RAINWATER HARVESTING IN MALI

A Country Overview with Case Studies from
the Duentza Cercle in Mopti and the Koutiala Cercle in Sikasso

Prepared by Evelien Kamminga

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I.R.C.
P.O. Box 93190
The Hague
Netherlands

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1. COUNTRY OVERVIEW

1.1 EXECUTIVE SUMMARY

For Mali, rainwater harvesting has always been important for domestic water supply and production. Since the seventies, the major source of water, wells and natural catchment areas (ponds, lakes and streams) are drying up or do not hold water year round. The National drinking water policy has focussed almost exclusively on the exploitation of groundwater resources (boreholes). Water specialists now realize that progress is too slow and the costs far too high. Complementary water resources have to be developed: surface water resources. The National policies for 1. increasing villagers' self reliance in food production and 2. fighting the desertification have also been emphasizing the importance of developing alternative water resources.

The traditional techniques for water harvesting are effective, cheap, socially adapted and labor intensive.

The non-traditional technique most applied is the building of small scale impermeable dams for watering of livestock, rice cultivation and gardening. Programs for increasing the productivity of ponds, lakes and streams (aménagement de bas-fonds) spring up like mushrooms. A whole spectrum of donors is involved. So far however, the results are rather disappointing. The activities are neither technically effective nor economically efficient. Community participation is unsufficient.

Programs for increasing the agricultural productivity through soil and water conservation methods are relatively young in Mali. Programs with explicit water harvesting goals are rare and concentrated in the less than 800 mm rainfall zone. Few projects however, collect hard data concerning these activities.

Water collection from rooftops is rare since roofing is unsuitable. Most dwellings have banco (mud) roofs. Only in urban areas water is collected from metal conjugated sheet roofing, but no investments are made to exploit this source further. The fact that rains are concentrated in a four month period seems the major constraint to recuperating the investment costs of more suitable materials.

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Map 1. Mali with areas with natural depression areas suitable for exploitation (see Annex C.).

Source: Marion, UNDP, Draft Document, 1988

Map 2. Mean Annual Rainfall 1920-1980

Source: TAMS, Mali Land and Water Resources, 1983

1.2 RAINWATER HARVESTING PRACTICES

1.2.1 Use of natural depressions

It is estimated that 80% of all villages are located near water catchments. In the past, these depressions held water the whole year round or during most of the year, now most contain water only during 4-6 months. See photos 3-7,12-13,15-16,30-36.

Traditionally few arrangements are made to increase the collection or storage capacity of these natural depressions. Sometimes low earth dams were made to regulate water for rice cultivation. Widespread, however, is the technique of "puisards". These are holes of 1-3 meters deep dug in the bottom of the pond, lake or in the stream bed just after the water has dried up. This way the period in which water is available can be extended with a few months. These holes have to be redone each year.

The Cercle of Bandiagara (Mopti Region) was the first area in Mali, where these surface water sources have been further exploited with innovative techniques. The first barrages were built on the sandstone plateau in 1932 with the assistance of the Catholic Church. Later many aid agencies got involved and by 1972, 94 dams had been built (Marion 1988:1). The Dogon used the water for intensive gardening, especially onions.

In the seventies and beginning eighties few dams were built in the country. The last 5 years, however, the natural depression areas in Mali have become a focus of attention of the government and aid agencies. This results from the national policy of increasing self reliance in food production and fighting the process of desertification. Programs for increasing the productivity of natural depression areas ("aménagement de bas-fonds") are implemented now all over the country. Map 1. gives an indication of the geographical distribution of the interventions (see Annex C. for details). There are three kinds:

a- construction of single "micro barrages" (water retention dams) of varying dimensions. These have multiple objectives and are found in all regions, but not in the far north.

b- deepening out of lakes and ponds for watering of livestock ("surcreusement des mares"). This takes place in the Northern regions, where pastoralism is important

c- building of series of small scale dams in shallow natural depressions for rice cultivation. These interventions are most recent and are concentrated in the Southern regions, where rainfall is higher.

Case study 2., the Micro-Barrage of Ntossoni (Koutiala Cercle, Sikasso Region), is an example of the a- category.

1.2.2 Soil and water conservation

Little is known about the application of traditional techniques to increase infiltration of water in the soil. Interviewed people believed such techniques are mainly practiced in the Mopti Region, and in particular by the Dogon. See photos 1-2,10-11,14,18-21,28-29. Most common techniques are:

- earth bunds (micro-catchments) and permeable bunds of rocks or stalks/ branches in lines or square pattern and

- water collection pockets (compare "zay" in Burkina, Reij e.a. 1988:44).

These techniques are labor intensive and are well adapted to the specific geographic circumstances of the Dogon: shortage of land, degrading soils, slopes, heavy run-off and erosion, and a low annual rainfall (400-500 mm, Sahelian zone).

The experience with the introduction of alternatives to traditional techniques is little developed in Mali. The anti-erosion activities being introduced by various forestry, agricultural and anti-erosion projects have an experimental character. Recently, more attention has been given to the water harvesting aspect. In July 1989 the World Bank organized a seminar on Rainwater Harvesting to exchange experiences and discuss methodologies. Government services and 12 projects participated from Mali and Burkina Faso. Some of the soil and water conservation techniques introduced are:

- plowing on contourlines
- "digues filtrantes" (permeable rock barriers)
- rock bunds and crescent catchments
- biological measures, like live fencing

Case Study 1. concerns traditional and innovative soil and water harvesting techniques practiced in the Duentza Cercle (Mopti Region).

1.2.3 Rooftop water collection

This technique is rarely practiced in Mali. The major reason is that most dwellings have banco (mud) roofs. Water is said not to be collected, because it is dirty and bad tasting. To guard against eroding the side of the house, roof gutters are made, but the rainwater is not caught. See photos 8-9.

In urban areas, however, where the number of households having corrugated metal sheet roofing is higher, rainwater is collected in buckets, pots, vessels etc. on a large scale. However, no investments are made to increase the storage capacity. The rainy season is too short to justify such investments. Very few households use an oil drum to store water. People appreciate the taste of rainwater. Also it can save women's time (instead of drawing water from the well or going to the public post) and money (instead of bying water).

No project interventions seem to exist in this field.

1.2.4 Ground reservoirs

In most villages banco is extracted in depression areas. These pits fill up with run-off and clay sediment during the rainy season, but generally the have little function as water supply. In the contrary they are often a nuisance, fill up with garbage and the stagnant water attracts insects. See photo 17.

In the Duentza Cercle (Mopti region) these banco pits have become useful water sources. These "bourogara's" are well maintained and the water use is regulated in such a way that the water is kept clean. They are located in the middle of the village and are a handy supplementary water source during about 6 months a year. See photos 22-27. Case study 1.

Another system found in the Duentza Cercle is the "jogodoji". These are tanks dug in the ground of about 30 m^3, which collect run-off water. Some are used for household water supply, others are sold to herders passing with their cattle. In this area the groundwater table is more than 100 m deep. See Annex B. for a description of the system.

Case study 1. gives more information on both systems. The Canadian project, Aménagement de Terroir, (Ségou Region), is planning activities around banco pits: improving sanitation conditions and promoting income generation (gardening). No other initiatives have been found.

1.3 UTILIZATION OF HARVESTED WATER

Water from ponds, lakes and streams is traditionally used for domestic use, watering of animals, gardening, rice cultivation and fish culture. Surface water and water from puisards, is still widely used for drinking, especially if alternative water sources (wells or boreholes) are scarce, arduous to use or not available. The quality of the water is of medical concern.

a. aménagement du bas-fonds Water for:
- livestock
- gardening and fruit trees
- rice cultivation and
- fish culture

Water is usually available for 6-10 months. For human and animal consumption other permanent water sources are still required.

b. soil and water conservation Water for:
- production of plants (crops, trees, fodder)

c. rooftop collection (urban areas) Water for:
- drinking and cooking (taste is appreciated)
- laundry and bathing (foams well).
- other uses like filling of batteries.

Rooftopwater is used only during the rainy season and is supplementary.

d. ground reservoirs (Duentza Circle) Water for:

Water from bourogara's is supplementary and is used for:
- all domestic purposes, watering of livestock and gardening

Water from jogodoji's is primary or supplementary and is used for:
- all domestic purposes and watering of livestock.

In most interviews with government and aid agencies the point was brought up that dams and soil and water activities could raise the water level of wells in villages ie. ground water recharge. A number of villagers in Ntossoni (Case Study 2.) were convinced that the water in their wells had risen since the construction of the barrage. Some thought it was the first objective of the barrage.

