for nitrogen and potassium. Recent estimates show that balances have become less negative, due to the increased area under cash crops receiving fertiliser and the increased use of compost from crop residues and manure (Doucouré, 1999; CMDT, 2002).

On cultivated fields, 14-50% water run off and sheet and small-rill erosion is estimated to lead to and 5-11 tons/ha soil loss (Roose 1985 cited in Hijkoop 1989; Roose pers.com. cited in Van der Pol 1992; Vlot, 1994).

The SWC programme

Since 1982, the Malian farming systems research group DRSPR (Division de Recherche sur les Systèmes de Production Rurale) has tested SWC approaches. In 1984, after farmers had complained about decreasing yields and water washing away their crops, tests were carried out in collaboration with the semi-government Malian cotton and rural development organisation CMDT (Companie

[1] Schrader, 1996. Data 1994 extrapolated with 2,5% annual growth to 2002.

Malienne pour le Développement des Textiles), resulting in the creation of the SWC project (Projet Lutte Anti Erosive) within the CMDT structure in 1986.
Tests in Mali and comparisons with other SWC programmes in the region made the project opt for a specific approach: a village rather than an individual approach; techniques increasing water infiltration rather than evacuation; simple low cost techniques; incorporation in a permanent local extension (Hijkoop, 1989). The CMDT extension service was paid by revenues from cotton export and partly by donors. Farmers did not receive incentives compensating their labour input but received planting materials and water level instruments for free and ox charts and wire fence on credit during the start up period (Schrader, 1996; Vlaar, 1992)

The SWC measures can be split up in erosion control (EC) measures and soil fertility improvement measures (SF). EC measures consisted of some line interventions: stone rows, live fences, grass strips, and crop residue lines, and some gully / rill interventions: stone check dams and crop residue check dams. Water evacuation dikes above the field were abandoned after the first project years, while contour marker ridges in the field were introduced later on. Stone rows are mostly installed collectively above the cultivated area; other erosion control measures are individually installed in or around the fields. SF measures were the improved cattle pens, where crops residues are mixed in with the cow dung, and compost pits.

Two phases in training activities can be distinguished:
First, the whole village is involved in a general SWC awareness programme, after which (at least) 5 voluntary young farmers form a village SWC team. This team receives a thorough training and helps other farmers with SWC in their fields. Although the accent lies on erosion control, the soil fertility aspects are being discussed as well. From 1986 to 2000, a SWC village team has been trained in about 50% of the villages.
The second step is the additional training in soil fertility management with an accent on improved cattle pens and compost pits. Villages are chosen where a SWC village team has already been installed, but farmers are trained directly without the SWC village team as intermediate contact group. About 25% of the villages have received the additional soil fertility training.
The other 50% that have not received any of the 2 formal trainings, are exposed to other trained farmers in neighbouring villages and are helped less intensively by the regular extension worker, often on an individual basis (Giroudy, 1996; CMDT, 2001; CMDT, 2002).

2. Hypotheses

About 72% of the farm families produce compost of some sort, including traditional practices as traditional cattle pens and waste heaps that were common even before the SWC programme started. And 38% of the farm families have some EC measures, which were almost non existent before the SWC programme started in 1986 (CMDT, 2001; CMDT 2002). There is a large variation in adoption between regions, between villages and even between farmers in the same village. Trying to explain this variation, the following hypotheses on factors influencing adoption were tested:

Agro-ecological zone:

1. Farmers in the North, where agriculture is more permanent, have less possibilities to 'escape' from declining soil fertility than farmers in the South, where rotational fallowing is still common. Farmers in the high land pressure zone are therefore more likely to invest in SWC measures.
2. Cotton growing farmers gain more benefits from agriculture and will invest more in SWC than the non-cotton growing farmers in the most northern villages

Farm equipment:

3. Farm families that possess more ploughing equipment are generally larger, cultivate more land, and are wealthier. They often lend out or let ploughing equipment to other families, often in return for money or labour (CMDT, 2000). Therefore, these better equipped families prepare their fields earlier and have more time and money available to invest in SWC.
4. Farmers that have a donkey (or horse) cart can easier transport stones, plant material, crop residues and compost which facilitates SWC activities.

Training:

5. Farmers in villages with a SWC village team will adopt more SWC measures. Farmers that have attended the additional soil fertility management training will adopt even more SWC measures.

