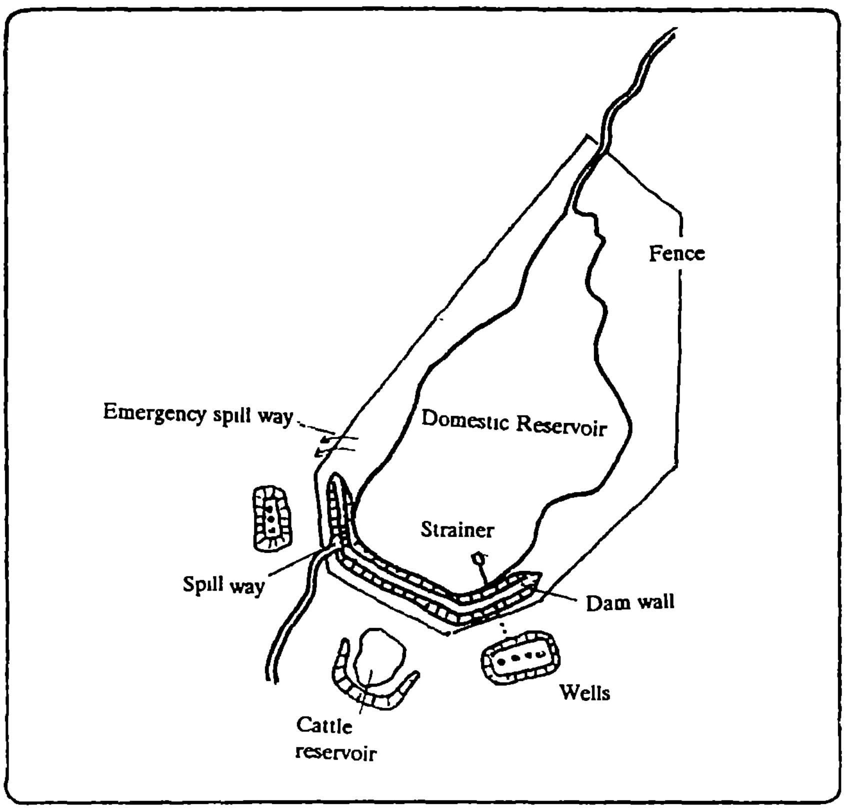
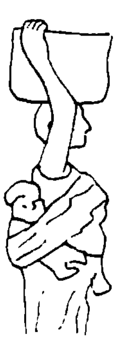
Water supply by dam construction on village scale,

the experience of the Village Water Reservoir Project in the Northern Region of Ghana





April, 1994

Archdiocese of Tamale

sawa

PREFACE

Since 1987, the Village Water Reservoir Project is constructing dams and reservoirs for villages in the Northern Region of Ghana. It was felt by the project, that a good documentation on the experiences of the project was not ready available for outsiders. The time has come that the valuable experiences will be shared with other people.

Therefor this book aims to reach two types of readers:

1. People who are interested in the services of the Project for direct application
2. People, who would like to know more about the ins and outs of dam construction at village scale.

The strength of the Village Water Reservoir Project is the integration of social activities in the sophisticated technology of dam construction and the resulting sustainability of these sources.
The book explains this approach, including all the steps in the design, implementation and maintenance phases. The final methodology and design has not been reached, yet, and the project is constantly adopting its activities to felt needs and changing views.

This book mainly focusses on the methodology and technical aspects of a dam building project. It gives hardly any information about the project set-up and the activities and approach to reach a sustainable organization. A book on this issue may be edited in future, when the learnt lessons can be evaluated in a better way.

The Project hopes that this example can get a follow up in other dam building projects, else in the world, and that the book may contribute to attract work for the project itself, to be able to contribute to the improvement of the water supply of many people.

If you like to get more specific information on the project, please don't hesitate to contact one of the following partners:

SAWA, Beukenlaan 2B, 6711 NH EDE, The Netherlands
telephone: (0)8380-53380; telefax: (0)8380-51636

Village Water Reservoirs Project, P.O.Box 1218, Tamale, Ghana
Yapei Road above Lamashegu; telephone: 2000

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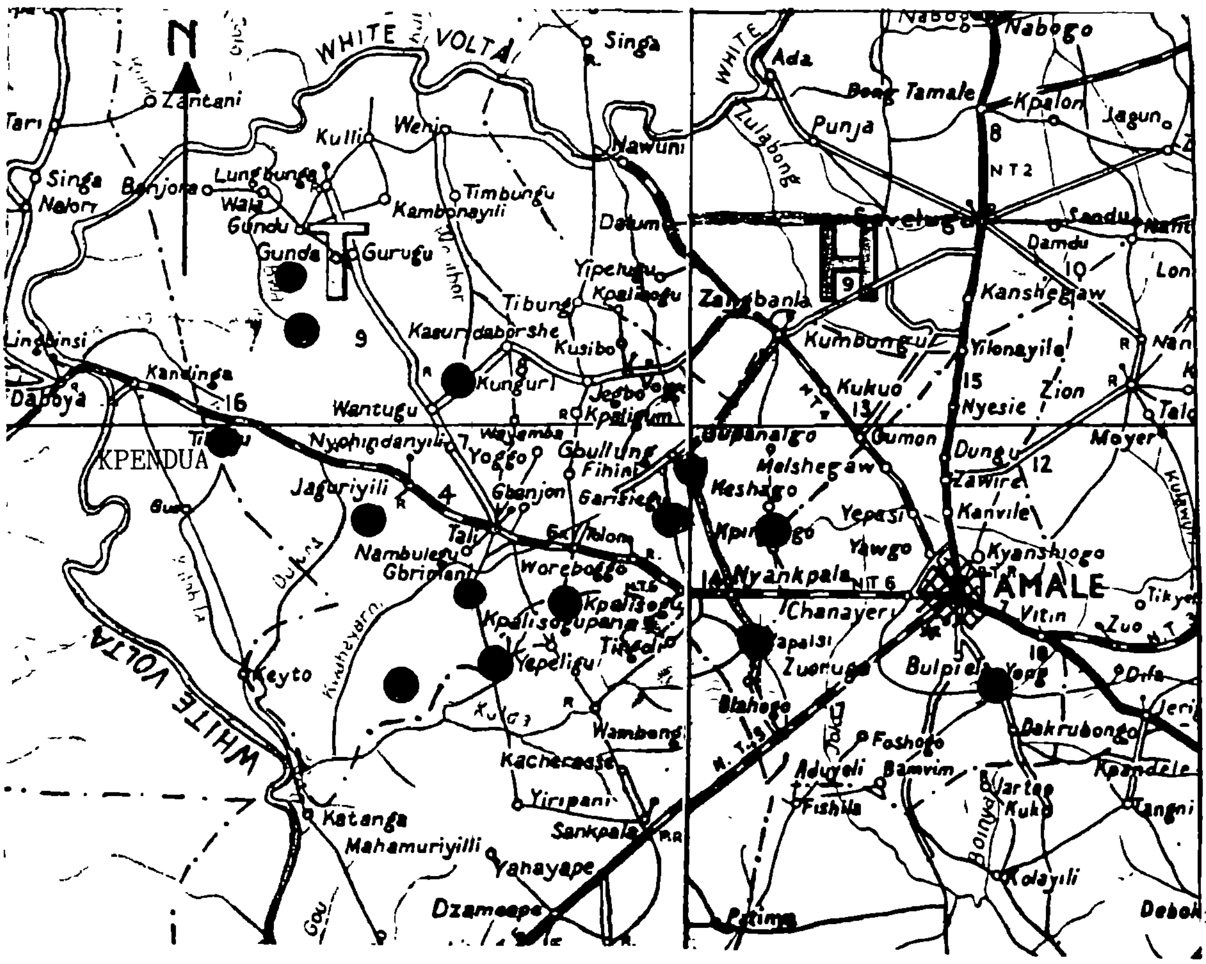
Figure 1: Project area and location of dams

