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A SUITABLE WATER MANAGEMENT
FOR THE REHABILITATION OF RICE CULTURE
IN THE ACID SULPHATE SOILS OF LOWER CASAMANCE (SENEGAL):
A SUCCESSFUL TWO YEARS EXPERIMENT

Fourth international symposium on acid sulphate soils

HO CHI MINH CITY, VIET NAM

March 2-6, 1992

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ABSTRACT

Situated in the south of Senegal, the Casamance region, in particular the lower lands, is historically a region of rice production auto-consumpted by the local population. Since the recent drought, the production has been dependent on the climatic variations and has been stagned. The quick growth of urbanization needs more and more rice imports.

Since the seventies, the government has taken several measures to increase the degree of self-sufficiency in rice. Among these, the development of mangrove rice production with the construction of dams is one of the most important. During the very dry years in the beginning of the eighties, the main objectives were to protect the rice-fields from the salinization disease on one hand, and to try to rehabilitate the areas of acid sulphate soils on the other. The efficiency of these anti-salt dams on the rice production was not so high as planned.

The small valley of Djiguinoum (150 ha of rice polder), directly in relation with the Casamance river, was chosen to experiment a new system of sluice which is easily manipulated and well adapted to water management. It allows to drain off the higher concentrations of salts and acids at the beginning of the rainy season and to maintain a sufficient quality of water for the rice culture.

Three experimental fields were settled on a very degraded area (about 1 ha) with an outer dike and with a drainage network connected to the main river-bed. The traditionnal techniques, used by the farmers in the valley, were applied for the wet rice cultivation. During two consecutive years with little rainfall, a significant paddy rice production has been obtained. The first year, the salts movement was controlled in the soil in regard with the water dam management. The second year, we tested also different techniques (ploughing, tolerant varieties, fertilization) to improve the chemical properties of these soils.

A social inquiry was held concerning the question as to whether the rice culture actually had any chance to become again the main interest for the population.

1. INTRODUCTION

The effects of the recent drought are now well known in lower Casamance, especially in the mangrove environment (MARIUS, 1979, 1985; MARIUS et al., 1986; BOIVIN et al., 1986; LOYER and al., 1988; PAGES, DEBENAY, 1987; PAGES et al., 1987; LE BRUSQ et al., 1987; DACOSTA, 1989; MONTOROI, 1990; MOUGENOT et al., 1990). We can recall the principal consequences:

- . decrease and destruction of the mangrove vegetation,
- . increase of the salinity of seawater, concentrated by evaporation,
- . chemical degradation of soils in lowlands,
- . stagnation and decrease of rice production with a development of cultures on the uplands,
- . increase of the run-off erosion in the uplands,
- . migration of population toward the cities.

The management of the mangrove soils is an old custom in this region because of the influence of the seawater. The water management is very clever and well-adapted in good conditions of pluviosity (PELISSIER, 1966). The soils have evolved in a short time with the dramatic decrease in rainfall (figure 1): most of them are now very saline and the acidity, issued from the geochemical transformation of pyrite, has extended in the mangrove area.

The Casamance region is historically occupied by a population of farmers and fishermen, the jolas. The production of rice is directly consumpted and stored by the local population.

The government wanted to develop the rice production, especially in the mangrove area, so that to reach a good level of self-sufficiency for the senegalese country. Among several projects, the construction of dams, across the main affluents of the Casamance river, has been studied. The aim was to protect the mangrove forest and to adapt the water management to the specificity of these soils: for example, avoid the acidification processes with the coming in of seawater during the dry season.

During the very dry years at the beginning of the eighties, the high levels of salinity in the rivers made it necessary to revise the water management. It was urgent to protect the rice-fields from the salinization disease. The construction of small anti-salts dams, hand-made by the populations, has been supported with external financial means (USAID/SOMIVAC/ISRA, 1985). They consist of an earthern dike with a water control structure. Some of these dams have been efficient, especially in the sandy valleys, but the water management was not well-adapted in the other cases. The rice production was not so high as planned. The rehabilitation of the degraded lands is always an actual problem, not resolved with satisfaction. Technical solutions exist for the reclaimation of acid sulphate soils, some of them were tested in Casamance before the severe degradation of soils (BEYE, 1973, 1973, 1974, 1977; BEYE et al., 1978).