Interaction between EC measures and SF measures:

Farmers often adopt both EC measures and SF measures. Farmers that already have adopted SF measures are more likely to start EC measures and vice versa.

3. Methods

A total of 298 farmers in 65 villages were interviewed and 841 fields were visited (2-3 fields/farmer). Two samples were used: one representative sample of 30 villages and 82 farmers, out of the regular sample used by the CMDT M&E Unit, and one biased sample of 30 villages and 216 farmers with high SWC adoption. This biased sample leads to higher adoption percentages than the actual average for South Mali. The reason for this biased sample was to have more yield data from fields with SWC measures (which are not discussed in this paper).

From each farmer the following information was collected:

- Land pressure: the average number of years the visited fields were under cultivation since the last fallow or clearing.
- Cotton growing area or non cotton growing area.
- Possession of ploughing equipment (plough and oxen) and possession of a donkey (or horse) cart.
- Training received: training of a SWC village team, and the additional individual training in SF management.
- EC measures installed: stone rows, live fences, grass strips, crop residues strips, stone check dams, crop residue check dams, contour marker ridges and water evacuation dikes.
- The actual quality and maintenance of EC measures.
- SF measures installed: improved cattle pens with crop residue supply and compost pits.
- Farmer intentions to install SWC measures in the future.

Among others the following analyses were undertaken, which will be discussed in this paper:

- Different degrees of adoption are described, distinguishing first installation, level of completion, maintenance, quality and intentions to continue in the future.
- Simple adoption (having or not having installed) of all SWC measures is described, varying one influencing factor at the time.
- Correlations and two-way interactions between different influencing factors are tested.
- The relative importance of each factor is analysed in a linear additive model with all 5 factors where non-significant factors are removed one by one from the model.
- Interaction between EC and SF measures is analysed.

4. Results

4.1. Different degrees of adoption

Stone rows and live fences are taken as examples to show different degrees of adoption.
Different degrees of adoption are distinguished: first installation, completion (in the sense of fully protecting the visited field), maintenance and planning further installation (either to protect the same field or other fields).
The different degrees of adoption for stone rows and live fences are shown in figures 2 and 3, varying from non-adoption (on the left) to complete and maintained structures (on the right). The dark lower part of each bar represents farmers that plan to install live fences or stone rows in the future, while the clear upper part represents farmers that do not. The quality of the SWC structure (% intact) is given for the different adoption degrees.