Scale 1: 500,000



● Constructed Village Water Reservoirs (project)

1. INTRODUCTION

In many areas of the world, ground water is selected as the principle source for rural water supply. The main reason is that ground water has less risk of contamination, sources can be constructed near homesteads, and well construction is a traditional technology. In many cases, well construction and even borehole drilling is cheaper than alternative ways of water supply.

However, ground water is not always available in sufficient quantity and of acceptable quality. Then people have to rely on surface water or rain water. And in some cases, salty water is desalinized for consumption, which is very expensive.

In semi-arid to semi-humid tropical climates, most of the rivers run dry after the wet season. Therefore, surface water or rainwater can only be used, when it is stored. This technology of rain water and surface water collection and storage is called "rainwater harvesting". Most of the literature on rainwater harvesting focuses on the collection of water from roofs or small fenced areas with impermeable soils (IRC 1992).

This book tries to fill the gap between the literature on small scale rainwater harvesting and large scale dam construction. It is based on the experience in the Village Water Reservoir Project in Northern Ghana.
The project is owned by the Archdiocese of Tamale, which got financial support of the Dutch Catholic Organization CEBEMO (1987-1994) and of the Dutch Government (1987-1990). The Archdiocese was assisted by the Dutch consultant SAWA, which provided expatriate staff and know how.

The book intends to socialize the experience of the project and to show to potential investors in rural water supply the advantages and disadvantages of this kind of water supply, as well as the experience with the participatory approach in this kind of projects.

THE VILLAGE WATER RESERVOIR PROJECT

The Village Water Reservoir Project aims at:

* *the quantitative, qualitative and sustainable improvement of the water supply in the "horse shoe" area around Tamale by*
    1. *the construction of dams and reservoirs for at least 6000 people and 2500 head of cattle per year (design population) and a safe water supply system*
    2. *taking measures to guarantee a water quality which is acceptable by its users and which has a minimum risk of Guinea Worm transmission*
    3. *a maximum involvement of the beneficiaries in all project phases, with major emphasis on women*
    4. *the set up of a sustainable village based maintenance organization*
    5. *the adaptation of the construction to the village level maintenance requirements and reduce the risk of dam bursts, seepage and erosion*
    6. *control and improvement of traditional wells*

Apart from the improvement of the water supply systems in the region, the project also aims at the development of a financial and organizational sustainable (project) organization. This aspect is left out of this book, although it is a very important aspect in the set-up of similar projects.

The VWR project started in 1987. In the 5 years period 1988 - 1992, it has constructed 15 dams for domestic purposes and 3 separate cattle dams. In their design year, these supplies will serve at least 33,000 people, 9,500 head of cattle and 19,000 head of small animals.
Total investment costs in these 5 years were 5 million dollars.

The Archdiocese of Tamale is the project holder. Between 1987 and 1990 the project was co-financed by the Government of the Netherlands and the Dutch NGO CEBEMO. After 1990, CEBEMO continued its contribution.
The project gets assistance of SAWA, a consultants company from the Netherlands.

The Project organization is simple. On implementation level there are the Technical Section and the Animation Section. On Service level there are the Workshop Section and the Administration Section. The fact that the Animation Section is recognized as an implementation Section is quite unique, but a pre-requisite for the chosen approach. It took some time to get this position fully recognized.
Presently, all 4 Section are on the same level in project hierarchy. The 4 Heads of Section, together with the Project Manager form the Management Team.

2. CHOICE OF TECHNOLOGY

The choice for dam construction for village water supply has to be made carefully. General disadvantages of this technology are:

1. construction is relatively expensive
2. water quality is relatively poor in terms of turbidity bacteriological contamination and the risk of Guinea Worm and bilharziosis transmission
3. Use and hygienic behaviour require a lot of attention;
4. Operation and maintenance can often not be done on village level
5. construction requires a relatively long time, a lot of sophisticated equipment and a specialized staff
6. there is an enormous loss of water by evaporation and seepage

Because of these general disadvantages, one should first look for alternatives:

- well construction
- borehole drilling
- use of nearby permanent springs
- use of permanent surface water
- rainwater harvesting from roofs
- rainwater harvesting from protected surfaces
- ground water dams in river beds

In the case of the area around Tamale, these alternatives are not feasible. Shallow wells have water in the wet season only, and deepening gives no solution.
Borehole drilling is unsuccessful. Only one in 5 drillings of 60 m has water, but in limited quantity (enough for 250-500 people). This means an investment of 75,000 US$ per 500 inhabitants for a still unreliable supply (125 US$/capita).

There are no nearby permanent springs or rivers. Roofs cannot be used, as they are made of straw, and digging of underground reservoirs for individual compounds is very difficult because of the presence of laterite. Villages are often too large for a protected collection area and an underground reservoir.
In a once in 10 year occurring low rainfall of 0.8 m/yr, a length of the dry season of 8 months, a daily consumption of 0.03 m3/capita and a collecting efficiency of 40%, a village with 1000 inhabitants needs an underground storage of 4,500 m3 (2* 48*48 m) and a paved area of 22,500 m2 (150 * 150 m). The investment will be about 90 - 120 US$/capita.

Groundwater dams are not possible, because of the high silt content of the soils.
Under the local circumstances, the technology of village water reservoirs has a number of advantages:

1. reservoirs are a known and preferred technology in the area: many villages had already reservoirs or dug outs for cattle, which were also used for domestic water supply
2. local contractors can be found, which may assist in the dam construction and major repair works
3. people prefer the taste of water from the reservoirs above the taste of ground water

PHYSICAL CHARACTERISTICS

The project area is located in a circle around Tamale with a radius of 50 km. Landscape is a plateau, slightly dissected by valleys with intermittent streams.