1.4 INSTITUTIONAL ASPECTS

Aménagement de bas-fonds programs

A large number of foreign organizations are actively involved as donors and/or implementors of "Aménagement de Bas-Fonds" activities in Mali: NGO's, religious organizations, bilateral and multilateral organizations, consultancy firms etc. The scale of the interventions and the costs per system varies greatly. Since 1972 the Ministry of Agriculture (Genie Rurale) and the Direction of Waterworks and Energy (Petits Barrages) are the promoters of such programs.

Enormous investments have been made by foreign agencies for the construction of barrages in the Bandiagara Cercle. According specialists, these can be easier justified in social than in economic terms.

Recently, dams are financed by Local Development Committees (local administration) and built by Malian private contractors without any foreign assistance. The LDC's collect taxes from the rural population, which are used for development activities.

An indication of the political importance of the development of water resources is that in September 1989 a national committee for the coordination and evaluation of water programs (surface and ground water) was created. Members are representatives from the National Directions of Waterworks and Energy, National Planning, Genie Rurale (Agriculture), Livestock, Territorial Administration, Opérations Puits and the Rural Economic Institute. The Forest Service (Eaux et Forêts) is not included.

Soil and water conservation programs

There are about 20 projects in Mali having activities in this field. Among them are NGO's, bilateral and multilateral organizations. The National Forest Service (Eaux et Forêts) of

the Ministry of Environment and Livestock is to a different degree involved in a number of the programs. Some programs work with other governmental organizations, the CMDT (Compagnie Malienne pour le Développement de Textile) and the ODIPAC for example.

1.5 RESULTS AND TENDENCIES

1.5.1 Aménagements de bas-fonds

a. micro barrages

People interviewed from government and aid agencies believed that there has been an uncontrolled growth of these kind of programs. (Compare Rapport sur l'Approvisionnement 1988:34). The performance of many dams is poor by faulty design or lack of maintenance. The objectives are often over charged or contradictory. Economically they are inefficient. Gardening is often hampered by lack of marketing possibilities. Community participation is limited and the replicability weak. Very little exchange of information exists and the same mistakes are made over and over.

For a long time aid agencies have been willing to finance these interventions, while little contribution from the communities was asked. Their approach is becoming more rational. In interviews it was pointed out that the participation of villagers must increase and better adapted technologies chosen. The UNDP project for the exploitation, evaluation and management of water resources intends to improve the coordination and is preparing a methodology plan (Marion 1988). Some other initiatives are:

- a project for repairing broken down dams in Bandiagara Cercle (GTZ, DED)
- a project proposal of the UNDP (MLI 84/005) for a research and training program for technicians of governmental institutions (Genie Rurale, CMDT, ODIPAC etc.) (UNDP, Projet Etude et mise en valeur des eaux de surface non-perennes, 1988).

b. deepening out lakes and ponds for livestock

The largest program is the World Bank project, ODEM II, in the Mopti Region. The project is deepening lakes and ponds, drilling boreholes and digging wells as large areas of rangeland are opened for livestock. The activities however, are costly, the participation of the nomads is difficult to solicit and maintenance problems are enormous (RIM 1987:72-4).

c. series of low dams for rice cultivation

According to local aid agencies the more recent programs assisting communities in revitalizing their rice cultivation are rather promising. Small scale earth dams are built to retain water during longer periods and to better regulate water levels.

After the rice has been harvested and stored, vegetables can be grown. The Canadian project, Micro-Réalisations, operating in the Sikasso region is an example. The objectives are clear, the technology rather simple and the costs relatively low. A training program is foreseen to increase the productivity of traditional rice cultivation.

Rice cultivation is traditionally a women's activity and according to sources, women continued cultivating rice fields after the dams were built. A summary report of the Ministère du Plan gives more details on the Projet Micro-Réalisations (Min. du Plan, 1988). Also Peace Corps is active in this particular field.

1.5.2 Soil and water conservation programs

The results of these programs are not really known. Most programs are too recent. In addition, it is also very difficult to measure the effects of these kind of activities. The programs are of a varying scale and the approach towards community participation varies greatly. Women generally are not a specific target group and little attention is paid to specific implications for women.

It is clear that the introduction of these activities is a slow process. The labor intensity of the activities seems to be a major constraint, especially for communities who have a high seasonal out-migration.

1.6 PERSPECTIVES FOR THE FUTURE

The importance of developing water harvesting in Mali was recognized by most people interviewed. Their arguments, however were often not so much for the potential of these sources, as much as the limitations of other water strategies:

- The national drinkwater policy aims to provide each 250 people with a borehole and pump. Despite enormous investments, only 21% of the population has access to a borehole (Pallas 1985:9). From a total cost point of view, surface water has the most potential (the cost of a bore hole is so much more than a dam). In addition, communities need from a security point of view, complementary water sources (even if not secured the whole year around). Too often small communities become dependant on one borehole/pump, a water source they can not maintain or finance.

- The intensive mining of ground water resources leads to a justification of surface water exploitation (compare RIM:80)

- Water harvesting might recharge the groundwater table. No systematic research on this subject has been done in Mali. The UNDP project has submitted a research proposal.

A negative aspect of the exploitation of surface water sources is the quality of the water and the possible effects on health. Some pointed out in this context, that boreholes are no guarantee for the consumption of clean water (Compare Condé, 1989:33). The need of hygiene education for the use of water in general was emphasized by all.

About the perspectives of rain water harvesting in Mali from a geographical point the following information was found.

- An assessment has been made by the UNDP project, "Exploitation, Evaluation and Management of Water Resources in Mali". On the basis of the TAMS/US Aid document, Mali Land and Water Resources (1983), it is concluded that all regions, except the Gao region, have depression areas in alluvial plains and river valleys, which offer possibilities for further exploitation (Marion 1988 :28). Map 1. and Annex C. give more details.

- For rain water harvesting techniques to increase on-field agricultural production, the 400-800 mm rainfall zone would have be a priority (see Map 2.). The need for increasing infiltration in the soil is much higher in this area, while in the areas with, say more than 800 mm, farmers are more occupied with diminishing the erosive force of run-off water by evacuating it away from the fields. The Case Studies illustrate this.

- Collection of water from rooftops. Most interviewed people do not see any potential for developing this technique, because the rainy season is only four months and due to the required investments in systems investments would be difficult to recuperate.

1.7 CONCLUSIONS AND RECOMMENDATIONS

Rainwater harvesting for domestic water supply, watering livestock and plant production has always been important in Mali. Recent drought problems rainwater harvesting have made these techniques even more relevant. The Malian government is strongly supportive of initiatives in this field.

Most perspectives seem to offer:

a- the introduction of techniques for increasing the production of plants (crops, trees and fodder) by soil and water conservation programs and

b- the introduction of techniques to increase the productivity of natural depression areas (water for rice cultivation, gardening, livestock, fishing) by "aménagement de bas-fonds" programs.

The perspectives for developing rainwater collection from rooftops seem to be slim, because most houses have banco roofs and the rainfall is unfavourable for this technique.

The banco pits, which are found in practically all villages, and which collect run-off, might have some potential.

A study is recommended on the possibilities for cleaning up and exploiting the banco pits. The bourogara concept needs further study to know their relevance in this respect.

ad a. Soil and water conservation programs

The Northern part of the country (400-800 rainfall zone in particular) can benefit most from these agricultural techniques. These areas in general have a very high seasonal migration and labor shortage is one of the major constraints for applying these techniques.

- The traditional techniques and experiences of farmers, like they were found in the Duentza Cercle, should be used to learn from.
- Innovative techniques must be as efficient as possible in terms of labor input. Measures which are small scale, manageable at individual (family) level and higher up in the watershed are probably most effective.

ad b. Aménagement de bas-fonds programs

Most "aménagement de bas-fonds" programs are limited to the construction of dams. The dams are technically seldom effective and economically inefficient. Replicability is low. In addition the existing dams are not rooted in the community social structure. It is recommended to develop and/or support programs having the following characteristics:

- selection of sites, where low cost and small scale and simple technologies can be applied. Technologies must be managed and maintained by the villagers.
- the program must have a component for a. identification of needs of different user groups, b. selection of objectives in relation to geographical and ecological possibilities, villagers priorities and c. market studies for products (especially vegetables).
- the program must have village level components for planning and management of the resources (land and water).
- the communities take total or partial responsibility for the financing of building costs, especially in higher income areas. All labor should be contributed for free by the villagers.
- financing of technical expertise is justifiable, but preferably only in pilot phase.