The present paper exposes the results of a field experiment, situated in the Djiguinoum valley. The sluice of the anti-salt dam has been improved to facilitate the water management and different culture techniques have been tried in several rice-fields.

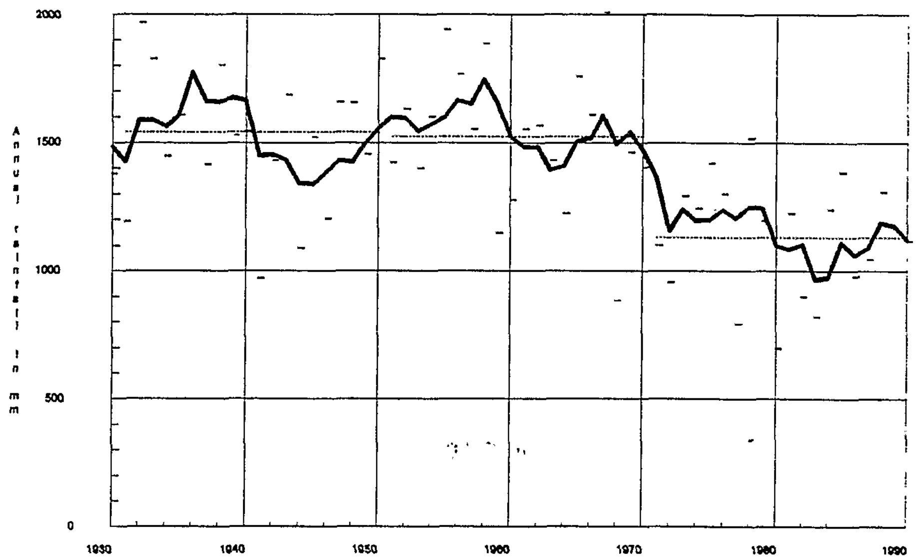

Figure 1Annual rainfall in Ziguinchor during the period 1930-1990
- in full line, moving five years averages
- in dotted lines, annual average value for different twenty years periods:
1931-1950: 1541 mm; 1951-1970: 1524 mm; 1971-1990: 1133 mm

2. ENVIRONMENTAL SITUATION

The Djiguinoum valley is located on the right hand-side of the Casamance river at about 15 km northeast of Ziguinchor city. The watershed is limited at the southern part by the anti-salt dam of Djilakoun which has a surface of 25.74 km^2 (figure 2). The flooded lands in the rainy season represent 150 ha. It is the area of hydromorphic and acid sulphate soil.

The field experiment is situated in the middle part of the valley, near the Ziguinchor track, at about 1 km north of the dam.

It was settled on a typical acid sulphate soil, well structured in the surface horizon and saturated in depth (BRUNET, 1988). The clay content was between 70 and 75% with a silt fraction of 20%. PH value was 3.5 for the surface horizon and 2.5 in depth. Exchangeable aluminium was present, especially in the deep horizons (4 mmol per 100g of soil) and the sulphur content was also high in depth (30 to 50 mg per g of soil). The groundwater level was at 1.2-1.4 m at the end of the dry season with a pH of 4, a EC of 16 dS/m and a high soluble aluminium content (0.6 mmol per liter).

Salt minerals are observed on the surface and form a fragile crust with clay particles or a saline clay powder in some places.

The upper lands of the watershed are occupied by red soils. The landscapes are especially composed with forest and peanut culture. The intensive human activity on these soils increases more and more the risk of erosion.