The area is underlain by siltstones and shales with very limited groundwater potential. Soils are mainly lateritic. On the plateaus, soils are imperfectly drained, whereas they are water logged in the valleys.

Climate is tropical. Rainfall is seasonal. The wet season is from April/May till October. In Tamale, the average annual rainfall is 1107 mm/yr (1955-1985). Once in 10 years, the rainfall is below 810 mm, and once in 100 years below 600 mm. Length of the dry season is 6 months on the average, but is assumed to be 7 months, once in 10 years.
The one-hour maximum rainfall is over 72 mm, once in 10 years. Maximum daily rainfall is 110 mm/day, once in 10 years, and 165 mm/day, once in 100 years.

Evaporation is 1751 mm/year and 156 mm/month during the dry season.

Physical conditions for dam construction are rather favourable:
1. *semi-impermeable soils and bedrock (although there are exceptions)*
2. *slightly rolling landscape (although it is sometimes too flat)*
3. *a relatively high rainfall during the wet season*

Peak flow is calculated with the ORSTOM method, an extrapolation of an empirical method, used in the semi-arid zone of West Africa, based on relief type, permeability class, and size of catchment.
Mean annual run off is also calculated with an extrapolation of the ORSTOM methods. The project uses a run off coefficient of 20% for the average rain fall and 10% for a once in 10 year rainfall. These estimates are not yet checked with real measurements.

Sediment load is very much relying on the local conditions. Suspended load is very fine and consists mainly of kaolinitic and montmorilinitic clays. Turbidity is a major problem in the reservoirs. But lifetime seems not to be influenced by the quantity of sediment load (a few centimetres per year).

The investment costs for the 17 reservoirs, constructed in the period 1987-1991 are 50 US$/capita, if a cow is calculated as a "man-equivalent" and 4 sheep/goats is a "man-equivalent". Hence the investment costs of the reservoirs are two times less expensive than boreholes or "controlled"water harvesting with underground storage.

Because of these circumstances, the technology of Village Water Reservoirs was selected as the best alternative.

However, the project had to eliminate a number of mentioned disadvantages, in order to come to a reliable and sustainable water supply:

<u>technical aspects</u>

1. Improvement of the dam construction by using concrete spill ways and a clay core: traditional dams broke easily and had a lot of seepage;
2. Increase of storage efficiency to reduce costs;
3. Design of dam which can be operated and maintained on village level
4. Improve water quality at source (pre-treatment)
5. Prevention of erosion

<u>social aspects</u>

1. Reduce the risk of contamination and break the transmission cycle of Guinea Worm
2. Hygiene education and measures, related to the use of dam water
3. Improve, control or eliminate the traditional sources in the village
4. Make separate supplies for cattle and men
5. Distinguish the gender aspects in this type of water supply; women being responsible for domestic water supply and men for cattle
6. Environmental education and soil conservation measures

<u>institutional aspects</u>

1. Let Village be responsible for their own dam
2. Formation and training of Village Maintenance Teams
3. Development of village funds for major repairs
4. Institutionalize a monitoring system of dams
5. Institutionalize the possibility for major repairs
6. Attention to relationships between villages and land tenure.

These factors have led to the following standard description of a "Village Water Reservoir".

In order to reach a sustainable and reliable water supply, the project has chosen for a participatory approach, in which the villagers participate in all stages of the dam project in their village.

In the Village Water Reservoirs Project, a Village Water Reservoir consists of a Dam and a Reservoir as well as of wells, which are in hydraulic connection with the reservoir and close to the dam. The whole inundated area is fenced. A cattle reservoir is a separate reservoir for cattle watering, and may be a dug-out or a dam with reservoir.

In conclusion, dam construction for village water reservoirs is certainly not the first choice for village water supply. In case it is the most suitable alternative, one should take a lot of measures to come to a reliable source with a long life time. These measures are technical, social, environmental and institutional.

3. APPROACH

3.1 Participatory approach

The project uses a participatory approach. This means that villages are actively involved in all stages of dam construction: decision taking, preparation, implementation and operation and maintenance. To a certain extend, one can say that the project assist the village in its desire to have a good water supply.

The project gives a number of possibilities for active participation:
- The project only starts after the Village has applied for a dam: the initiative comes from the village
- Villages have to make a financial contribution (in advance) to show their willingness to participate
- Villages and the project jointly decide on the dam site and the technical alternatives (water supply system etc.)
- Villages contribute during surveys and the implementation with labour, shelter and food
- Village Water Committees are formed and trained; they play an important role in the contact between project and village, in the organization of work, and in coordinating after project activities
- Villagers choose for subjects in the hygiene education programme
- Village Maintenance Teams are formed and trained
- The dam and reservoir are handed over to the Village after inauguration
- The village is fully responsible for the operation and maintenance of their dam

Despite of this extensive list of village involvement, the technology of dams is restricting the intensity of participation to a certain extend:
- good dam sites are limited; often there is only 1 possibility; freedom of choice is limited, then
- because of high construction costs, the villages can have only a limited financial contribution (5-10%)
- because of the involvement of heavy machinery, most of the work is done by these machines, and few work is left to the villagers
- another implication of the presence of these machines is that the condition of efficient use of the machines makes the labour contribution dependent on the calendar of these machines
- village responsibility for maintenance cannot include big repairs; it is not yet sure whether villages can organize sufficient funds for these repairs; if they are subsidized

The Animation Section is mainly responsible for these activities and functions as a bridge between village and project. Its role is fully recognized by the technical staff.

SOCIAL CONDITIONS

Population density decreases from 100 inh/km2 around Tamale to 50 inh/km2 at a distance of 50 km from town. Half of the people live in settlements with less than 500 inhabitants.
The Dagomba ethnic group predominates in the project area, with the Gonja as the second group. Nomadic herds of the Fulani pass the area. Land conflicts between these groups exist as well as political conflicts within these groups. They have an impact on the project (and reverse).

About 70% of the population lives from agricultural production and fishery, 11 from trading, 8% from handicraft and 6% from community and service work. Important village functions are blacksmiths, drummers, mallams, teachers and traditional birth attendants. Additional activities are mat-making, sheabutter processing, charcoal production etc.

Main crops are yam, corn, guinea corn, rice, millet, groundnuts, beans, tobacco, cotton and "soup"vegetables. Land is under control of men. In the Dagomba culture, women are not allowed to use the hoe. Therefore men do most of the agricultural work. Harvesting is a combined male and female activity and food processing and trade a female activity. Most of the "wild" fruits are in the domain of the women.

Water fetching is mainly done by women and children. At the end of the dry season, they are assisted by young men.
Village life is highly seasonal with peaks in the wet season and early and late dry season.