Figure 2. Adoption degree live fences

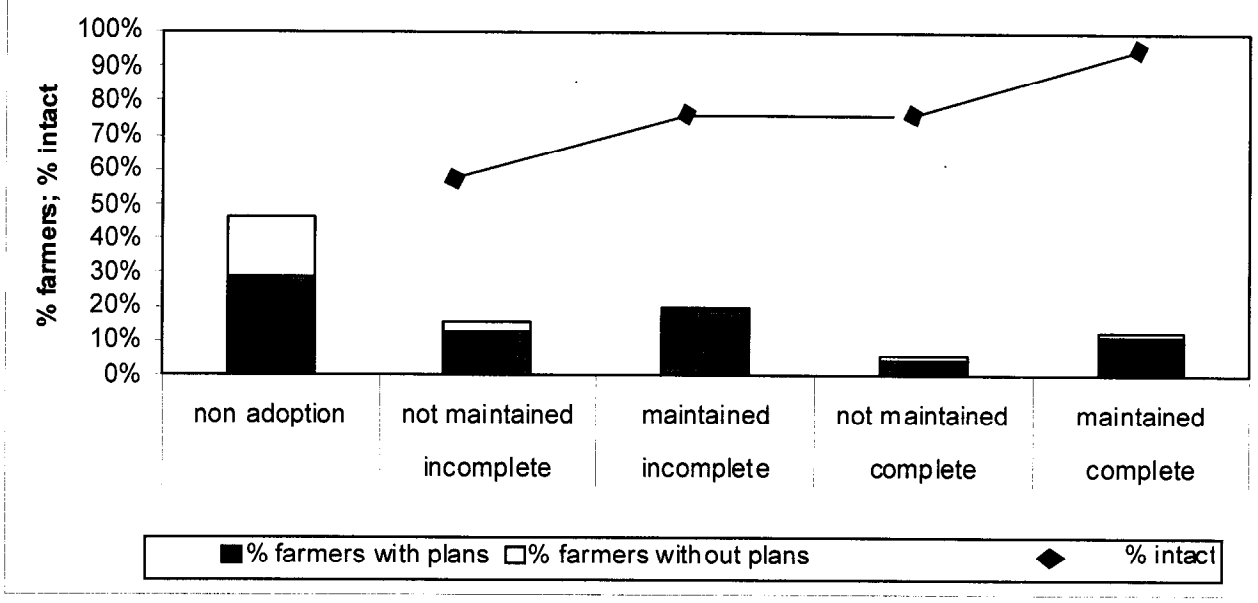
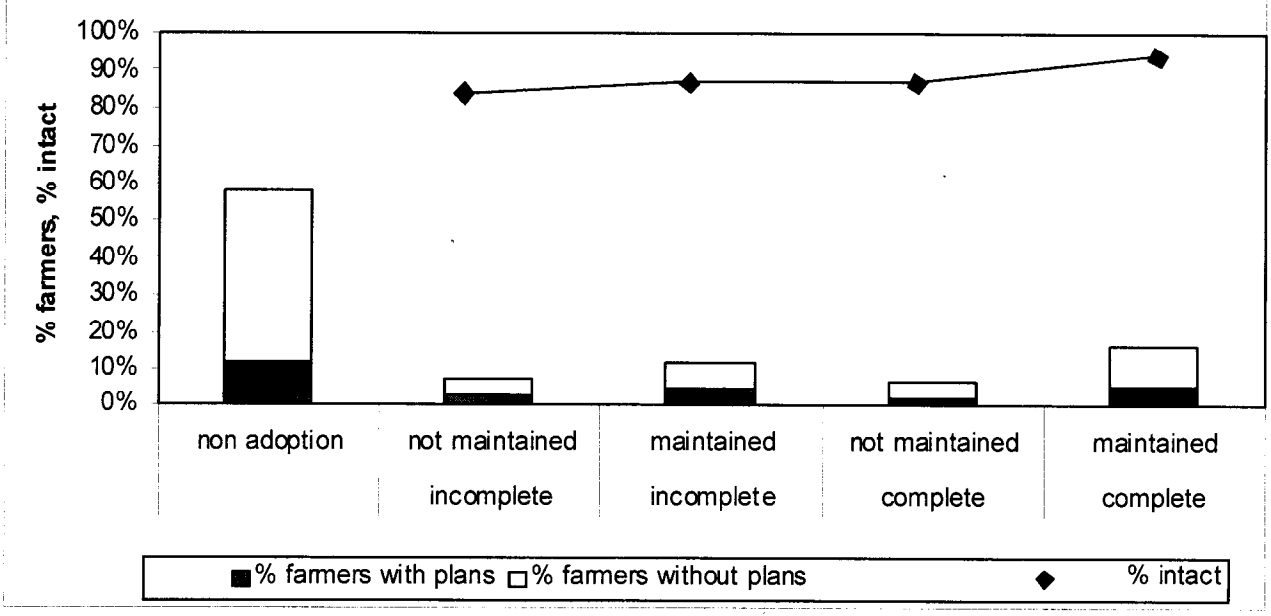


Figure 3. Adoption degree stone rows



Only a minority of the adopters have SWC structures that are complete and maintained.
There are a number of differences between the adoption of stone rows and live fences:
Not only the actual adoption of live fences is higher than the adoption of stone rows, much more farmers intend to install live fences than stone rows in the future.
On the other hand, stone rows are more complete and are of better quality than the live fences. Once installed, stone rows hardly need any maintenance while live fences do. Another reason for the lower quality of live fences is fact that farmers do not only plant live fences to control erosion but also to demarcate their fields.

On average 50% of the adopters of any EC structure have continued installation after the first year of installation. About 30% had continued in the year of the interview (1999/2000).

Adoption of SF measures is very promising. The annual work needed for the SF measures (e.g. transporting crop residues, cow manure and compost) was done by all adopters of improved cattle pens and by 97% of adopters of compost pits in 1999-2000. However, the 'quality' of the compost made in improved cattle pens is not according to the recommendations: on average 4 carts of crop residues are added per cow while the recommended rate is 8 in the north-east and 12 in the south-west.

