Building Small Scale Water Harvesting Dams

The Experience Of Intermediate Technology Development Group
North Darfur State - Western Sudan

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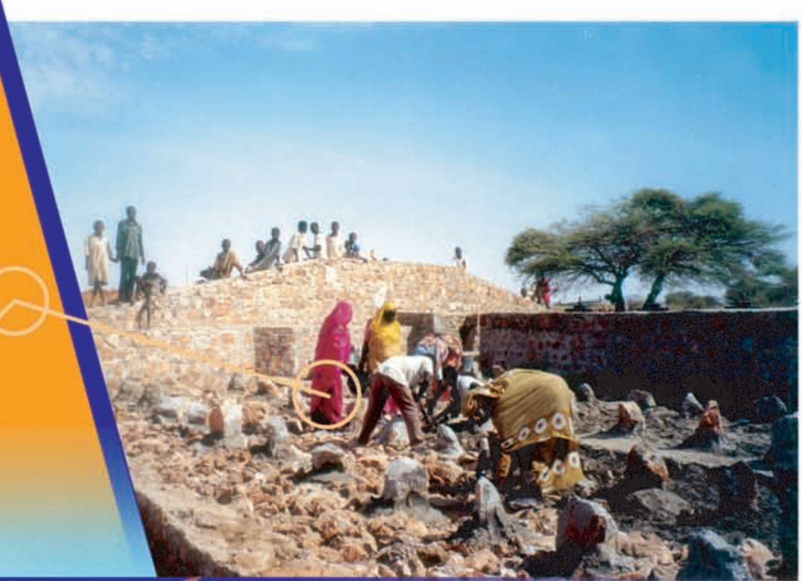

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ITDG
PRACTICAL ANSWERS TO POVERTY

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I. INTRODUCTION

1.1. Sudan

THE annual precipitation in Sudan is estimated at 1000 MD cubic metres. The two Niles and their tributaries bring about 122 MD cubic metres only 14.6 MD cubic metres are being utilised by Sudan out of its share of 20.5 MD cubic metres as per the Nile water agreement of 1959.

Other seasonal surface water (water courses known locally as khors or wadis) is estimated at 7.8 MD cubic metres with only 160 million cubic metres have been utilised.

1.2. North Darfur

NORTH Darfur is situated within the marginal tropical zone, in which precipitation is concentrated in a short summer period. The area has been struck with a series of droughts since the famine of the mid-eighties, which was followed by droughts in the years 1989, 1990, 1992, 1994, and partially in 1997. The ecological balance is getting worse and worse. Rainfall is described as increasingly more erratic, irregular and unreliable in its amount and pattern of distribution. Between 1967 and 1982, the mean annual rainfall decreased by 42%. The average rainfall in Kutum, for instance, has dropped from 345mm to 243mm annual mean. This has resulted in great losses of livestock, crop production, natural vegetation cover and wildlife.

During the last few decades, the rapid growth of human and animal populations, and the occurrence of a long drought phase, from 1968 to the present date, has resulted in desertification. This phenomenon of ecological imbalance has brought the spread of desert conditions south of the Sahara and into the savannah zone. For the resident populations adaptation to the new reality is a necessity.

As a result of drought and desertification, farmers' yields have dropped dramatically. Over many years, the poorest families have consistently harvested only one bag of food, and some have even seen zero production. Dry natural pastures have led to the death and loss of animal resources. With losses in crops and herds, people have become food insecure.

Coping Strategies: A common way of coping with drought for many households is to migrate out of the area.
A recent study estimated that around one third of the total population has left their households and local areas for good. The remaining inhabitants have found themselves facing serious hazards. Many have realized that the only way to combat macro- environmental hazards is by adapting coping strategies. The most common of these can be summarized as follows:

Polygamy: Increasing the size of the family also increases the labour force allowing more food to be secured by more hands planting and harvesting.

Increased Cultivation: By expanding areas of cultivated land, farmers can compensate for losses caused by the drop in soil fertility.

Ploughing: Animal-drawn ploughs, mainly donkey drawn, have been introduced and adapted by many farmers in the area to reduce dependency on inanimate power in the overall farming process.

Inter-cropping: This technique to produce a variety of crops from the same plot of land is being practised by farmers as the best way of exploiting available resources.

Water Harvesting: Farmers have started to copy terrace building from other farmers in their area who are using existing local knowledge in water harvesting.

Diversification of Products: Growing more than one crop in the same plot means that part of the farm can be allocated for millet, another for sesame and a third for sorghum.

Farming on Different Plots: Some farmers are choosing to plant in small plots in different areas and different directions.

Cultivation of Wadi Lands: With the decline in soil fertility, and hence productivity, farmers have moved to make use of the more fertile wadi clay soils.

Using Early Mature Crop Varieties: Because of the unreliability of rainfall and the fluctuations in the rainy season, farmers have been forced to grow early mature seeds.

Planting of Nitrogen-fixing Plants: Farmers use cowpeas both as food and as a nitrogen-fixing plant to enrich the soil.