Over-population in the area around Tamale results in an increase in poverty and degradation of the soils. Most of the villages in the outer areas are richer, men possess a number of cattle.

The Islamic Religion is the most widespread official religion in the area. Christianity is limited in relation to muslims and animists.

Degree of alfabetism is very low. Only 17 % of the children of school-going age were enroled in schools in 1980. Only 400 of the 3000 villages in the Region have a school, whereas most of the trained people leave the villages.

The health situation is poor. Diarrhoea is the most common disease. Malaria is the most severe one. And Guinea Worm is endemic in most of the area. Bilharzia only occurs in the fringe of the plateau, near the White Volta valley.

3.2 Flexible approach through monitoring

The above described approach describes the relation between the project and the beneficiaries. For the development of the project itself, the flexible learning approach has been applied, where possible. The methodology and the product are still under development.
For this, the project has set up an internal Monitoring System. It is collecting data to check, whether the project attains its goals, and it makes adjustments, when needed. Especially in this monitoring, the social and technical teams work closely.

As an example, the project had planned to use local contractors for the construction, first. But this proved to be very difficult and unreliable, whereafter the project changed its policy and bought own equipment.

The water quality in the dam and the wells is monitored, continuously. No Guinea Worm Cyclops have been found in the reservoirs or wells, so far. Which means that the measures of fencing, education and wells outside the reservoir area are very effective.
The bacteriological contamination of the water in the wells, however, is often worse than in the reservoirs. Causes may be the infection by dirt from buckets or the death of animals (lizards). As a result of this analysis, the project thinks about the introduction of a "one-bucket" system, in which each well gets its own bucket. In preparation of the start of a pilot project, the Animation Section has made a Water Quantity survey, in which it has observed and analyzed the number of people and their behaviour during peak hours.

Another example is the modification of the daily consumption of people. In another water quantity survey, the Animation Team has monitored for several days in different seasons the volume of collected water in a number of families. As a consequence, the design use could be reduced from 50 to 30 l/cap/day, and the way of questioning in the Social Survey could be modified.

3.3 Efficiency versus Effectivity

For reason of cost efficiency and the attaining of targets, the project is constantly forced to give priority to larger villages, groups of villages and villages that can afford their contribution. However, it is the policy of the Project Owner to include the marginal villages in the programme.

It is the experience of the project that forcing the villages to share a reservoir is often problematic and endangers the effectivity of the project activities. In a group of villages there is always a strong village and a weak village. This gives a lot of tension in collaboration and cooperative operation and maintenance.

Some people argue that the involvement of the people and the Animation Team is not efficient. It requires extra time and extra money. But the project has proved that

it is very cost-effective, as the impact of the project has increased considerable because of these activities.
Hence, the project gives priority to the effectivity above the efficiency.

3.4 Institutional linkages

The project has also followed an integrated approach. It didn't isolate the problem of water shortage from the context in the village, and has made linkages with other issues, where possible. However, the project has decided to restrict itself to the specialization of dam construction and hygiene education and not to integrate all kind of activities into the project like soil conservation, latrine building, fishing and health education.
The project has tried to create institutional linkages with other agencies and to function as a facilitator and mediator to other programmes in the area, specialized on these issues. These agencies may be Archdiocesan projects as well as government programmes.
As a consequence, the project has a widely known name, even beyond the boundaries of the Region.

4. STEPS IN A DAM PROJECT

The main phases in the dam project are:

1. Application and selection
2. Preparatory surveys and design
3. Construction and training
4. Operation and Maintenance during warranty period
5. Monitoring of Village Level Maintenance activities

Hygiene education, conscientization and capacity building on village level is done during all these phases.

The project has resumed procedures and instructions for all these steps in various reports:

1. Step by step manual
2. Questionnaire for the social survey
3. Design criteria and construction standards
4. Procedures for topographical surveys

4.1 Application and selection

A village's involvement with the project starts when it applies in writing for a reservoir. Typically the chief or the assemblyman signs the letter.
An appointment is then made for an orientation visit to be paid to the village by a combined technical/animation team which reports on the level of water need, feasibility of dam construction, alternative possible sources of water-supply and apparent capacity of the village to mobilise itself for its part as a partner to the project.

Based on this visit, the project owner decides on the approval of the application, the priority ranking of the village, whereafter the project includes the village in its planning for the coming years.

Further action is only taken if the village makes a financial contribution of 40% of the total required sum of 2,000 Cedi per inhabitant. If the village is not paying before a certain limit and cannot give any good arguments, it will be removed from the list.

4.2 Preparation

After a village has been selected and served with its bills, the next contact is after forty percent of the bill has been paid when the social survey begins.

To facilitate the communication between the project and the village and to give a certain importance to the project within the village and to strengthen the development

CHECK LIST SOCIAL SURVEY

Household population
- *names and age*

Interview for household head
- *water for sheep and goats during 4 seasons*
- *responsible for cattle*
- *water for cattle during 4 seasons*
- *expected changes with future cattle dam*
- *drinking of water during farming*
- *harvest of maize, millet, guinea corn, cassava, yam, groundnuts, rice, cotton*

Interview to women on household
- *Storage of water*
- *Water filtering*
- *Health (hospital, health committee, Birth Attendents, frequency health workers)*
- *Outside and Village organizations*
- *Organization of women*
- *Attending meetings*

Interview to young men
- *Village health workers/health committee/visit to hospital*
- *Outside and Village Organizations*
- *Organizations for young men*

Well survey
- *type of source, owner, user*
- *when used, purpose*
- *permanent*
- *construction (year, initiative, constructor, time)*

Dam survey
- *Location*
- *construction (year, initiative, constructor, time)*
- *Land owner, Dam Owner, who paid*
- *Use (when, Purpose, cattle)*
- *Maintenance*

Natural water source survey
- *Location, distance*
- *Land owner*
- *Use (who, purpose, permanency)*
- *Maintenance*

GUINEA WORM ERADICATION

The Guinea Worm disease is best described by its cycle of transmission:

1. *Larvae develop in shadowed shallow stagnant water*
2. *Cyclops are infected by these larvae*
3. *Infected cyclops are consumed by men*
4. *The larvae develop to worms in the human body and forms eggs after copulation*
5. *After a year, the uterus of the adult worm breaks through the skin, which hurts and may form an ulcer which can be infected by other diseases*
6. *When the uterus comes into contact with water the larvae escape into the water*

Guinea Worm is endemic in the area. People fall sick in the period at which the worm breaks through the skin, and after a period of some 40 days when the worm leaves the body. In a number of cases, complications may do more harm. The impact of the disease on agricultural production is not well known. The Government has launched a Guinea Worm Eradication program with education and the distribution of filter cloth to filter the water before consumption. This programme is not very effective in the area.