In the results below, the adoption presented means simply 'having installed', regardless of continuation, completion, maintenance, quality or future plans.

4.2. Agro-ecological zone

Land pressure is determined here by the number of years the visited fields have been under continued cultivation since last clearance or fallow. For each village, the average land pressure of the visited fields was classified : 'very extensive' under cultivation less than 10 years, 'extensive' under cultivation 10-15 years, 'moderate' under cultivation 15-20 years and 'intensive' under cultivation over 20 years.

Table 1. Effect of land pressure on adoption of SWC measures

	very extensive (<10 yr)	extensive (10-15 yr)	moderate (15-20 yr)	intensive (>20 yr)
number of farm families	51	76	85	63
% with stone rows	22%	53%	48%	40%
% with live fences	43%	46%	60%	63%
% with grass strips	8%	14%	9%	30%
% with stone check dams	45%	51%	39%	29%
% with crop residue check dams	4%	17%	8%	13%
% with evacuation dikes	0%	0%	9%	2%
% with contour marker ridges	2%	0%	2%	5%
% with improved cattle pen	6%	34%	31%	56%
% with compost pit	41%	76%	62%	83%

In areas with higher land pressure farmers adopt more SWC practices (Table 1). The availability of enough fertile fallow land in the South reduces the need for SWC measures. The exception are stone check dams which are more often adopted by farmers in low land pressure areas. This can be explained by the steeper slopes and more visible gullies and rills in the low land pressure areas in the south-west.

Table 2. Effect of cotton growing on the adoption of SWC measures

	non cotton growing area	cotton growing area
number of farm families	42	256
% with stone rows	43%	42%
% with live fences	69%	51%
% with grass strips	14%	15%
% with stone check dams	31%	41%
% with crop residue check dams	17%	9%
% with evacuation dikes	0%	4%
% with contour marker ridges	7%	3%
% with improved cattle pen	31%	36%
% with compost pit	81%	64%

There does not seem to be a clear effect of cotton growing on adoption of SWC (Table 2). The fact that these farmers are generally poorer, less equipped and cultivate in a relatively flat and dry area, does not decrease SWC adoption.

4.3. Farm equipment

On the basis of the availability of ploughing equipment, farm families are classified in 3 groups: those not possessing one complete set, consisting of 1 plough and 2 oxen, those possessing 1 complete set, and those possessing at least 2 complete sets.

Table 3. Effect of ploughing equipment on adoption of SWC measures.

	not 1 complete set	at least 1 set	at least 2 sets
number of farm families	31	128	131
% with stone rows	26%	36%	53%
% with live fences	42%	50%	60%
% with grass strips	3%	11%	23%
% with stone check dams	35%	36%	47%
% with crop residue check dams	10%	8%	13%
% with evacuation dikes	3%	1%	6%
% with contour marker ridges	0%	5%	3%
% with improved cattle pen	6%	27%	50%
% with compost pit	55%	63%	75%

Better equipped farm families adopt more SWC measures, especially more stone rows, grass strips and improved cattle pens (Table 3). This could be due to their higher availability of time and money to invest in SWC.

Table 4. Effect of donkey cart on adoption of SWC measures.

	without cart	with cart
number of farm families	49	249
% with stone rows	33%	44%
% with live fences	47%	55%
% with grass strips	2%	18%
% with stone check dams	43%	39%
% with crop residue check dams	4%	11%
% with evacuation dikes	2%	4%
% with contour marker ridges	4%	4%
% with improved cattle pen	6%	41%
% with compost pit	37%	73%

Most farmers have a donkey (or horse) cart. There seems to be a minor effect on the adoption of EC measures and a major effect on the adoption of SF measures, which need transportation of crop residues, cow manure and compost (Table 4).

4.4. Training

Three levels of training are distinguished: farmers in villages without a SWC village team, farmers in villages where a SWC village team is installed and trained, and farmers in villages with a SWC village team and who have also attended the additional training on soil fertility management (SF).