II. THE NEED TO RETAIN MORE WATER

AS is the case in most regions of the arid zone, North Darfur faces the problem of acute deficit in its water balance. The greatest part of the state is desert and semi-desert, with 10–12 arid months annually. The rest of the state has 8–9 arid months. The prevailing aridity of North Darfur constitutes the most important precondition for the process of desertification. For farmers in the area, the need for water in domestic use and cultivation has forced them to try and adapt their practices and conserve more water.

Potentially, the water resources in Darfur are estimated at 31 Million cubic metres only 0.5% of it is being exploited at about 5 litres/person/day, which represents only 25% of the recommended minimum required average consumption per individual. 60% of the water is consumed by the 33 million heads of livestock. The equivalence of 150-240 days a year of families' time is spent in water collection. (Dr. Hamid Omer, Al Ayamm daily newspaper, issue 8151, March 2005).

Millet is the main nutrition for peasant families in North Darfur. About 90% of the labour force working in the millet fields is female. Fetching water is also the responsibility of women, mainly young girls, and it is one of the hardest tasks to perform, with long distances to travel in order to find water. Their most likely destinations are wadis, which sometimes form a source of subsurface water. Women usually dig shallow wells on wadi beds, locally known as 'tumad', that reach about 50cm to 1m in depth.

As wadi land becomes more valuable, the richer people are trying to acquire as much of it as possible. This means that poor farmers are often denied access to wadis and are forced to depend on 'goz'– sandy soils – in spite of their low productivity. The severity of the water shortage has led village chiefs to take preventative measures that will limit ownership of wadi land by the wealthy few.

This situation shows that efforts are being made to reclaim more wadi lands for use by more people, especially poor farmers. Methods of reclaiming such lands are many, but the most effective one is through building earth dams and terraces to catch more water for direct and flood irrigation.

ITDG Sudan's efforts in this field are concentrated on training farmers in water harvesting techniques. These are mainly building terraces on wadi beds and building dam structures supported by earth embankments to catch as much water as possible for both domestic use and irrigation.

The purpose of this document is to focus on ITDG's experience in building dams and earth embankments, and to show the impact of these methods on people's livelihoods and on the environment.

III. CURRENT PROJECTS

ITDG Sudan has five projects in the Darfur area that focus on water retention and harvesting.

Community Participation:

ITDG has considered the scope for beneficiary participation in each project, throughout the project cycle. Community members have been involved in planning, implementation, monitoring and evaluation. In particular, local knowledge has provided information regarding the history of flooding and watercourses which helps technicians design the maximum possible storage capacity based on the highest experienced floods in each area. Communities have also participated by providing local materials and non-skilled labour.

Community Training

The communities at all sites have been trained in the management of the dams in terms of opening and closing the gates, cleaning the silt, undertaking necessary maintenance, and assessing potential damage.

1.0 Shangil Tobaya Water Harvesting Project

Location and Inhabitants: The project is near the village of Shangil Tobaya, 84km south east of El Fashir, North Darfur State. The area is populated by multi-ethnic people; the most prominent are the Tunjor tribe (60 %). Others include the Zagawa, Berti, and Fallata tribes.

Number of Beneficiaries: There are 800 families benefiting from the wadi water. In addition, 2,000 workers have been employed to work as casual labourers by farmers who use the water on their farms.

Amount of Surface Water Captured in Cubic Metres: 240,000 cubic metres per storm.

Irrigated Area in Feddans: Due to ITDG's intervention the irrigated area has increased from 450 to 5,141 feddans.

1.1 Problem Statement

THE water-harvesting project has been established at Wadi Abu Hamra, near Shangil Tobaya village, since 1963. The system is based on the fact that floodwater is retarded by the masonry control structure so that it can be diverted by distributory canals, or small watercourses, to irrigate agricultural land. However, due to silt build-up over the years since the project began, the existing control structure is no longer functioning.

1.2 Project Goal

THE aim of this project was to collect and analyse hydrological data and use it to design and construct a new improved irrigation system near the village of Shangil Tobaya.

1.3 Project Description

THE project conducted a hydrological analysis that showed:

- Maximum flood discharge = 18.74cu.m/sec

- Estimated flood duration = 7 hours

- Volume of flood per storm = 240,000cu.m

Based on these figures, the newly designed water-harvesting project is composed of:

a. Flood control structure

b. Branch canals

c. Protective embankment

The following solutions were introduced for the rehabilitation of the existing control structure:

i. Heightening the structure by 1m to make a new main spillway with two side spillways.

ii. Clearing the silt upstream of the structure to a depth of 1m. The amount of silt to be cleared is about 350cu.m.

iii. Three trenches to be dug in the existing structure for the erection of 3 steel sluice gates each with a steel pipe.

Spillway System

The total length of the main spillway including the two side spillways is 13.80m. The length of each side spillway is 1.20m. Timber logs are used to control water flows of the two side spillways. Three timber logs are used for each side spillway. The length of each timber log is 1.60m.