The construction of reservoirs in the area may have a very negative impact on the occurrence of the disease. Hence, the project has made an enormous effort to compensate this negative impact. Main measures are:

1. *intensive education campaign*
2. *demonstration and monitoring of use of filter cloth*
3. *distribution of filter cloth*
4. *stressing the need to take a filter on travel (market days and work on the fields)*
5. *break the transmission cycle by preventing the people from entering the reservoir by:*
   - *5.1 education*
   - *5.2 fencing*
   - *5.3 making separate well systems*

The project has been very effective and has reduced the Guinea Worm incidence in the project villages with 50 to 100%, whereas the general incidence in the district has increased with 34% between 1989 and 1991.

The Guinea Worm Eradication activity covers several years for each village. After the education programme, the Project continues monitoring by household visits during 2 years after construction, whereafter monitoring is continued by village health workers of the Government Programme.

capacity of the village, the village is asked to create a Village Water Committee. Later, this Village Water Committee is partly transformed in a Village Maintenance Committee. Preferably, half of the Team is female of whom one is the traditional birth attendant. Sub-villages need to be represented, too.
First a rapid investigation is made about alternative possibilities for siting, which can be used in the discussions with the villagers during the social survey.

The social survey comprises three main parts; the water sources survey, the administration of interviews and focus group discussions.

The water sources survey is done first so as to supply the technical section in good time with the information that it needs to start its topographical survey.
The animators interview informed persons about every known water source. These include traditional and improved wells, natural wells, dams and dug-outs, ponds and streams. The interview schedules are focused upon the water source rather than persons. In the case of traditional wells those who made them and use them are usually women. The older men have most knowledge about the history of existing dams, who initiated their construction, which other villages were involved and how the siting was decided upon. Young men are usually the best informants about maintenance activities like periodic de-silting of the reservoir by hand. Animators visit the water sources and mark them on the map.

For interviews and focus groups the team stays for a few days in the village. The main aims of these research instruments are to get a picture of the village's social organisation, economic characteristics, facilities, water fetching and water-use patterns, organisational capacity, and exposure to the Primary Health Care Programme. At the same time it sets in motion a first reflection on the various alternatives for the location and design of the reservoir. The team also explores the people's perceptions of water quality, both in terms of cleanliness and taste. Quantifiable date about behaviours and activities is mainly collected through interviews, whilst information on attitudes and preferences is collected through focus-group discussions with different categories of people, grown-up and young, male and female.

Important issues during the survey are land ownership, the status of a cattle dam and the sharing of the dam by other villages.
Land ownership and traditional rights are a major problem, which needs early attention. Cross-checking with neighbouring villages is required. In 2 of the 15 cases, conflicts have risen about this issue during implementation.

The social survey is resumed in a "Water Source Report", which forms the basis for the technical surveys.

Depending the timing in the schedule, the Technical Section makes a topographical and a soil survey and calculates the design parameters for the village.

These are required for a good design and planning of the construction works. Special attention is given to:
- storage efficiency in the selected area

- depth of the permeable weathering layer, to determine the required depth of the clay core
- presence of hard layers for excavation
- presence of construction materials in the dam area; e.g. clay for the core of the dam
- possible environmental effects

The designs are based on a number of parameters (see block).

The "discussion of technical alternatives" involving the villagers, the Animation and the Technical sections, is an explanation to the villagers of the plans for the siting and design of the dam. When there is more than one feasible alternative the villagers views are sought, especially concerning the location of the wells. With regards to the siting of the dam, much of the discussion with the villagers takes place ad hoc during the process of survey and making of test pits.
After the Village and the Project have come to an agreement on the site, a final design is made, possibly with extra land surveys. This design is presented in a "water supply report".

Parallel to the technical surveys, the Animation Section starts with a guinea-worm survey and hygiene education activities. In the Guinea Worm Survey, the incidence of guinea-worm is measured. It also investigates knowledge of guinea-worm prevention, and possession and use of filter cloths. The guinea-worm survey is repeated two years after dam construction to see to what extent health education and improved water supply appear to have had the desired impact.

After the initial guinea-worm survey comes a period of health education starting with education on guinea-worm and filtering.
Because of the long time between the application and the start of the construction, it may be 3 years or more, the Animation Section pays a number of visits to the village to keep up the links and to start with the Guinea Worm Eradication activities. These activities have proven to be very successful in the villages. They are additional to the activities of the Government.

When the Technical section is nearly ready to begin construction, meetings are held in the village to inform the people of the need to choose maintenance team members, two men and two women, and to discuss what the qualities of these people should be, their role, and what kind of support they need from the rest of the village. Villagers are taken on visits to other dams built by the project so that they can see the facilities and talk to maintenance teams that have already experienced construction and maintenance.

Before construction the animator responsible for liaising with villagers and Technical Section also discusses with the chairman and the Magasia about arrangements for feeding the workers of the technical section. If they do not already have a plan for rotating the responsibilities it is suggested that they devise one.

HYGIENE EDUCATION

In many water projects, hygiene education is a top-down message from the project to the villagers. In the VWR project, the Animation Section has tried to involve the population in the education activities, although there stays a obligatory message which has to be given.
As an example, the project doesn't impose on education on latrine building, but only starts with information when the village comes with a request.

The education programme uses the following means, in which the Deles method and the Graap methods are widely applied:

1. *Talks*
2. *Slide shows*
3. *Role plays*
4. *Discussions*
5. *Monitoring of behaviour/household visits*

The education programme mainly focuses on the women, but includes men in a number of activities.

The Education Programme covers at least the following activities:

1. *Hygienic behaviour around the wells*
2. *Transport and storage of water, including filtering*
3. *Hygienic behaviour in the compounds*
4. *Water related diseases*
5. *Training of Village Maintenance Team Members on Maintenance Activities*

In addition to these obligatory activities, the villagers may select other topics for discussion and training. A complicating factor of this approach is that many villages choose topics which can not dealt with by the project staff. The project then functions as an intermediate to other projects or agencies, but cannot held responsible for the output. For health topics the Archdiocesan health workers or the District Health Centres are mobilized; for the formation of women groups, the Archdiocesan Women programme; for the construction of Latrines the Governmental Latrine Building Programme. A problem is that most of the governmental agencies have lack of means, which may give disappointing results.

4.3 Implementation

The implementation starts with the mobilization of equipment and materials and the installation of a base camp near the site, including a repair workshop.