Women are sometimes the major beneficiaries of rainwater harvesting activities (especially in gardening and rice cultivation), but generally do not participate in decision making, planning and construction. The effects of these interventions can also be negative for women. In certain cases women have lost the land, they used for cultivation of rice or millet. It is not unusual in Mali that as land becomes more productive and/or new production technologies are introduced men take over. Therefore it is recommended that:

- the active participation (meaning not necessarily work) of women in all stages of the program (needs identification,

defining objectives, planning, execution and training is encouraged and

- the positive as well as negative effects of the rain water harvesting activities on the socio-economic position of women are systematically monitored.

2. CASE STUDY 1. RAINWATER HARVESTING PRACTICES IN JANVELI MAOUNDE VILLAGE

Arrondissement Centrale, Cercle of Duentza, Mopti Region, Mali

2.1 INTRODUCTION

In the Cercle of Duentza, traditional rainwater harvesting techniques are widely applied by the Dogon, Rimaebe (sedentary Fulani) and Sonrai. The Janveli Maounde village was chosen as a case study site, because this Dogon village is experimenting with an innovative rainwater harvesting technique: "digues filtrantes". This activity has been recently introduced in the framework of a Soil and Water Conservation Program of a non-governmental organization, the Near East Foundation (NEF). The objective of the digues filtrantes (permeable rock barriers) is to slow down the erosive force of run-off water, to enhance infiltration of water on the fields and to improve soil fertility through sedimentation.

Between 1987 and 1989 three large digues filtrantes and some subsidiary smaller diguettes were built in the valley of Janveli Maounde. For 1990 no other project activities are planned as yet in this village. However, when villagers express an interest, the project will be available to help them.

The NEF project started in the Duentza Cercle in 1986 and is longterm (undefined, but at least 5 years). The project team consists of two expatriate social scientists and 12 extension agents recruited by the project. The goal is to hand the project over to a Malian NGO structure after another 2-3 years. The project has three programs: a. soil conservation, b. forestry and c. credit (cereal banks and seed banks). Funding is received from NEF, Band Aid and Oxfam UK. The project works under the official auspices of the Centre d'Action Coopérative (CAC), but in practice the project functions independently. The nature of the program is experimental.

The Duentza Cercle is located in the 400-500 mm. rainfall zone and has a Sahelian climate. The landscape is diversified: sand stone and laterite outcroppings (mountains), sand plains, flood plains and a tiger bush vegetation configuration. Since the drought period, people have settled increasingly in the lower, more humid areas. Large numbers of Dogon migrated here from the mountains. The population pressure is strong in these agriculturally productive areas. The economy is based on three elements: agriculture (mainly subsistence), livestock raising and labor migration to neighboring countries and southern regions in Mali. Since the seventies, food shortages have occurred regularly and the area received food aid during several years (Hesse 1987:45).

Map 3. Duentza Cercle with case study village

Source: Hesse C. and Thera, S., 1987:51

Water resources are limited in the Duentza Cercle . Access to groundwater is difficult. Wells are deep (40-75 meters) and drawing of water is an arduous task for women. Artesian springs are found in some of the mountain villages. In 1988, 7 % of the population had access to a borehole (Rapport sur l'Approvisionnement 1988:47b). Many of these boreholes however, cannot be used because they are not equipped with a pump or are out of order (Hesse 1987:24). During the rainy season (July to October-November) ponds, lakes and streams are used for all domestic uses. Waterborne diseases, like dysentery and guinea worm are very widespread in the area and of medical concern. Health workers believed that even boreholes do not guaranty a source of clean water. Water is often contaminated when it is finally consumed, given the long periods taken for acquisition, transport, and storage.

2.2 RAINWATER HARVESTING TECHNIQUES

2.2.1 Agricultural techniques

- earth bunds of varying size according to slope and soil qualities, "bondés". (Photo 21). The size of these micro-catchments varies from 1 m^2 to 100 m^2 according to slopes. The shape can be regular square or irregular following the slope.

- permeable bunds (rocks, bundled stalks and/or branches) of varying length and orientation, also called "bondés". Sometimes in squares, sometimes in parallel lines. The dimensions vary greatly. This technique does not concentrate run-off, but enhances infiltration.

- water collection pockets of ca. 30-40 cm diameter and ca. 10 cm depth (Photo 28 and 29). This is especially practiced on degraded soils and observed only in the plains. Holes are dug, in which manure is mixed and a few seeds are sewn. This technique seems similar to the "zay" technique in Burkina Faso as described by Reij (Reij e.a.1988:44).

NEF project personnel as well as interviewed farmers confirm that these techniques increase infiltration of rainwater on fields, diminish soil erosion and promote sedimentation. These techniques are traditional, use locally available materials and tools, and are labor intensive. Farmers carefully plan these activities for their different fields. Especially the pocket technique is labor intensive and is therefore practiced to a limited extent. The use of rocks was said to be most popular, but rocks are not available near all fields.

These techniques require a substantial investment of labor and continuous maintenance. Farmers explained that earth bunds are a yearly activity, constructed after sowing. Rock bunds can be prepared during the off season. Water pockets have to be maintained or partly reconstructed annually. Labor availability seems the major constraint for farmers to apply these technique on their fields, especially given high temporary migration. In rare cases hired labor is used.

2.2.2 Multipurpose techniques

- "bourogara's: artificial surface reservoirs (banco-pits). Their dimensions are variable, ± 20-40 meters diameter and 4-10 meters depth (Photo 22-27).

Janveli Maounde has 7 bourogara's. Some collect run-off from the mountains (Photo 26). Others collect run-off from the village (Photo 27) and thus may have a drainage function as well. All have their origin as a banco-pit. Over a period of years, the water storage capacity was enlarged and the reservoirs developed into an important temporary water source (ca. 6 months per year) for watering animals, gardening, laundry and bathing. The water is little used for drinking and cooking, because women are said to consider the water dirty and not good tasting. There are two wells in the village used for this purpose. The reservoirs are located in the middle of the village and are thus easily accessible.

While banco-pits are probably found in every village in Mali, the use of these pits varies greatly depending on water scarcity and local traditions or needs. The level of organization and regulation for these pits and the implications for management are some what unique for the Malian context. This

system was said to be specific for Dogon villages on the plain in the Cercle of Duentza.

The regulations for water use are, that villagers can take water out freely, but they are not allowed to bath or do their laundry in it etc. The use of soap is strictly forbidden. Observation showed that some of the reservoirs are kept in better shape than others. It seemed that the older ones in the middle of the village were best maintained. The older ones are all reinforced with rocks and have a nice round shape. They are kept covered with water plants (scientific name unknown). Villagers expressed that the purpose of the plants was protection of the water against dust/dirt, but this may also slow evaporation and is said to purify the water. Elsewhere in Mali water plants were also found to be used for this purpose (Condé e.a.1989:63). No information existed on the quality of the water in the bouragara's from a biological or chemical point of view.

- Natural depressions collecting run-off from small watersheds.

Lakes and ponds are used for watering animals, drinking and bathing by farmers working on their fields, which are too far away from the village to return each day. Some of these surface catchments have plenty of mudfish, which pass the dry season in hibernation in the mud layer. Access to water in these depressions is extended by the installation of "Puisards" (holes).

2.2.3 Digues filtrantes

The major technical difference between the traditional rock bunds and the digues filtrantes is, that the new system has an imbedded foundation and is of larger scale (NEF 1988:8).

A digue filtrante does not arrest the flow of run-off, but checks it sufficiently to enhance infiltration and sedimentation, and to reduce the erosive force (NEF 1988:2).

The villagers constructed three large digues filtrantes and a system of subsidiary diguettes (see photos 18-20). The first and largest barrier is 90 meters long, 2 meters high and 5 meters wide. To protect this large structure and to experiment with lighter and less costly structures, two smaller barriers were built upstream. They are ca. 50 meters long, 70 cm high and 4.50 meter wide. The subsidiary diguettes are about 30 cm. high and are built like wings at the end of the barriers. The first barrier was built in a ca 30 meter wide ravine, the other two were made in an upstream part of the valley without gullies yet.

Local materials (rocks from the nearby mountains) were used for the construction. The project provided three donkey carts and a truck for the transport of rocks. The villagers used their own tools and the project provided pickaxes and hammers.

Sketches of diques filtrantes

Source: NEF 1988 and 1989

The construction of the barriers was a collective village activity and took place in three subsequent years during a couple of weeks in the dry season. On average 40-50 people would have been on the building site. No exact information was available. The labor needed was essentially unskilled. The NEF technical advise was required for major decisions like barrier placement, how many and of which dimensions. The villagers built the barriers independently with the project team visiting the sites once a week for monitoring.