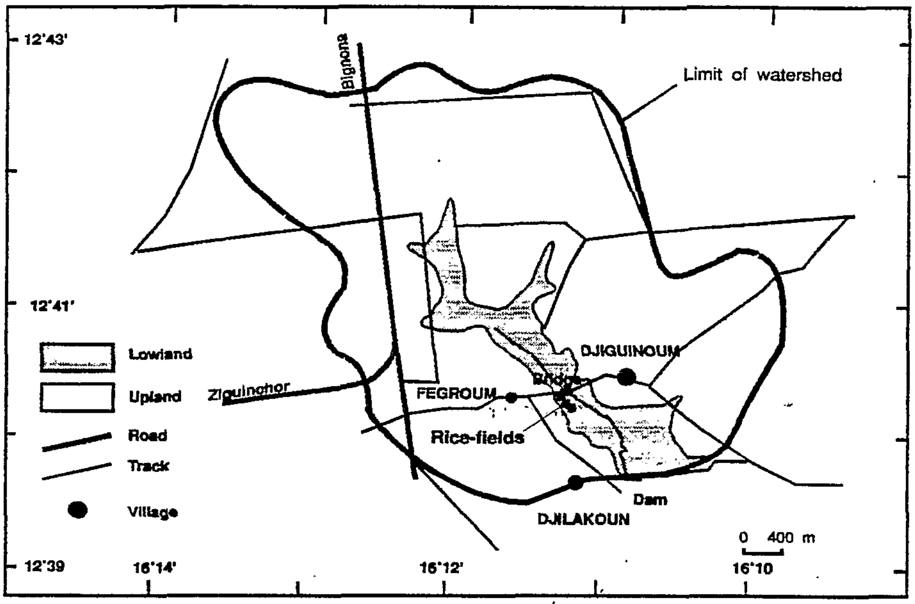

Figure 2 Field experiment site in the watershed of Djiguinoum

3. METHODOLOGY

3.1. Water management

The original sluice system consisted of several wooden boards. The regulation of water level was very hard when the upstream side was full of water. A new system has been installed in 1988 (ALBERGEL and al., 1990). It consisted of wooden vertical slide gates manually operated to drain saline water from the bottom.

Four rules are applied at the anti-salt dam to improve the water management:

- wash out the first run-off flows which contain a high level of salts at the beginning of the rainy season,
- maintain a water level compatible with the rice growing during the wet season,
- avoid the flooding of the track crossing the valley in the middle part,
- open the sluices when the upstream level is higher than the seawater level with a 4 cm difference which can be read at two hydrological scales.

Different experimental devices (piezometers, water level recorders) were installed to provide hydrological and hydrochemical information.

3.2. Field experiment

Two kinds of rice-fields are settled on, on one hand a traditionnal field (figure 3), on the other hand an hexagonal field (figure 4). Both of them are hand-made with a local instrument, the "kayendo" (MARZOUK-SCHMITZ, 1988).

The traditionnal rice-field has eight plots separated by drainage canals. A surrounding canal allows the drainage toward the river-bed. In 1990, two plots were divided into three strips where no tillage is executed. Three salt tolerant varieties were tested. The total surface of the rice-field was 2500 m^2. The dimensions of each plot were 20 m length and 10 m large.

The hexagonal rice-field was divided in three losangic plots which received different types of fertilization (lime, lime plus phosphates and phosphates plus gypsum) for only one rice variety. The cultivation surface of this rice-field was 1875 m^2. For a second hexagonal field, the fertilization has been mixed with rice straws.

The rice was transplanted in August from the uplands when the rice-fields were flooded. The rice was harvested in December

The variations of the chemical properties of the tillage soil were known with the collection of drainage water. The soil solution was extracted every week with in situ water samplers. These devices were installed at different depths before the flooded period.

A rainfall simulator was used on a bare and a tillage soil to observe the run-off and the salts movements.