The technical work consists of:
1. stripping of top soil and removal of unsuitable materials
2. Excavation of trenches (dam core)
3. Excavation of clay pits, transport of clay and filling of key trench with clay as well as compaction
4. filling of dam wall with selected local material
5. finishing embankment by back pushing of stripped material
6. gravelling of dam embankment
7. Earth work for spill ways and drainage
8. Concrete and gabion constructions of spill way
9. Earth work for wells and cattle dam outlet
10. Special concrete works like wells and aprons
11. Excavation of separate dug out for cattle
12. transport of aggregates for concrete works

The cost of clay core construction (3) makes 30% of the entire earth works costs in dug out types to 60% in gravity types. The cost of the total dam construction (3-5) makes 54 to 62% of the total costs, respectively.

For the construction the project possesses the following equipment (utilization efficiency within brackets):

2 bulldozers B6H (55%)
1 excavator (80%)
1 wheel loader (67%)
3 Trucks (79%)
1 Big compactor (45%)
1 Vibromax (17%)
1 small compactor plate (29%)
2 compressors (20%)
2 small motor pumps (8%)
1 big motor pump (8%)

With this equipment, the project can work on two sites at the same time.

During construction the animator liaising on labour organisation goes twice a week to the site and meets the chairman and the foreman to see if there are any problems in labour organisation or provision of food. The chairman and maintenance team members spend a lot of time at the site during construction so that they understand something about how it works, an important background for their work in its maintenance. They have to understand the function and maintenance of the strainer and the floater and the importance of keeping the well-aprons clean and well-covers ventilated and painted.

IMPACTS

The main aim of the project is the improvement of water supply in quantitative and qualitative terms:

1. *water within 1000 m from homesteads*
2. *more than 30 l/cap/day during whole year*
3. *more than 50 l/head of cattle per day*
4. *water of quality, acceptable for villagers*
5. *Guinea worm free water at consumption*

The water quantity targets have been reached by the project. The distance to the source is sometimes difficult to attain, and mainly depending on the number and distance of sharing villages and the availability of a good site. Water quality targets have been reached in most of the dams. Turbidity and algae contents are critisized in some villages. It must be stressed, however, that the water quality standards will never attain the standards for safe domestic water.

Other impacts, defined by the beneficiaries are:

1. *Decrease in diseases of beneficiaries, especially Guinea Worm and diarrhoea*
2. *Decrease of diseases and starvation of cattle, because they do not have to be herded at long distances*
3. *Increase of organization capacity in the villages*
4. *Increase of social activities within villages, because women have to spend less time on water fetching and (young) men can stay closer to the village with their cattle*
5. *Formation of women groups in various villages*
6. *Starting cooperation between many villages (people have formed their own umbrella organization)*
7. *Introduction of fishery activities in reservoir and resulting income or improved protein diet.*
8. *(Limited) Increase of some economic activities, like vegetable growing near wells and brick making (water mainly fetched from cattle reservoir)*
9. *Growing awareness of soil erosion and introduction of some soil conservation techniques*
10. *Growing awareness of need of improved sanitation and the start of some activities in this field (soak aways and requests for pit latrines)*

On a general meeting of more than 100 Village Maintenance Committee members three other impacts were mentioned:

11. *Improvement of micro-climate in villages, because of the cool breath from the reservoir at night time*
12. *Increase of education potential, because teachers are willing to live in the villages with water supply, now*
13. *Increase of status of the families living in villages with water supply: women do not refuse marriage any more, because of water shortage*

Not well known are possible negative impacts on health (malaria) and the environment, because of the possible increase of cattle density.

The construction is concluded with an official inauguration. The dam becomes the property of the village, then.

4.4 After dam construction/warranty period

The first 2 years after dam construction is seen as a warranty period, in which the Animation Programme is continued and the Technical Section makes corrections on the design, if required.

A Project Maintenance Team visits the dams each year to evaluate the performance of the dam and its maintenance. Technical failures like excessive seepage and erosion at the spill way are corrected on account of the project.

After dam construction health education continues with the villagers choosing health topics that are prepared by the nurse-animator. Common topics are cleaning of surroundings, diarrhoea treatment and prevention, guinea-worm and malaria.

During the first rainy season in the life of the dam the Animation section, shows the villagers how to plant and space clumps of vetiver grass on the inner and outer embankment, and how to fill erosion gullies.

At some stage after dam construction, usually in the next dry season, the animation section organises a training session for the maintenance teams of the villages with newly constructed dams. There are substantive health topics and an organisation and approach component in which maintenance teams explore with the animation section how best they can communicate what they have learnt to their fellow-villagers and mobilise them for maintenance work.

For the next two years the village maintenance teams receive periodic follow-up visits from the Animation Section to encourage them in sustaining their health promotion activities.

4.5 After the warranty period

The project has a long-term maintenance programme in which the partnership between village and project continues. Two years after the construction of a dam, when the project warranty ends, the animation section encourages the villagers to participate in its long-term maintenance programme. Minimum participation in this programme involves payment of a fee for two monitoring visits a year by the Project Maintenance Team. During these visits, the performance and the condition of the dam are checked, the water use and maintenance activities are monitored, and the team responds to questions from the Village. As a result of the visit, action is proposed if required. Consequent activities have to be paid by the village.
The project is still working on the development of a village fund for major repairs.

DESIGN PARAMETERS

In the intervention area of the project, the following design parameters have been selected:

Expected lifetime of water supply system	*30 years*
Design period	*20 years*
Growth rate of population	*4 % per year*
Growth rate of cattle	*4 % per year*
Domestic water use	*30 l/cap/day*
Cattle water use	*50 l/head/day*
Small animal water use	*5 l/head/day*

Hydrological parameters are:

Annual run off *is equal to run off in a once in 10 years dry year. In the project area:*

Design Precipitation	*810 mm/yr*
Design Run off coefficient	*10 % **
Design run off:	*81,000 m3/km2/yr*

* *for most common imperfectly drained plateau soils, but must be defined for each case with ORSTOM method*

Required Storage *is dependent on evaporation, water demand, and seepage. These parameters have to be determined for each individual case. In most of the reservoirs, constructed by the project, the relation between water consumption by evaporation:seepage:water use is 50:15:35. This relation is highly dependent on topography (steep slopes give higher efficiency), sub-surface (sandy soils or cracks give higher seepage) and construction quality.*
Point of departure is that the reservoir is full at the end of the wet season.

Evaporation in dry season months	*156 mm/month*
Design length dry season	*7 months*
Design evaporation in dry season	*1092 mm/7 months**

* *Evaporation from reservoir area should be calculated as a function of surface area of water at a certain water level; simply one can state that water level will fall about 1.1 m as a consequence of evaporation*

Seepage is also calculated as a (exponential) function of water level. In the calculation model of the project, it is calculated as a linear function of surface area.

Dimensions of the spill way *are determined for a once in 10 years flood. The peak discharge is calculated with an empirical formulae, in which project area, collection time, run off coefficient and once in 10 years daily rainfall are the most important parameters.*

Design peak precipitation	*110 mm/day*
Design run off coefficient	*dependent on several parameters*

For the emergency spill way, the once in 100 years peak flow is determined.