According to project personnel the maintenance of the barriers does not require much skill, but should be maintained each year before the rainy season starts. At the beginning of the 1989 rainy season a heavy rainstorm washed away the largest barrier (see photo 18.). NEF staff were undecided as to the reason for the washout, but lack of maintenance on the part of the village was suggested.

2.3 SOCIAL ASPECTS

Janveli Maounde is a large village with about 1200 inhabitants. They belong predominately to the Dogon ethnic group and are called "Dogon Kombejum", because they have always lived on the plains and never in the mountains (to be differentiated from the Dogon who traditionally lived in the nearby cliffs).

Staple crops are millet and sorghum. Land is generally cultivated with the hoe and very few households use a plow. There is a shortage of cultivable land and soils are increasingly degraded. Gullies and ravines cut the fields. The agricultural productivity is low and yields fluctuate strongly according the amount of rainfall. For example, 1987 was a bad year, but 1988 was a relatively good year. The rainy season of 1989 was not very good (especially the distribution of the rains). At the time of the study crops had almost matured, but unfortunately grasshoppers and other insects were causing severe damage.

Janveli Mounde has a primary school (6 grades), a health post, a weekly market and a mosque.

The water supply is perceived as a problem, although not as an urgent problem. There are only two wells, but both give water the whole year round. The best well was constructed with the assistance of CARE International in 1979 and is ca. 40 meters deep. Saudi Arabia financed in 1986 the drilling of a borehole and the installation of a pump, but these are not used anymore since the pump broke down in 1988. No plans exist to get the pump repaired. Women said that at the end of the dry season the drawing of water gets very time consuming and waiting lines are long. Some of the neighboring villages are even worse off. Women from these villages come at the end of the dry season to Janveli to get water, because their own sources are totally depleted.

Following the Dogon tradition, the village chief and spiritual leader of Janveli Maounde (the "Ogon") is the oldest man of the village. The actual Ogon is so old, that he is represented by a son, but he is still making major decisions, assisted by advisers. The national political party (UDPM) has committees for the youth (UNJM) and for the women (UNFM), but these were said do not to be very active.

Women do not participate in village meetings and are generally not involved in village affairs. They form savings groups to finance ceremonies and working groups for sheabutter production ("tons"). These groups have a mutual aid function.

The various water harvesting techniques are organized at different levels:

- agricultural techniques at family level
Every family applies these techniques on its own land. Since land preparation is considered the task of men, these activities are primarily their domain. Women were not found to participate in these activities. Women who have their own fields are dependant on male family members to apply these techniques or must hire labor. This year only one woman had her field done with water pockets. She paid somebody to do the work.

- bourogara's at section-level
The village is divided into three sections and each of the seven bourogara's is owned and managed by a specific section. The section Chief mobilizes a few times a year young men form his section to clean and maintain the reservoirs.

- digues filtrantes up to now at village level
So far the NEF project activities have been the responsibility of the village authorities and collective labor was used. All men had to contribute labor, despite the fact that only some of them use land benefited by the barriers. The NEF team is looking for ways now to organize the activities more at family (or group of families) level to increase villagers participation through a better distribution of benefits.

2.4 THE DIGUES FILTRANTES PROGRAM

The Near East Foundation is based in New York and was founded in 1930 with the objective of institutional support for the Middle East. It received capital from the Near East Relief, which was founded in 1915 to assist the Armenian minority in Turkey. The NEF still has activities in the Middle East, but has extended itself to projects in several African countries. The NGO receives funding from various sources. Oxfam UK and Band Aid are major funders of the Duentza project.

Janveli Maounde was one of the first villages NEF started to work in. It was the NEF team who took the first initiative. The project visited the village, raised the subject of erosion, helped to identify and prioritize problems and find solutions.

NEF's role has been educational and organizational rather than executive. Most important elements have been:

- technical advise where to build the barriers and how

The choice of the site had immediate implications for who was going to benefit and therefore was a very strategic decision. In the end it was agreed to work in a single water-course shared by Janveli and two neighboring villages. Each village would take similar measures. (NEF 1988:8-9). There are also very important technical aspects to take into account, which are beyond the scope of this report.

Janveli Maounde, like other project-villages, preferred to build just one big dam where the ravine is deepest, instead of what the project promotes: a series of smaller dams higher up in the watershed. In the end a compromise was found by building first a large barrier and later smaller ones.

The NEF team made the technical design for the construction and visited the building sites regularly for monitoring.

- material support

The NEF lend several donkey carts and some tools, and provided transport by truck.

The NEF team has recently started organizing inter-village meetings between villagers who have experience with the program, and those villagers who do not have experience. These meetings last several days. Sites are visited, experiences and ideas exchanged, and appropriate techniques discussed. The intention is that villages themselves will take initiative to make requests and proposals for technical advice and material support. The villagers having experience with these activities are seen as local 'experts'.(Compare NEF 1988:16-7 and 1989:6).

The NEF programme, despite the widespread practice of soil conservation programmes in the drier parts of Mali, is opposed to giving "food for work" or other incentives. However, this is a relevant point of discussion, given labor migration is at times stimulated by food shortages. Shortage of labor resulting from labor migration is a serious constraint for the execution of soil and water conservation activities.

The programme has no specific target groups in the Janveli Maounde community. The team followed the traditional structures and dealt mostly with village authorities. No efforts have been made to actively include women in decision making, execution of activities or diffusion of information.

2.5 ECONOMIC ASPECTS

Traditional water harvesting techniques

The agricultural techniques require high labor investment for construction as well as maintenance. In addition a large part of these activities are executed in the beginning of the

growing season, when labor is most scarce and valuable. Only farmers who find their investment justifiable in terms of increased yields will undertake these activities over time. Villagers explained, that the most labor intensive technique, the water collection pockets, was performed by those farmers who have little land and/or by farmers whose land is very degraded.

The banco-pits, "bourogara's", are efficient from an economic point of view. The construction is done over the years, when banco is extracted for the building of houses. The maintenance (cleaning and reinforcement of sides) requires two days of collective work a year during the off season. The crucial element here seems to be organization. These pits have become the object of a high level of social organization, because their value is appreciated.

Digues filtrantes

The total budget of the NEF Project for 1989 was $156,250 US. This did not include the expatriates' salaries, nor the amortization costs of the truck. The truck was a gift from Band Aid for a food aid programme in 1988. The 1989 budget of the Soil Conservation Programme was $18,750 and was paid by Band Aid. It included 3 months running and maintenance costs of the truck, training costs, but no administration costs.

Labor for construction and maintenance is the major cost. The costs of the individual rock barriers varied and were not systematically specified in project documentation. The distance of raw materials from the building site and the dimensions of the dam define for a large part the labor and transport needs.

For example the major costs for the construction of the third dam (50 m. long, 0.70 m high and 4.50 m. wide) were:

- 480 man days and
- 2 days of truck transport

The project valued a villager's work day at 500 CFA and one truck day at 10.000 CFA, which make the costs 260.000 CFA or $812.50. (NEF 1989:4,10). The value of 500 CFA for a working day is probably too high for off season labor, while the real costs of the truck are higher if the amortisation costs would have been included. Not calculated are the costs of tools, donkey carts and project personnel.

A condition for the village to borrow tools and donkeycarts from the NEF was the formation of a committee of 3-4 villagers who would be responsible for repairs.

It is more meaningful to look at the costs per benefited area (in terms of improved yields) than comparing costs of individual barriers. The real benefits however, are difficult to measure and in the case of Janveli Maounde not known. The NEF's experience is that smaller barriers (higher up in the watershed) benefit larger areas than bigger barriers (in deep ravines), and so are more efficient in terms investment (NEF 1989:5).

2.6 ACHIEVEMENTS OF THE VARIOUS TECHNIQUES

Traditional techniques

No information is available on the number of families practicing agricultural techniques for water harvesting and over what area. It is clearly done on a minority of fields. Farmers interviewed were convinced of the positive impact on their yields, but were said to have been hampered by lack of time and labor. The water collection pocket technique is probably least practiced, but is considered as having the most potential for increasing production. Research in Burkina shows that this technique ("Zai") increased yields spectacularly. The yield was doubled in a test area (Reij e.a.1988:44).

The seven "bourogara" ponds provide an easily accessible complementary water source during about 6 months a year (July to January). Everybody can use this water for domestic and productive activities. It is possible that richer families, for example civil servants, do not use these ponds much, but prefer to use cleaner water from the wells. They have servants to draw the water up. As was mentioned above, water borne diseases from the bourogaras were a concern of local health workers.

Digues filtrantes

A total of three large digues filtrantes and some smaller diguettes have been built over a period of three years. In June of this year the first rains swept away the large barrier (Photo 18). At the time of the case study the village had not yet decided how to solve this problem.