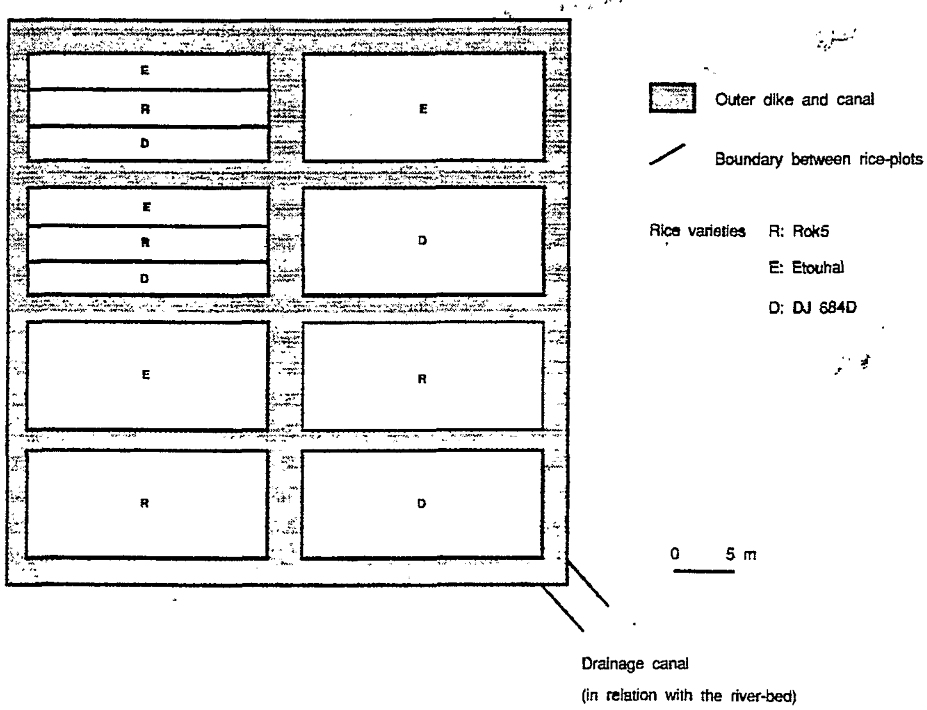

Figure 3 Traditionnal rice-field with the salt tolerant varieties used in 1990. The two rice-plots divided in three strips are not ploughed before plantation time. No fertilization.

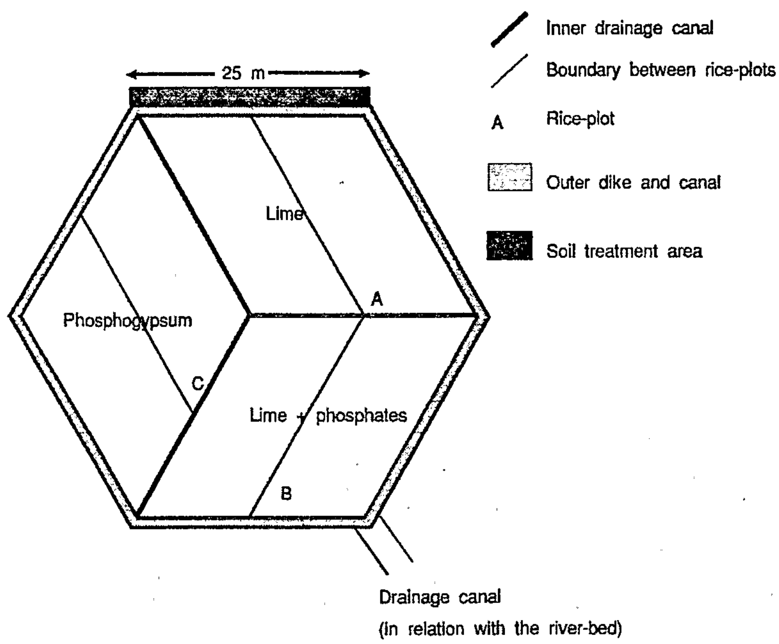

Figure 4 Hexagonal rice-field with different fertilization. One rice variety is used (Rok5).

4. RESULTS

4.1. Water management

The variations of upstream and downstream water levels are shown on figure 5.

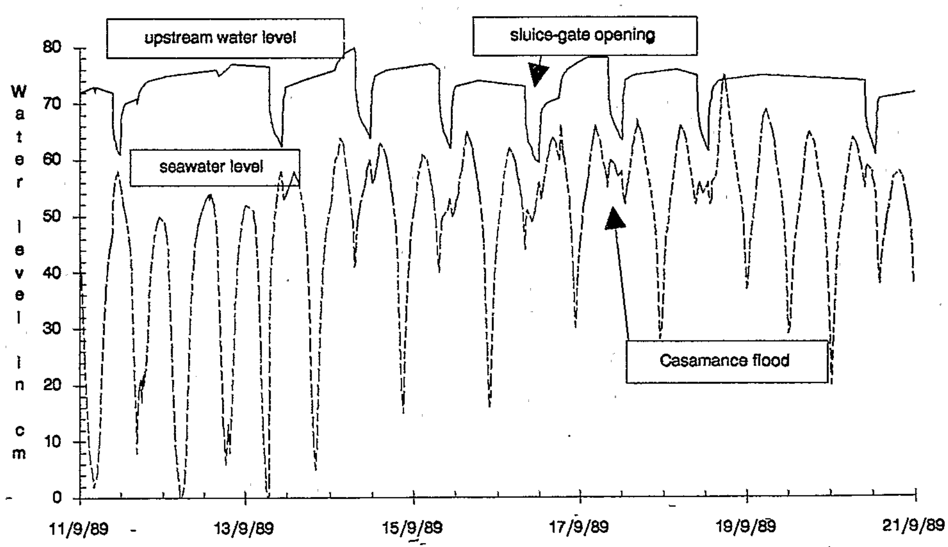

Figure 5 Upstream and downstream water levels at the anti-salt dam of Djilakoun in September 1989.