Table 5. Effect of SWC training on adoption of SWC measures

	no training	SWC team	SWC team + SF
number of farm families	25	163	107
% with stone rows	8%	40%	53%
% with live fences	44%	55%	55%
% with grass strips	4%	13%	21%
% with stone check dams	8%	38%	50%
% with crop residue check dams	0%	12%	10%
% with evacuation dikes	12%	2%	3%
% with contour marker ridges	0%	5%	3%
% with improved cattle pen	16%	34%	43%
% with compost pit	48%	67%	73%

The installation and training of a SWC village team increased adoption of erosion control measure and soil fertility measures (Table 5). Water evacuation dikes, a traditional measure, were dissuaded some years after the SWC programme had started.

The additional soil fertility training increases adoption of both erosion control and soil fertility measures, but it's effect is less pronounced than the effect of the SWC village team.

4.5. Correlation and interaction between factors influencing adoption

There are significant correlations between the 5 factors influencing adoption (Table 6).

Table 6. Correlations between factors influencing adoption

	land pressure	cotton area	ploughing equipment	donkey cart
cotton area	--			
equipment	++	++		
donkey cart	++		++	
training				+

+, - Correlation is significant at the 0.05 level (2-tailed).
++, -- Correlation is significant at the 0.01 level (2-tailed).

In the zone of high land pressure, going from the south-west towards the north-east, farmers have more ploughing equipment and more donkey carts. However, the most northern area is the non-cotton area where farmers have less ploughing equipment.
Farmers with more ploughing equipment have more often a donkey cart as well.
There is no correlation between training and any other factor except a weak positive correlation between training and the possession of donkey carts. This could be explained by the fact that during the a certain phase of the SWC programme, additional credits for donkey carts were given in villages with training activities.

4.6. Relative importance of influencing factors

Because of significant correlations between factors, one should not test one factor at the time but analyse the relative contribution of each factor in a model containing all factors. There are no significant two-way interactions between factors, therefore a linear additive regression analysis of all 5 factors is done (Table 7).

Table 7. Effect of factors on adoption for each SWC measure

	land pressure	cotton area	plough	donkey cart	training	R2 adj.
stone rows			++		++	0.074
live fences		-	++			0.037
grass strips	+		++			0.054
stone check dams	-				++	0.047
crop residue check dams						0.000
evacuation dikes	+					0.011
contour marker ridges		-				0.018
improved cattle pen	++		++			0.156
compost pit	+	-		++		0.180

+, - Effect is significant at the 0.05 level; ++, -- Effect is significant at the 0.01 level.

In higher land pressure areas, farmers adopt more SWC practices, especially SF measures: improved cattle pens and compost pits.
In the non cotton area, in spite of farmers being less equipped and generally poorer, farmers adopt more live fences, contour marker ridges and compost pits.
Families with more ploughing equipment adopt more EC measures and more improved cattle pens.
A donkey cart only influences adoption of compost pits.
Training leads to higher adoption of EC measures, not to higher adoption of SF measures.

4.7 Interaction between the adoption of EC measures and SF measures.

The correlation between the number of EC measures and the number of SF measures adopted is significant (Pearson correlation : 0.325).
The number of EC measures is more determined by the number of SF measures, and vice versa, than by any of the 5 factors tested above.

One would think that there is either an overlooked farmer characteristic triggering both adoption of EC and adoption of SF measures, like being 'innovative', 'intelligent' or 'SWC aware', or that the adoption of one measure triggers the adoption of the other.

5. Discussion

The 5 factors (land pressure, cotton area, ploughing equipment, donkey cart and training) explain only part of the variation in adoption of erosion control measures (11%) and soil fertility measures (23%) so a large part of the variation remains unexplained.

Adoption of SWC measures in the non-cotton growing area covered by the SWC programme is perhaps surprisingly high. This area has had additional assistance to compensate for the lower farm income in the form of longer credit refund periods for improved cattle pen materials (5 years in stead of 3 years) and subsidised donkey cart credit facilities. Moving more north, out of the CMDT zone and out of the research area, one enters a much less developed area where adoption of SWC measures is very low.

One tends to overemphasise the effect of ploughing equipment on adoption because the better equipped farm families are larger and cultivate more land: families with at least 2 sets of ploughing equipment consist on average of 26 persons and cultivate 17 hectares on average, families without one complete ploughing set consist of only 9 persons and cultivate 4 hectares on average (CMDT, 2000).

The effect of SWC training, when simply comparing 'formally trained' and untrained farmers, is underestimated because of 'informal training' of untrained farmers. Untrained farmers get information and assistance from other farmers from neighbouring villages and by the local extension worker.