Farmers pointed out that the millet and the trees on these fields were greener above the last barrier than below. Organic material which otherwise probably would have been carried away by run-off was visibly retained by the dams. The ravine was said to have continued to advance below the dam, but its rate had slowed down.

Like most soil and water conservation programmes the impact of the rock barriers on the erosion process in the valley and on the productivity of the land has not been systematically monitored (Compare Reij e.a. 1988:74). After the first barrier was built, project personnel and villagers noticed a positive effect on sedimentation and water retention on the fields immediately upstream. This motivated the villagers to continue (NEF 1988:4).

Village authorities said that five families profit directly and maybe another fifteen families indirectly, which is about 20% of the population.

2.7 CONCLUSIONS

Women

Women did not participate in the application of the traditional techniques nor in the digues filtrantes program. The planning and execution of the activities, and the management of the systems are almost exclusively a males' domain. Women, however, can be the (indirect) beneficiaries. The bouragara's offer women a convenient complementary water source. The agricultural techniques are usually applied on men's fields only. Since men are responsible for the family's staple crop, women can benefit from an increased yield.

Traditional techniques

People were enthusiastic about the agriculture techniques for water harvesting and soil conservation. The Dogon have been applying these techniques since generations. Recently, the lack of time and labor is a major constraint for applying these techniques on a larger scale due to migration. The value of labor outside the village is higher and cash money is used for payment of taxes and other costs. There is a vicious circle of lack of labor causing less labor input in agriculture, causing declining yields, causing migration (compare Hesse 1987:62).

These water harvesting techniques may not be directly replicable on a large scale in Mali. In other parts of Mali, the strategy for dealing with unfavorable climatic conditions and degrading soils tends towards more capital intensive methods: investment in oxen and plow to use larger surfaces. In Southern Mali where rainfall exceeds 800 mm, tendencies in agriculture are towards increasing capital inputs (CMDT: fertilizers, improved seeds etc.) to increase productivity rather than increasing labor inputs.

The bouragara is also a system which is well adapted to the Dogon context: well organized people, concentrated settlement pattern and scarcity of water for domestic supply and production. Almost every village in Mali has a number of these banco pits, but these are often dumps for garbage and are filled with dirty stagnant water. In addition, many villages have problems with drainage of water during the rainy season. A Canadian project in the Circle of Ségou is exploring possibilities to combine improved sanitation and income generation (water for gardening) around these pits. In this context, the bouragara concept might be interesting to look at.

Digues filtrantes

Villagers interviewed had a positive opinion about the (potential) benefits of the rock barriers. Their major contribution was always mentioned as the increase of humidity on the fields. Some considered it as a disadvantage that only a minority could benefit while many more villagers have similar

problems. Some pointed out that everybody had to contribute to the construction, while only a few received benefits. The destruction of the large barrier during last rainy season was disappointing to the villagers, having seen all their hard labor washed down the gully. No concrete plans existed yet for rebuilding the dam.

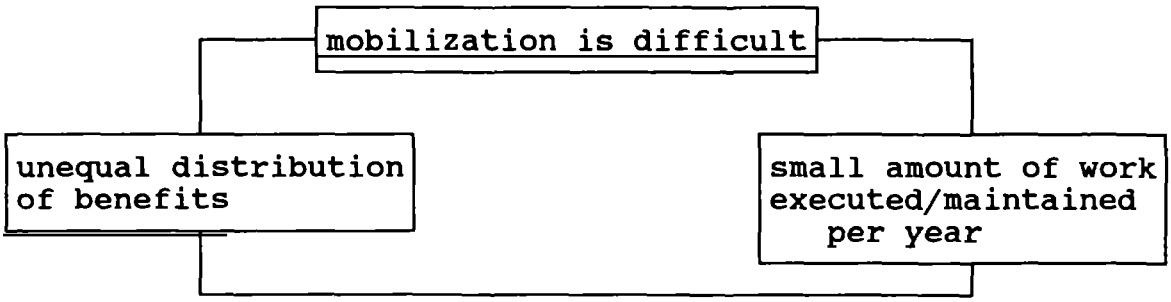
The major problems of digues filtrantes in Janveli Maounde and also in other villages are cited by NEF as:

- labor shortage

The digue filtrante is very labor intensive. Villagers have to undertake these kinds of activities during off season. In that period many young men are absent. This is a serious constraint on the amount of work that can be undertaken by a community or individual families. Some villages decide for this reason not to participate in the programme (NEF 1988:12).

- the mobilization of villagers for collective construction and maintenance

It is difficult to mobilize the community as a whole, especially if the work takes a long time and a minority of the family benefits. There seems to be a vicious circle:



NEF 1989:11-12

The NEF team looks for ways to organize work in such a way that the minimum is done at collective level, but as much as possible on group or individual level. Reij has come to a similar conclusion and states that farmers often seem to favor an individual (family) approach rather than a collective approach (Reij e.a. 1988:78).

- technical problems partly related to the scale of the intervention

In Janveli Maounde, but also in other project villages, the villagers preferred to build one large barrier where the ravine was deepest and the problems most manifest, hoping to see greater benefits. Project personnel tried to convince villagers to build smaller dams at places where the erosive force of the water would be less. The programme will try to promote smaller structures.

The NEF programme is a young programme and the basic method is of trial and error. So far the programme concentrated on one technique, the rock barriers. For more effective fighting of degradation and increasing of water infiltration a larger package of activities will have to be developed, better responding to local social and physical conditions. The project plans to develop a larger technical package of soil and water conservation activities with mechanical as well as biological measures (compare NEF 1988:15). The inclusion of trees and grass cover has been neglected by this project.

Some lessons learned:

* the Dogon agricultural rainwater harvesting techniques are not directly replicable elsewhere in Mali, but they can be used to learn from and to develop techniques which are more efficient in terms of labor input.

* some aspects of the bourogara system could be relevant for projects involved in sanitation and income generation. The system can only become a supplementary water source, not serving needed water throughout the year.

* soil and water conservation measures, which are small scale higher up in the watershed and manageable on individual (family) or group level are less complicated (socially and technically), are probably more effective and have more lasting results.

* attention should be paid to the participation of women in water harvesting activities for household water use and gardening. Attention should also be paid to the positive and negative impacts of these activities on the socio-economic position of women.

3. CASE STUDY 2. THE MICRO BARRAGE OF NTOSSONI VILLAGE

Arrondissement of Mpessoba, Cercle of Koutiala, Sikasso Region

3.1 INTRODUCTION

This case study concerns the construction of a small scale dam ("micro-barrage") in the village of Ntossoni in the cotton producing zone of southern Mali.

The major objectives for retaining water were:

- watering livestock
- gardening and
- rice cultivation.

The dam was built in a temporary stream (marigot) 4 km outside the village and created a basin holding water up to 8 months per year. Before the dam was built, the stream depression held water during 4 months a year.

The dam is officially a village initiative, but no doubt outsiders have had a strong impact. As a result of the national policy of increasing food self sufficiency and fighting the process of desertification the Malian Government encourages "aménagement de bas fonds" programs (increasing productivity for natural depression areas). In the Cercle of Koutiala for example almost 20 dams were built since 1984 and others are foreseen in the near future. See Annex D. for a map of the Cercle of Koutiala with barrages.

The first dam in Ntossoni was built in 1986 with the assistance of the Catholic Mission. The first rains washed it away and a year later, a larger dam was built with technical and financial help from the CMDT (Compagnie Malienne pour le Développement des Textiles) Anti-Erosion Project (PLAE) in Koutiala (Royal Institute of the Tropics, Netherlands) and the Local Development Committee (local administration). An experimental model was chosen with a below ground foundation made out of local materials and reinforced with cement. The dam did not totally withstand the rains and needed repair in 1987 and 1988. The PLAE offered again financial assistance, but their involvement seems now definitely ended. The dam resisted the rainy season of 1989.

The study area receives an average rainfall of 800-900 mm (see Map 1.). Since 1972 precipitation has been on average 100 mm less, so between 700-800 mm (van Campen e.a.1988:4). The rainy season lasts from May to October. The rains are often very intense and occur irregularly over space and time.

The landscape is characterized by a savanna forest on the slopes and planes with fields under permanent cultivation in the lower parts. The CMDT zone is economically prosperous and finds itself on the richest ferruginous soils in Mali. The groundwater table is not very deep (in Ntossoni 9-13 meters for example).