4.2. Effect of the water management on soil salinity

The water management at the anti-salt dam, allows to diminish the salinity level of the acid sulphate soil, especially in the first decimeters (figure 6). The electrical conductivity decreased at 25 cm depth from 30 to 10 dS/m in 1990. The salinity level increases rapidly at the end of rainfall.

The saline profile is always increasing with depth, even with the lower values during the flooded period.

As the high salinity of groundwater does not change in depth during all the year, the increasing of the saline profile become very sharp in the wet season. The salinity of the surface water is about 3 dS/m at the lower value (table 1).

The rice roots have grown and spread only in the first centimeters of soil where the plant is able to support such a salinity.

Table 1 Chemical composition of the surface water on 16 September 1989 (BRUNET, ZANTE, 1990)

pH	EC (dS/m)	Soluble ions, mmol per liter								
		Na	K	Ca	Mg	Cl	SO4	Al	Fe	Si
3.6	3.1	21	0.7	0.85	2.25	21	3.65	0.2	0.001	0.07

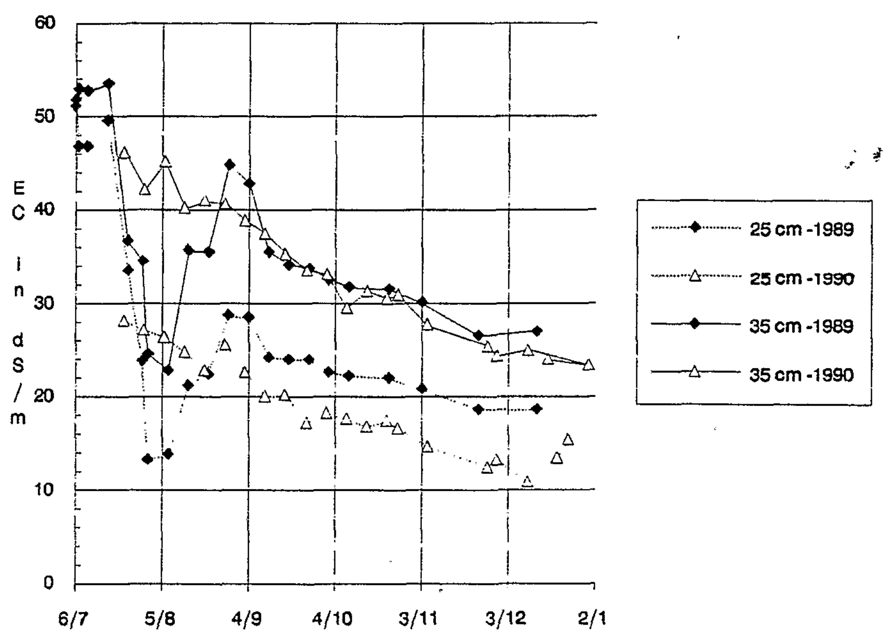

Figure 6 Effect of the water management on the electrical conductivity (EC, in dS/m) of a cultivated acid sulphate soil in the Djiguinoum valley (in dotted lines, depth at 25 cm and in full lines, depth at 35 cm for two rainy seasons).

4.3. Redistribution of salts

The decreasing of salt content is improved with the tillage (figure 6). The simulated rainfall has run off on a bare soil. A saline crust is formed after each rainfall and no infiltration is effective.