The effect of SF training, when simply comparing the actual adoption by trained and untrained farmers, was not significant. However, when analysing relations in time between the year of training and the year of adoption, the effect of training becomes evident: adoption very often takes place in the same year or in the year following the SF training.

6. Conclusions

High land pressure in the north-eastern area decreases the possibility to include rotational fallow in order to restore the soil organic matter content. Farmers have responded to this problem by adopting improved cattle pens and compost pits as soil fertility measures.
The traditional water evacuation dikes and grass strips are found more often in high pressure areas, where SWC awareness is generally higher. However, stone check dams are found less in this relatively flat area with fewer gullies and rills than in the south-eastern low land pressure area.

Farmers in the most northern non-cotton growing area adopt more live fences, contour marker ridges and compost pits. The lower income of these farmers by the absence of cotton does not discourage adoption of SWC measures. These farmers are in a difficult situation: rainfall is limiting crop yields so they need to maximise rainfall infiltration using SWC measures; they don't receive fertiliser on credit as cotton growers do and they can not clear new fertile land, so they have to recycle the maximum of cow manure and crop residues. Trying to explain SWC adoption by means of cost benefit analysis, one could argue that by lack of alternatives their opportunity costs are lower than in the southern cotton growing area.

Farm families with more ploughing equipment, at least 2 sets of ploughs with 4 oxen, adopt more stone rows, live fences, grass strips and improved cattle pens than families with less ploughing equipment. Not too many conclusions should be drawn from the effect of ploughing equipment because this correlates with family size and cultivated area.

Families possessing a donkey cart adopt more compost pits. The effect on the adoption of improved cattle pens is not significant. Because compost pits are adopted by all types of farmers while improved cattle pens are mostly adopted by farmers with more ploughing equipment, the effect of donkey carts on improved cattle pen adoption is partly 'captured' by the strongly correlated possession of ploughing equipment.

Training, especially the installation and training of a village SWC team, increases adoption of EC measures. When looking at the situation in 1999/2000, the effect on SF measures was not significant.

7. Recommendations for a follow-up study

In addition to the analysis of influencing factors on the actual adoption of SWC measures, an analysis can be done in which the year of adoption and the year of training can be used to better understand their relation in time.

This analysis of factors influencing adoption is imbedded in a proposed larger study on the impact of 20 years of SWC activities in Southern Mali, which would involve additional field work and data collection. The paper presented here is based on already available data. Additional field work and data collection will help explain more variation in farmer adoption of SWC measures. Factors, not included in this paper, that will be looked at are:

The need for SWC measures. Adoption has to be related to the need for SWC measures. In South Mali, there are definitely fields without erosion problems. It would be best to map and categorise the area in several 'erosion risk' classes. Unfortunately, no good data are available on 'erosion risk'.

The potential of SWC adoption. Adoption has to be related to the possibility to adopt. Even if, for example, erosion control is needed and a farmer is trained and willing to install stone rows, there may not be any stones available within a reasonable distance. No data are available on the availability of stones, plant material, crop residues, cow manure, etc.

The cost of SWC practices. The 'cost' to an adopter is his labour for installation and maintenance of SWC measures and for the annual transport of residues, manure and compost. The time needed for installation is known, although some assumptions on the availability, for example the distance at which stones could be collected, were not explicit (Schrader, 1996). The time needed for maintaining EC structures and for transporting residues, manure and compost are not yet known.

The benefits of SWC practices. The actual large scale adoption should be related to the actual yield benefits farmers achieve in South Mali. Benefits are proven in the villages that received intensive assistance during the early phase of the SWC programme. However, in the later, large scale phase of the SWC programme, assistance could only be less intensive, SWC measures are less complete and less maintained so effects on crop yield are expected to be less as well.

Alphabetisation as an element of training. Due to the functional alphabetisation programme, on average 70% of the farm families have nowadays at least one literate member. However, during interviews for another study, some villages were found with very few literate farmers. Here, farmers explained that they would have benefited much more from the SWC training if the literacy rate had been higher. The training brochures in local language can only be red by a limited number of farmers, who are often already occupied by other tasks (Bodnár, 2002).

Family characteristics. In order to better understand labour constraints, it will be helpful to add other family characteristics : number of active persons, area under cultivation and whether external labour is hired or family members work elsewhere.

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