The Cercle of Koutiala has a high density of boreholes relative to population, compared to the Cercle of Duentza for example. Respectively, 20% of the Koutiala population as opposed to 7% of the Douentza population have access to a borehole (Rapport sur l'Approvisionnement en Eau en Milieu Rural 1988:47b).

Map 4. Koutiala Cercle with Case Study Village

Source: van Campen e.a.1988:32.

3.2 RAINWATER HARVESTING TECHNIQUES

3.2.1 Traditional techniques

Ntossoni's experience with water harvesting is limited to the use of run-off water collected in natural depressions (ponds and streams) for watering of livestock, rice cultivation, banco extraction and some vegetable growing. Traditionally, no special arrangements are made for improving the collection and/or water storage capacity. Gaining access to water after the surface water has dried up, villagers dig holes ("puisards") in the depression. These are generally used for watering of livestock and to a minor extent for irrigation of vegetable gardens. Annually, there might be about 50 of these wells in this village

territory. They have to be dug out each year. The use is also labor intensive.

No traditional agricultural techniques are used to enhance infiltration of rainwater and run-off water in the soil. Some farmers, however, protect their fields with earth and rock structures against excess rain water run-off. The activities of the Anti-Erosion Project (PLAE) in Ntossoni are also primarily focused on diminishing the erosive force of run-off water, rather than increasing the water-use efficiency associated with rain water harvesting. For this purpose kilometers of rock bunds and live fences are built on the fields and on the sloped grazing areas higher up. The explanation of project personnel and farmers is that in this rainfall zone, major problems are the excess of water during and immediately after the rains and its damaging effect. Bunds are made to divert water away from the fields.

No rainwater harvesting practices are used for improving the access to drinking water. The wells and boreholes guarantee a sufficient supply of drinking water. Collection of water from the roof is non existent. Almost all houses have a banco roof, which makes drinking water collection difficult.

3.2.2 The Ntossoni dam

Dam for the collection and storage of water is a new concept for Ntossoni. The chosen model is experimental. It is a submerged foundation dam, with a water force dissipation basin, made out of local materials and reinforced with cement and gabions. This model was developed on the basis of a study of other dams in the area and on the experiences with the previous dam (no foundation or dissipation basin and made out of earth). The alternative could have been a much more expensive dam constructed out of concrete blocks. This has been the first model of this kind in the Cercle of Koutiala (see construction plan).

Most construction materials were found locally: boulders, gravel, termite mounds ("termitière noire") laterite, sand and clay. In addition some externally manufactured components were used: bags of cement and wiring to fabricate gabions. See for quantities of material Annex E.

The barrage has the following dimensions:

-	length of dam foundation	:	130.00 m
-	length of the dam above ground	:	80.00 m
-	width of the top of the dam	:	1.50 m
-	maximum depth of the basin	:	2.50 m
-	volume of the basin (peak period)	:	± 80.000.00 m3
-	volume of the dam	:	± 800.00 m3
-	Maximum charge (calculated as maximum probable flood in ten years)	:	1.0-1.5 m/s

Construction Plan of Ntossoni dam

Source: Hassing 1988

Some of the tools, hoes particularly, came from the village, other tools, wheelbarrows, pickaxes, shovels, earth compactors, handless were manufactured elsewhere in Mali. All tools were hand tools. For transport, village donkey carts and a donated truck were used.

Most work (collection, transport and placing of the local materials) was done by unskilled labor. Skilled labor was needed for the masonry that were available in the village. For the design of the dam and the implementation of the plan, a Dutch technician was contracted. He was present during the whole period of construction (about two months). Several CMDT agents have been responsible for the supervision of the work.

The life of the dam is estimated at ten years, which represents the probability of a rainfall exceeding approximately 80 - 100 mm of precipitation in 24 hours, above which the dam would be severely damaged or washed away (Hassing 1988:iii,25).

The technical report states that the dam needs yearly or biannual maintenance, especially the dam top and the basin side of the dam (Hassing 1988:iv). It was not foreseen that the basin would have to be emptied regularly because of sedimentation, which is a problem.

3.3 SOCIAL ASPECTS

Ntossoni is a large and well organized Mianka village 60 km North East of the town of Koutiala. There are 2600 inhabitants with 220 male headed production units ("exploitation" in CMDT terminology). Cash crops (cotton and some peanuts) as well as staple crops (millet, maize and sorghum) are cultivated in rotation. The village territory, mainly permanent fields and pastures, is increasingly degraded and erosion is severe.

The village is considered to be rather rich, but income levels vary. One of the indicators of wealth is the number of heads of cattle. The number of work animals effects directly the surface the households can cultivate, implying peak period labor scarcity. Animal husbandry is a common form of investment, since banking institutions do not offer better alternatives. According to interviews the poorest 10-20% of households have no cattle at all and the richest 10% own 50-100 heads. Several rich outsiders also own cattle pastured on the village territory.

The village has a primary school (6 grades), medical and maternity clinic, pharmacy, veterinarian post, a weekly market and a mosque. Most of these community facilities are built and financed by the village itself.

Ntossoni promoted in 1983 their "Association Villageois" to a "Ton Villageois" (the later having political recognition, whereas the former being traditional). This is a political title and means that the village has proven to be organized around common goals for development and has taken charge of the practical organization of cash crop production and

commercialization. Under the supervision of the CMDT, village technical committees with literate and trained villagers are managing credit funds, inputs, and weighing of produced cotton etc. The village is divided in three sections ("marchées"), which each have their own committees.

Because the traditional village chief is also the vice-president of the Ton, it is not always possible to distinguish between the Ton and other activities not included in the ton. In addition the village has political committees, representing the national political party, the Union Démocratique du Peuple du Mali (UDPM), and the sub-parties, UNJM for the youth and UNFM for the women.

For the provision of drinking water and domestic supply the village has:
- ca. 300 wells in the village (most of them holding water the whole year round)
- 2 boreholes equipped with India-Mali pumps, built in 1987 and 1988 with the help of the CMDT (water of good quality the whole year round).
- water from ponds, lakes, streams. This water is used only by herders and during the monsoon season, when villagers work on fields far away from the village.

For livestock watering the village has:
- surface water in ponds, lakes and streams (from July-November)
- some 50 shallow wells ("puisards") outside the village in the depression areas (after the ponds etc. have dried up until the next rains in normal years)
- water in the basin behind the dam

For agriculture and gardening the village has:
- temporary ponds and intermittent streams for rice growing
- the dam for gardening

There is no specialized institution for water matters. The wells are individually owned, while the boreholes and the dam are communal facilities and are the responsibility of the Ton and the Village Chief. It was the Ton who took the initiative for the construction of the dam, who arranged external assistance and who mobilized the labor. The Ton is also responsible for repairs and maintenance.

Promoted by the CMDT, women have their own associations related to the "marchées" mentioned above. The women of each section have a communal field and a pair of oxen. As a group they have access to credit and other CMDT programme benefits. The women have representatives in the Ton Villageois, but the Women's President reported that she did not have hade much influence on the discussions about the dam and that she is not aware of financial aspects.

The availability of water for human and animal consumption is not perceived as a problem. According to interviewed women, the second borehole (1988) has improved the drinking water situation sufficiently. In the past, water shortage occurred

which manifested itself in long waiting lines at a small number of water points. It seems that there was never an absolute lack of water for animals, but the "puisards" had to be continually made deeper and drawing of water for animals became time consuming. The dam did not solve the problem of water shortage at the end of the dry season (March-June), however. The quality of the water supply seems never to have been a concern for the villagers. Off-season employment and increasing incomes probably has the highest priority among the population at this moment.

The construction of the dam was a collective effort. Probably all households participated, but not each household to the same extent. No reliable information exists. Probably an average of 100-200 men per day worked on the building site during about 8 weeks. The youth did most work. Women did not participate in the building of the dam, but they prepared and delivered food.

The actual dam was built in the months february - april by men from Ntossoni and from two neighboring villages, Zantona and Diéla, which "own" land in the area profiting from the dam. In principle, each production unit provided a young man ("petit frère") and an adult ("grand frère") about twice a week. The young men had to do most construction work, while the older men were responsible for the transport of construction material. A third group were the black smiths (a caste) who were responsible for the demolition of the previous dam and the maintenance of tools and equipment. A fourth group was formed by men from the neighboring villages who were also divided into young and adult men. (compare Hassing 1988:17).