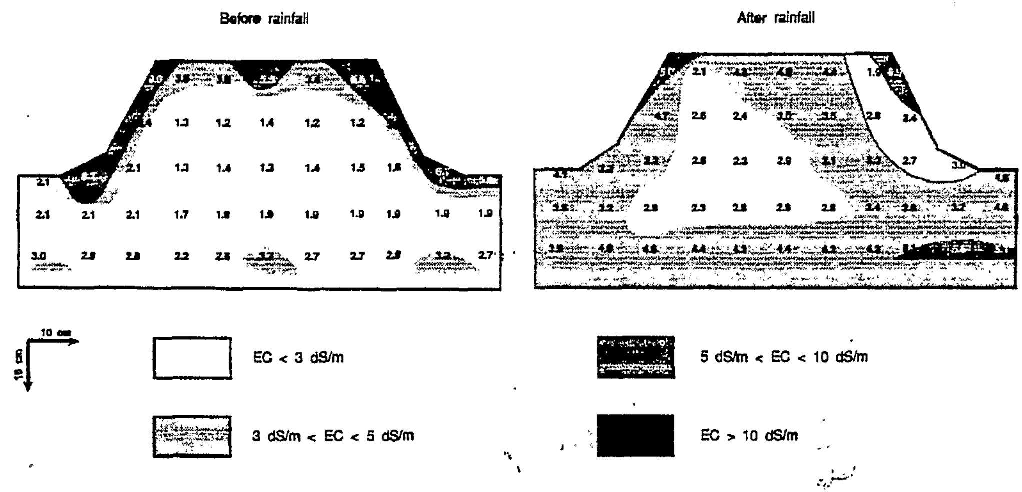

Figure 7 Redistribution of salts in a crossing section of a tillage rice-plot after three simulated rainfall (60 mm during one hour for each rainfall).

4.4. Rice production

The yield obtained in 1989 and 1990 were higher than the average yield of the Casamance region (about 1ton/ha).

The results were better in 1989 for the traditionnal rice-field. The rainy season pattern was different and the water management has been adapted. The decrease of salinity water was less effective.The no tillage plots have given a significant production because the soil has conserved a good level of fertility with the rice straws ploughed-under after the former harvesting (table 2).

Table 2: Average paddy rice yield (in tons/ha) for different salt tolerant varieties of rice and for two type of tillage in the traditionnal rice-field (BRUNET, ZANTE, 1990; BRUNET et al., 1991)).

	Rice variety	1989	1990
Tillage	ROCK 5	2.8	2.8
	DJ 684D	2.6	1.0
	ETHOUHAL	2.8	1.9
No tillage	ROCK 5	-	2.2
	DJ 684D	-	0.8
	ETHOUHAL	-	2.1

The lower yields obtained in the hexagonal rice-field are explained with the different density of plantation (table 3). The density was125,000 plants per ha against 200,000 plants per ha for the traditionnal rice-field.

Table 3: Average paddy rice yield (in tons/ha) for different type of fertilization in the hexagonal rice-field (DOBOS et al., 1991).

Treatment plot	Paddy rice weight per plot (in kg)	Yield (in tons/ha)
A lime	62.0	1.0
B lime + phosphate	74.5	1.2
C phosphate + gypsum	44.0	0.7
Reference	29.3	0.5

5. CONCLUSION

The good results of rice production obtained in Djiguinoum valley must be taken in account with a moderate satisfaction. Several problems must be solved before a regional extension. Two successful years (even three in 1991) show that there is no fatality and man is able to struggle against the disease.

In Casamance, each valley has a particular configuration and the applied techniques must be adapted to each case. The knowledge of environmental conditions are required. For example, a hydrological study must determine the well-adapted parameters for a dam construction.

A major problem for the water management at a central sluice in a valley is that the users of plots of land depend on the water level control at the dam. The risk of conflicts between users is high because they cannot regulate it individually. It is necessary to educate them for the manual operations at the sluices and for the maintenance.

The rice cultivation has a dominant role in the economic system of jola people. Ethnic influence, urban migration, drought have diminished this role. The stagnation of rice production is not able to solve the problem of food at the end of a too long dry season. More rewarding crops, like peanut, allow to buy imported rice. The quick increase of urban population diminishes the self-sufficiency rate of the country (40% in 1970 and 20% in 1984). This population is a high rice consumer and does not produce anything else (160 kg per annuum and per capita in Dakar). Imports of rice are more and more important at present and Casamance region cannot avoid this evolution alone.

The field experiment in the Djiguinoum valley has stimulated the interest of the local population to struggle against the dramatic effects of the drought on their fields. They want to come back in the valley with the desire to copy the management model used by the project (SALL, 1991). An organizational structure will be essential to develop the whole valley on this pattern. However, a new management must be adapted to allow the reclaimation of all the polder-plots, for example with intermediate sluice structures. Socio-economic conditions have changed in Casamance and the future projects have to consider this reality. The difficulties for the reclaimation of acid sulphate soils exist in other West Africa countries like Guinee-Bissau.

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