Design peak precipitation	*165 mm/day*

5. TECHNICAL ELEMENTS IN THE CONSTRUCTION

5.1 Siting

For siting of a dam, the indication of locations by the villagers and the position of an old cattle dam are valuable.
Land tenure, cultural traditions assigned to land etc may be of relevance.

The following points are important for the technical surveys:
- size of catchment in relation to required design capacity
- size of catchment in relation to expected peak flow
- natural narrows in valley section
- depth of weathering mantle/presence of a sub-surface permeable layer
- need and potential for silt traps
- potential for concrete and emergency spill ways
- potential for fencing
- storage efficiency/slope of terrain
- presence of construction materials
- evidence of erosion on upper slopes

An extra element in the siting is the size of the catchment in relation to turbidity of the water. It has been observed that water in reservoirs with very small catchments is very turbid.

5.2 Dam type

<u>single dam/multi-purpose</u>

The project focuses on the construction of reservoirs for domestic water supply. It was recognized, however, that the project would gain much more confidence with the villages, when the water supply for livestock would improve, at the same time. Absence of water for livestock would diminish the effectivity of the project; people not wanting to participate, and cattle contaminating the good source by entering the water. Hence cattle reservoirs were included in the project.

In most cases, a small dug out is made for cattle watering downstream of the domestic dam. This dug out is normally fed by seepage water from the dam, but can be filled with a syphon, when required. However, in most cases seepage is sufficient.

<u>gravity type/dug out type</u>

Two main types of dams can be distinguished: a dug out type and a gravity type. Most of the constructed dams are in between: a dam with a dug out near the dam for the ultimate water storage. Most of the time, this dug-out is the borrow pit, made where good clay is found for the clay core of the dam.

The selection of the dam type depends on topography and on the size of the village.

In the dug out type, 1 m3 of earth work will create a capacity for 1 m3 of water. In the pure gravity type the construction of 1 m3 of earth work can create capacity for 10-15 m3 of water, depending the topography and the dam height. Effective storage is lower than this figure, because of higher evaporation losses from the large surface area. Additionally, materials have to be transported over longer distances in gravity types; hence earth movement can be more than 5 times higher in small gravity dams in relation to dug outs.
In the project area, for the smaller villages (<400 people) the dug out type is the most economic option.
Efficiency increases with the height of the dam wall. However, risks of burst, as well as the tendency to keep the number of beneficiary villages as limited as possible form contrasting arguments.

alternatives

Depending the topography, one can select different types of configurations.

1. Wide gravity dam in centre of the valley; this is the main type in the project area. It is applied for larger populations in relatively small catchments

2. Dug out type in centre of the valley; this is the second main type in the project area. It is applied for small villages in small catchments

3. U-shaped gravity type; this is made in case of absence of a clear valley shape, whereas the land slope is considerable; wall height is high and hydraulic pressure facilitates the construction of treatment plants

4. Dug out next to centre of the valley; this type is made in large catchments where run off in the river is high. Water will enter into the dug out only at high stages; water in this type is less turbid.

5.3 Dam body

In the traditional dams in the area, seepage is a major problem. Although the soils are very silty or even clayish, sub-surface layers are often more permeable, e.g. a lateritic layer. Hence it was decided by the project to construct a clay core on to the top of the rock, whereas the borrow pits near the dam may not be dug below the bottom of the clay layer.

The top of the dam lies 0.5 m abobe the once in 100 year water level. This extra height is necessary to compensate for wave action during such heavy storms.

The dam embankment is planted with Vetiver grass, a locally available grass type which is very strong and drought and fire resistant, whereas it is not eaten by cattle. The grass is protecting the embankment from erosion, whereas people are afraid to

pass the grass because of snakes.
The Village Maintenance Teams are trained to nurse, plant and maintain the grasses. They are also trained to mend the gullies which appear on the dam slopes.

5.4 Spill way

Bursts are a common problem with the traditional dams. As a consequence, villagers have the habit to break the dam on a certain spot to avoid major damage, in case of heavy storms.
Because of this general problem, the project has decided to include 2 spill ways in the design: one concrete spill way, which is designed for a once in 10 years flood, and an earthen emergency spill way for a once in 100 years flood.
Spill way design has got a lot of attention in the project.
Most of the spill ways have the following characteristics:

1. not located in the centre of the dam
2. concrete wall, strengthened with gabions
3. erosion protection at both sides of the dam
4. chute blocks and baffle piers in sill
5. protected downstream channel

5.5 Water supply types

Surface water reservoirs are important factors in the transmission of diseases. This is especially the case in the project area, where Guinea Worm is endemic. In the area, there are many open water sources with stagnant water, like traditional pools, dug outs and reservoirs.
One of the measures, taken by the project to reduce the risk of contamination, especially in respect to Guinea Worm, is the prevention from people of entering into the water. The people are educated on this issue, the inundation area is fenced, dam water is supplied in separate wells at some distance of the reservoirs and people are motivated to filter the water before consumption.

Water supply without the need to enter the water could be reached in different ways.

1. protected intake device at the margin of the reservoir
2. wells tapping ground water around the reservoir
3. wells tapping seepage water downstream of the dam (wells in an infiltration gallery)
4. wells at some distance from the reservoir with a hydraulic connection (sand bed or tube or both)
5. public tap, downstream of the dam

A protected intake at the margin of the reservoir is too risky. People come close to the reservoir and are easily attracted to enter into the water.
Wells tapping ground water around the reservoir are not feasible, because of the impermeability of the soil.
Wells tapping seepage water downstream of the dam is hardly feasible, because of the

PRE-TREATMENT

The project has experimented with several types of pre-treatment/filtering by sand filters. The following configurations were tested:

1. *wells in a sand body in the dam*
2. *sand body in the reservoir with a drain inside*
3. *horizontal roughing filter*

None of these 3 alternatives proved to be feasible under the local circumstances. Main problem is the high content on very fine particles.

<u>wells in sand body</u>
Problem with this type is that construction is expensive and cleaning/maintenance is impossible. Efficiency in treatment is not very high and contamination of the wells cannot be excluded.

<u>sand filter in reservoir</u>
This type has functioned satisfactory for several years. However, the flow is diminishing, now. The villagers are difficult to motivate for cleaning operations, for which the sand should be removed from the reservoir, be washed and be returned. The procedure is too complicated.
Efficiency is quite low, as long as the wells can be directly contaminated.

<u>horizontal roughing filter</u>
A horizontal rouging filter is a rapid sand filter. It has the advantage that water will not be contaminated afterwards and that the cyclops cannot pass the filter. One experimental plant has been tested. The treatment efficiency has not been satisfactory, because of turbidity of the water. Maintenance requirement is high. And the filter is often not applicable, as it needs some hydraulic gradient.

bad quality of the water, which has passed the lateritic layer (high iron content and bad smell).