During the planning of work, a disagreement surfaced between the villagers and PLAE/CMDT personnel about the organization of the work. The villagers wanted to work in 3 groups, one from each village-division (market), and found it most practical that the dam or work be divided into 3 equal parts. Project personnel believed this not to be possible for technical reasons and wanted to build the whole dam up from the bottom to the top. According to PLAE/CMDT, motivation has been a problem and was often difficult to get enough workers at the site. Officially the work was obligatory and without pay. There was a sanction (an extra day of work) for not turning up at the site. In practice the authorities were not always consequent in applying this rule. Villagers could send a replacement to the site at a daily salary of 250 CFA. The division of tasks and also the relatively large amounts of costly materials the community had to manage created social conflicts that resulted in splitting up the community.

3.4 PROJECT ORGANIZATION

The true initiative source for building the dam in Ntossoni was impossible to determine. The building of dams in Mali is politically promoted. Two state institutions (CMDT and the Local Development Committee), have strongly encouraged the building of the dam. The CMDT played an intermediary role to get funding (Catholic Mission, PLAE and the Local Development Committee). It

is possible that important cattle owners who keep their animals on the village territory, but live elsewhere (usually traders or civil servants) also have had some influence.

The CMDT is the host organization of the PLAE. The project promoted anti-erosion activities in Ntossoni even before the dam was built. Project personnel consider the building of this dam as an exceptional activity which took place near the margin of the project's program. Project personnel were not knowledgeable in this field. As such, a technical expert was brought in specifically for this task.

The Ton villageois (including the Village Chief) has been representing village population in discussions with the CMDT and the PLAE. It had clear objectives for the dam, its location and the organization of work. The villager's conception of the dam and its implementation was based on the experience of the previous dam. For example, the previous dam had been built in vertical parts for which different work groups had responsibility. Initially the village foresaw a solid dam of concrete blocks, which they believed necessary to withstand the potential erosive forces, but agreed to build a less expensive model out essentially local materials. The village contributed organized labor, transport (donkey carts), tool repair (smiths), masons and tools. The PLAE contributed an expatriate consultant, tools, transport, cement, metal caging for gabions, a driver and a technician. Supervisors and organizers were provided by the village, CMDT and PLAE.

The construction took place in about 8 weeks. From the PLAE or CMDT point of view there were no specific target groups in the community. No effort has been made to involve women in planning, decision making and/or execution of activities. While several organizations have been involved in the building of the dam, no assistance has been given related to the use of the water and the land around the basin. On a small scale, Peace Corps volunteers are promoting fruit tree planting in the gardens around the basin. At the time of the study no outside intervention of any kind in relation to the dam took place and none were planned.

3.5 ECONOMIC ASPECTS

The following overview of construction costs is given in the technical report on the Ntossoni dam (Hassing 1988:33-4).

Costs of the Ntossoni dam

	CFA	%
Materials, tools and transport	926.715	17.0
Technical assistance	2.090.000	38.4
Village contribution	2.424.800	44.6
Total	5.441.515	100.0

320 CFA = 1 US dollar Total costs dam = 17.008 US Dollar

- The technical assistance costs do not include the expert's salary (3 months). This would bring up the costs of the dam substantially, but may be considered as a necessary subsidy for the promotion/elaboration of a pilot activity.

- The village contribution may be overestimated. The labor is valued on 800 CFA. per day, while the real value of labor at the time of the building of the dam was only 250 CFA reflected in the cost of finding a replacement. Villagers could send replacements to work on the dam for 250 CFA. This labor price may be a better estimate of the real cost of labor. On the basis of this labor value the village contribution would have been only 23.9 % of the total costs. See Annex F.

- It is not clear if the Local Development Committee paid for part of the above costs or that their contribution was in addition, which affects the calculation of real costs.

- There was no specific training component nor socio-economic analyses. The administration costs have been low and were incorporated in total functioning costs of the PLAE.

Looking at the opportunity costs, the costs of alternative water supply for livestock could be expressed in labor needed for supplying water to the animals by digging of shallow wells and watering the livestock. It is not conclusive that the dam justifies its costs, especially given the fact that the dam is empty for a few months before the rains when water is the scarcest. In addition, herders loose time going to the dam in the valley from the grazing grounds on the plateau.

An indication of the villager's perceived value of the dam, the village has taken little responsibility for functioning and maintenance costs. The necessary repairs in 1987 and 1988 were partly paid by PLAE (bags of cement). During the study, village authorities were soliciting assistance for the excavation of basin sediment. The basin sedimentation is in fact an annual occurrence and should be included in any maintenance program. In addition, anti-erosion activities should be foreseen in the dam's water catchment area to diminish the flow of silt and sediment into the basin.

3.6 PROJECT ACHIEVEMENTS

Water for livestock (photo 35)

Livestock watering is the major objective of the dam. Indeed, the availability of surface water in this particular stream has been extended from 4 months to 8 months. But it did not succeed in providing water during the most critical period before the rains, March-June, and livestock still has to depend on the traditional water sources. Evaporation and infiltration are high (approximately 1 cm/day), and the basin silts up quickly.

In principle the majority of the village population can profit from this improvement, since most people own cattle. The CMDT is promoting one pair of oxen per production unit. The number of cattle owned per unit varies greatly. It is assumed that large cattle owners are the major beneficiaries.

The actual use of the basin for watering of animals has been limited. Villagers gave as the basin's drawbacks for the recent watering of livestock is that the basin is too far from the grazing grounds, that there was enough water available in other places and that the water in the basin is too cold during the winter months. The village chief pointed out that a concentration of cattle at the basin must be avoided because it will lead to degradation of the village territory.

Water for gardening (photo 31 and 33)

This has been the second objective of the dam. Indeed the number of people gardening has increased. At the moment of the study few people were gardening, but as the water recedes more gardens will be started in the basin. Last year about 20 men had requested a garden and all received one. They probably belong to the poorest households, since several of them do not own any cattle and no one owned more than 1-2 heads of cattle. The women as a group had a collective garden, but they did not get much out of it, because the water was finished before their vegetables had matured.

Although the traditional Land Chief (Chef du terre) is still in charge of the distribution of land in general, the allocation of land for gardening around the dammed basin has become the responsibility of the Village Chief. With respect to the dam, if the original user (always male) of land received from the Land Chief before the dam was built does not use all his land for gardening, the Village Chief can seasonally reallocate land to someone else (male or female) requesting a garden. However, the original user maintains the longterm usufructuary right.

One landowner was a real victim of the dam, since his banana and palm tree plantation was totally inundated (see picture 34). He was furious and refused to give permission for gardening on his land. In the end the village authorities obliged him to.

The development of gardening has several serious constraints which have not been foreseen by the project:

- lack of marketing possibilities for vegetables. The nearest town, Koutiala is already saturated. Gardeners expressed their worry about this.
- distance from the village. The dam is 4 km from the village. This is especially a problem for women, who can only work for short periods in the garden and have to bring their children. Women have refused a communal garden this year and no individual women have requested a plot.
- problem of distance between the water and the fields. Water has to be carried in calabashes. Some gardeners have

rudimentary canals and shallow wells ("puisards") for irrigation (photo 33). Peace Corps considers the introduction of treadle pumps.

- damage by livestock coming to the basin to drink. This creates conflicts between herders and gardeners. The gardeners did not find it worthwhile (yet) to invest time or money in fencing.

At the time of the study it was not yet clear how many people would start gardening. It was explained that this would partly depend on the needs of people related to their harvest this year. Gardening offers a potential source of food and income for poorer households.

Water for rice cultivation (photo 32)

Rice is traditionally cultivated in depressions and is an important women's activity. Originally, in the stream where the dam is built was used for rice cultivation. Women consider the distance not as a problem because for this activity they do not have to be often at their field. Rice is cultivated above and below the dam. It is not clear what the effect has been on the fields above the dam, but the women using land below the dam complained of a lack of water. The dam is not designed for rice growing. It is impermeable, there are no locks to let water through and there is no way that water levels can be regulated. The techniques used for rice growing are little developed and technical assistance is probably needed to increase the productivity.

Raising of the groundwater table

Several villagers and also officials, when asked about the benefits of the dam, mentioned the raising of the groundwater level in the village. Some people had the opinion that this had been the major objective of the dam. The level of the groundwater table (levels in wells and puisards) is said to have increased since the dam was built in 1986. Project personnel and officials wonder if this is a coincidence. The precipitation has been above average since the dam was built. Hassing states, that it is unlikely that the dam effects the wells in the village, because the level of the basin is lower than the bottom of the wells and the village is 4 km from the basin (Hassing 1988:19).

Fish culture

Fishing was said to have been practiced traditionally in the stream when it was still holding water permanently. So far the dam did not stimulate any fish culture yet.

3.7 CONCLUSIONS

Generalizing the people interviewed seemed slightly disappointed about the intended benefits from the dam. Several of them however, had the opinion that the dam is having a positive effect on the availability of water in the wells and the "puisards". As above this relationship is debated. The

benefits for livestock, gardening and rice growing have been smaller than expected. On the one hand the dam is only two years old and time may have been a constraint to the organization of certain activities, especially for gardening and fishing. On the other hand people had their own reasons for being pessimistic about the benefits they might derive.

The Ntossoni dam cannot serve competing objectives at the same time. For watering of cattle during the period just before the rains, maximum water retention is required. For rice growing below the dam, water level in the dam is regularly decreased to irrigate rice paddies. A decreasing water level in the dam exposes more land for gardening, but enough water should remain in the basin to permit the vegetables to mature. Also, gardeners are bothered by livestock damaging their gardens. The objectives of raising the water level in the village and storing water are competing.

Not only the Ntossoni dam is characterized by technical design problems and lack of maintenance, but most barrages built in the Koutiala Cercle had similar problems. A study DRSPR in 1988 showed that of 14 dams constructed since 1984, 5 were not able to retain any water, 4 were damaged but could still hold some water, 3 were in good state but were repaired and 2 needed no repair since construction (see Annex G.).

While cotton growing is an intensive form of production for which villagers are willing to make capital investments for a return in the short term, livestock keeping is an extensive form of production with the primary objective of gaining a return on investment in the long term. It must not be assumed that because villagers are willing to invest readily in cotton production that they will also invest in same way for cattle. Investments for cotton are to increase yield per unit area. Therefore, any investment that is capable of justifying itself through increased production, has a possibility of being undertaken. In general, the local criteria for investment in cattle is not the maximization of production per animal unit, but rather the proliferation of cattle head. It is not sure that capital to be invested in cattle would be invested in a dam as opposed to additional head of cattle. One might ask if this investment is what a villager would do with his own money.

The building of a dam has environmental implications. The major objective of the dam was water for livestock. According to the PLAE is the area under strong ecological pressure (erosion and degradation problems). There is a lack of fodder and pastures are degraded. It should be asked if by decreasing the water availability constraint for cattle, one does not encourage environmental degradation. Village authorities expressed their worry that a strong concentration of livestock in the area around the dam would lead to further erosion.

The "aménagement du bas fonds" program of Ntossoni was like the majority of such programs, focused on the construction of a dam. The plan for the dam was not based on a thorough analysis of the existing situation: land rights and land use patterns, livestock watering and grazing patterns, user's group needs,

women needs, market analysis, soils, etc. No organizational assistance was given concerning use of the new water source and land around the basin.

Some lessons learned from the Ntossoni experience are:

* The Ntossoni dam has competing objectives. The multiple objectives may have been used to justify the high cost of the dam and external financial support. Better elaboration of objectives.

* The major focus of the dam was its construction. Little attention was paid to the management of the resource or the social organization necessary for its efficient exploitation.

* The social and technical complexity of the dam is an important factor that should have been taken into account during the conception and planning of the activity. In addition, the complexity of the dam may be out the conceptual grasp of the villagers and beyond the traditionally experimented forms of land-use. If these activities can be justified within the village context, it is likely that they should be of a smaller scale and with simpler objectives.

* Better coordination of the different actors (authorities, different users groups, PLAE, CMDT, Local Development Committee ect.) is needed, so that objectives, uses, responsibilities and conditions can be clearly defined. Politicization of the activity disregards economic, social, environmental and physical realities of the villagers and should be avoided.

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ANNEX A. LIST OF CONTACTED ORGANISATIONS AND PEOPLE

- Projet Exploitation, Evaluation et Gestion des Ressources en Eau du Mali (UNDP, MLI/84/005), Direction Nationale d'Hydraulique et d'Energie, B.P. 66, Bamako, tel. 224877

Mr. Marc Simonot , project manager

- Direction Nationale d'Hydraulique et d'Energie, B.P.66, Bamako

Mr. Makan Sisokko, Chef Division Petites Barrages

- Direction National des Eaux et Forêts, B.P. 275, Bamako

Mr. D. Traore, Chef Division Conservation des Eaux et des Sols

- Projet Micro-Réalisations, Cooperation Canadienne, B.P.198, Bamako, tel. 226393

Mr. Karel Pazlar, project manager and Mr. Diaura, counterpart

- UNICEF, B.P. 96, Bamako

Ms. Senghor, Administrator of water and sanitation projects
Mr. Criotti, Program Officer

- PIRT (Projet Inventaire Ressources Terrestres), B.P. 2357, Bamako, tel. 226428

Mr. Allassane Kanouté, sociologist

- Projet Lutte Anti-Erosive, CMDT, Koutiala, tel.640103

Wim van Campen, Chef du Projet and Jan Heykoop, consultant

- Near East Foundation, B.P.2627, Bamako

Duncan Fulton and Mike Winter, Duentza project

- Safe the Children Fund UK, B.P. 2145, Bamako

Dr. Daouda Male (Duentza), project manager health project
Mr. Adam Thiam (Mopti) and Mr. Collin

- Projet Foresterie Rurale Ségou, B.P. 87, Ségou, tel. 320389

Mr. Mike O'Brien, project manager

- Direction Régional de l'Urbanisme et de la Construction, B.P. 255, Ségou, tel.320029

Ms. Ula Santara-Messerich, urban planner

- Peace Corps, Bamako

Lynn Utah, APCD Water and Jack Brooks, water volonteer

- Bureau de Cooperation Neerlandaise, Bamako

Arjan Hamburger

- Projet Action à l'Animation Féminin, CMDT, Koutiala

Ms. Lyda Zuidberg

- Projet Aménagement des Terroirs, Cooperation Canadienne, Ségou

Mr. Pierre Bonin, Chef du Projet; Maimouna Diarra, Economiste

- Projet Aménagement des Terroirs Villageois, CMDT, Fana

Mr. Amadou Dicko, topographe

ANNEX B.

JOGODOJI GROUND TANKS IN THE DUENTZA CERCLE (MOPTI REGION)

In the Arrondissements of Hombori and Mondoro, where the groundwater table is often more than 100 meters deep, a kind of ground tank is used for domestic water supply, watering of animals and income generation. These "jogodoji's" are said to play an important role in the economy of the Rimaebe (sedentary Fulani or Fulbe) and in the pastoral strategy of the Fulbe. Time was too short to further study this remarkable technique. A village study of 1983, however, gives some useful details:

> "Girol village has 44 cisterns of varying shapes and sizes: they average 4 meters long, 3 meters wide and 2-3 meters deep, and are surrounded by an earth embankment. The cisterns are entirely dependent on the rains for replenishment and, depending on the years rainfall, they do or do not suffice until the following rainy season. As each cistern's water level goes down in the dry season, the sediment and other debris are removed, thus preserving not only the depth and quantity of the water, but also its cleanliness and quality".
>
> "Every resident family of Girol has a cistern and several households three or four. Few cisterns have been dug over the last 10 years. Households prefer to deepen their existing ones, because before a new cistern will retain water 2 or 3 wet seasons have to pass. During the wet season individual cisterns are no longer distinguishable: the whole area becomes a small lake with the earth embankments retaining the water. So long as the individual cisterns do not show, there is free access to the water for domestic or pastoral needs. However, when the water level drops after the rains and the cistern outlines can be seen, the water belongs exclusively to the cistern owner. Each cistern is surrounded by a thorn barrier to prevent livestock from drinking at will".
>
> "The sale of water only began 20 years ago and ever since water for pastoral use has been exchanged for either cash or manure. In the past the Rimaebe preferred to barter water for manure but over the past 10 years they have increasingly chosen for a second strategy, whereby they sell all the water of the cistern at once. The second most common exchange was the partial sale of water to a predetermined number of animals for one month at the time, giving the owner of the cistern the opportunity to assess the state of his water supply at the end of each month. The existence and manner in which these cisterns are managed by the Rimaebe gives them a considerable income, at a time of the year when, if their harvest is poor, they can still buy grain at reasonable prices. They can also increase their millet yields through manuring of their fields; and finally by attracting the Fulbe to the village they are able to exchange millet for milk" (Hesse, Thiam, Fowler and Swift 1983: 118-121).

ANNEX C.

LAND RESOURCES AND EXPLOITABLE SURFACE WATER

Continued.....

Source: Marion 1988, Appendice, 2/1 and 2/2

ANNEX D.

MAP OF THE KOUTIALA CERCLE WITH BARRAGES

ANNNEX E.

CONSTRUCTION MATERIALS FOR THE NTOSSONI DAM

ANNEX F.

COSTS OF THE NTOSSONI DAM

ANNEX G.

SURVEY OF BARRAGES IN THE KOUTIALA CERCLE