A public tap downstream of the dam is not very feasible, because of limited pressure. Furthermore, the supply of turbid and possibly contaminated water by taps is in conflict with the Government Education Programmes, which proclaims that tap water is safe water.
Hence, the project has chosen for the alternative of wells, which are hydraulically connected to the reservoir. Although this method has also some disadvantages. It is much more expensive than the construction of a tap. For hydraulic reasons, the top of the wells have to rise above the maximum water level in the reservoir, which means that people have to climb to the well and have to lift the water more than 3 m. In water fetching with private buckets, contamination of the water in the wells is a high risk. For the last reason, the project is doing an experiment with a one-bucket system.

The project has experimented with several pre-treatment options.
1. Wells tapping water from a sand body in the dam; the sand body being connected to the reservoir
2. Wells downstream of the dam body, tapping water from a sand filter in the reservoir;
3. The installation of a Horizontal Roughing Filter, downstream of the dam
4. Wells downstream of the dam body, connected with the reservoir by a tube, held near the surface with a strainer (no treatment)

In practice, the last option seems to be the most feasible. The high silt content is easily clogging the different types of sand filters, whereas the construction of a sand body requires a lot of time. Cleaning of the sand filter under the water level is not easily done by the villagers.
For more information regarding pre-treatment, one is referred to the text box.

Technical problems encountered in the "strainer system" are:
- the quality of the strainer: UV-light had made the strainers made of jerrycans permeable; hence the strainer had sunk to the bottom, after which mud entered and clogged the connecting tube; now, the project is experimenting with Galvanized iron strainers
- clogging of the connecting tube; in one case, the project didn't succeed in a recovery of the system and had to replace the tube
- lifting the intake for cleaning purposes of the wells; people need a boat or need to swim to bring the strainer to the dam; in the case of crocodiles this gave major problems.

The siting of the wells is made in discussion with the villages. Mostly, 2 or more well areas are made, each with several wells in one line. One well serves about 100 people.

Per group of wells there is one feeder well, which is hydraulically connected to the other wells.
In the project, the wells are not circular but hexagonal, because people found these easier to construct. The well walls are made of pre-fab "rings".

The top-ring has a metal inside ring to protect the rope and the well rings from rapid wear. The wells have wooden covers to prevent the entering of dirt and dust during heavy sand storms. These covers wear easily and need frequent painting. Villagers are trained how to deal with these covers.

The wells are surrounded by concrete aprons. These are sloping slabs with a surrounding gutter. This gutter drains towards a main gutter which spills outside the well area in a small concrete pool, where goats can drink.
The construction of the aprons can only be finished one year after the construction of the wells, because the (compacted) soil still needs some settling afterwards.
The well area is fenced.

People are trained to clean the aprons regularly, which is monitored by the Village Maintenance Team. The Village Maintenance Team is further responsible for the condition of the wooden well covers and for the cleaning of the wells.

Wells need to be cleaned regularly, because of the entrance of sediment with the water and from the air. For the cleaning operation, the inflow is blocked by removing the strainer and the wells are drained, after which the wells are cleaned.

5.6 Fencing

One of the means to prevent people from entering the reservoir is by fencing the entire inundation area. Education is not sufficient, as many people who pass the reservoir may not belong to the village, and cattle may pass, too.
Presently, fences are made of (pre-fab) concrete poles and barbed wire. Experiments with poles of local wood have failed, because of termites. During the first years, the fence must stay in good condition, and needs to be checked, regularly.
After some time, the Vetiver grass in the reservoir area develops so dense and high, that it forms a natural barrier for strangers and cattle. However, the risk of contamination will increase.
The fence stays a vulnerable element in the measures against Guinea Worm.

5.7 Erosion control

Until recently, the project limited the erosion control activities to the dam area: Gully erosion at the entrance of the reservoir; erosion of the embankments and erosion of the spill ways and the run off channel. For these purposes, Vetiver grass was planted, gullies were mended with stones and streams were lined with gabions (stones in wire mesh) where needed.

In future, high turbidity and rapid siltation of reservoirs may force the project and the villages to extend the erosion control activities to the soil conservation in the entire catchment. For this activity, other agencies need to be activated. Stone lines, grass strips, fallow practice, agro-forestry and zero grazing may be measures which may diminish the silt content of the water.

5.8 Maintenance requirements

The whole design of the dams and the water supply system is adapted to the requirement that the (trained) members of the Village Maintenance Committee must be able to operate and maintain the dam. For example: the gutters of the aprons have been widened to enable the local tools to enter. The filtering systems have been eliminated because of too high maintenance requirements.

6. FINANCIAL ASPECTS

Examples of costs of surface and sub-surface harvesting systems (source = IRC, TP 30)

Description	Volume m3	Country	Cost per m3 storage volume (US$)	Storage Efficiency %	Cost per eff m3 of total volume (US$/m)
Ground tank	17	Botswana	19.1	95 ?	20.1
Sub-surface dam	3,500	Kenya	2.5	50 ?	5.0
		Tanzania	3.9	50 ?	7.8
Charco dam	8,000	Tanzania	2.4	40 ?	6.0
Rock catchment	13,000	Kenya	1.6	40 ?	4.0
Small earth dam	30,000	Tanzania	1.9	30 ?	6.3
Medium earth dam	60,000	Tanzania	2.1	30 ?	7.0
Village Water Reservoirs Project*					
Dug out type	47,000	Tolon Cheshegu	1.3	28	4.6
Intermediate types	70,000	Kunguri	0.7	33	2.1
	80,000	Kukuo	1.1	26	4.2
Gravity type	130,000	Jakpahi	0.6	21	2.9
	150,000	Kpendua	1.0		

* Investment costs are earth moving costs * 1.5 for overhead

Examples of costs of surface and sub-surface harvesting systems, calculated as equivalent costs per m3, spread over a lifetime of 30 years, interest is 10% (IRC 1992)

Description	Cost per m3 use in US$/m3 used
Shallow wells	0.60
Ferrocement	
ground tank	0.12 - 0.27
standing tank	0.22 - 0.49
Rock catchments	0.90 > 2.3 *
Sub-surface dams	1.1 > 2.8 *
Village Water reservoirs 17 dams, interest is 10%	1.3

* for rock catchments and sub-surface dams it was assumed that entire volume is used; this is not valid because of seepage and evaporation; hence the second figure gives a corrected value

Budget 1992-1994 (excluding external support ca 30% and depreciation land, buildings and heavy equipment)

Technical section	54 %
Animation Section	7 %
Workshop Section	13 %
General costs	27 %