The main spillway is designed to pass a maximum of:

- 6.35cu.m/sec, at maximum water level of 103.60m, if the two side spillways are closed.
- 5.25cu.m/sec, at maximum water level of 103.60m, if the two side spillways are opened.
- 3.73cu.m/sec, at maximum water level of 103.60m.

Sluice Gates System: The three sluice gates are introduced to pass extra floodwater and clear silt upstream of the structure. The diameter of each sluice gate is 76cm. The length of each steel pipe is 2.50m with 76cm diameter. The three sluice gates are designed with 76cm diameter to pass a maximum discharge of 6.42cu.m/sec, at a maximum water level of 103.60m.

Canal System: Branch Canals: There are a number of small watercourses upstream fed by Canal A and Canal B, which divert part of the retarded floodwater to irrigate agricultural land. Canal A has a water discharge rate ranging from 3.26 to 23.96cu.m/sec at a maximum water level of 103.60m. Canal B has a water discharge rate ranging from 0.0cu.m/sec to 1.69cu.m/sec at a maximum water level of 103.60m.

- Canal A:

bottom width = 8.3m and crest level = 102.24m

- Canal B:

bottom width = 2.0m and crest level = 103.00m

If Canal B is widened to a bottom width of 4.0m, the diverted water discharge will be doubled.

Protective Embankment: Shangil Tobaya village needs to be protected against the backwater effect of retarded and stored floodwaters. The existing embankment needed rehabilitation to withstand the maximum water level of 103.60m. The typical cross-section of the embankment can be taken to be:

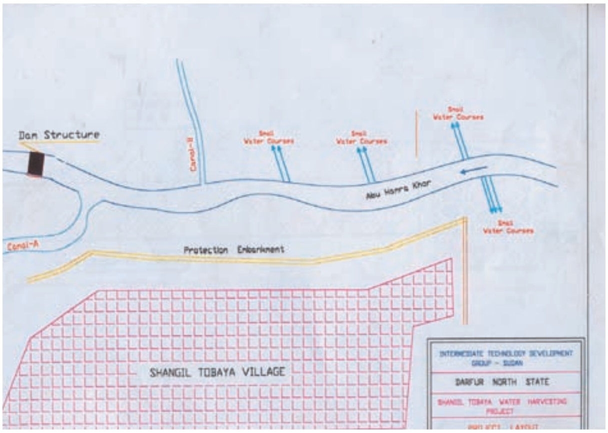
- Bottom width = 7.25m
- Top width = 1.00m
- Upstream side slope = 1 vertical: 2.5 horizontal
- Downstream side slope = 1 vertical: 2.5 horizontal

Operation Procedures: Most of the floodwater is diverted to irrigate adjacent agricultural land. If the three sluice gates are closed for some period, silt is expected to be deposited upstream of the earth dam. Therefore, these gates should be opened frequently to flush the deposited silt. The sluice gates can also be opened to meet irrigation demands downstream.

If flooding is heavy the two side spillways can be opened to increase the passing capacity of the main spillway by removing the timber logs. Each timber log is 1.60m long. The three sluice gates can also be opened.

Upstream and Downstream Considerations:

The communities living down and upstream of the dam were consulted and their concerns have been considered.

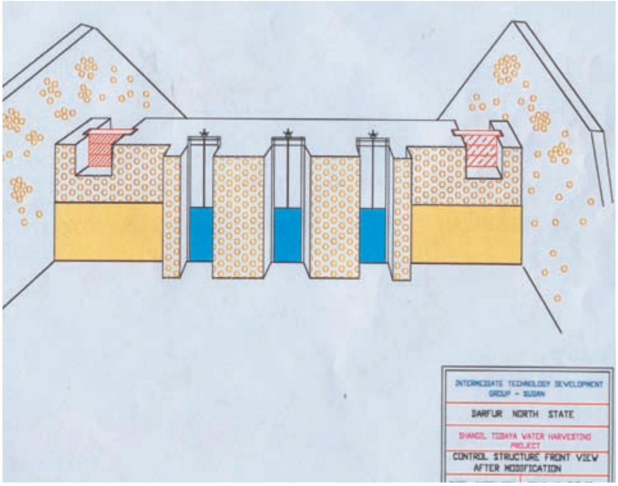


Drawings for Shangili Tobaya Dam

1.4 Impact of Project in its First Year

THE total area cultivated increased 11 fold from 450 to 5141 feddans. The number of beneficiaries rose to 800 families. Floodwater reached areas that had not been reached for almost 40 years previously. Flooding also enabled soil to regain its fertility as indicated by the quality and quantity of crops produced per feddan.

The expansion of land suitable for cultivation helped farmers to diversify crops by introducing some important cash crops.



- Crop productivity increased across the board. Tomato and okra increased by 114% and 100% respectively. This mainly occurred because the dam helped farmers recapture water for longer periods, giving time to infiltrate deep into the soil. The rise in productivity was reflected in an increase in incomes of 83.3% and 100% for the two crops respectively.

- Rehabilitation of the dam created employment for local workers. Female farmers benefited in terms of family food security, self-employment, paying school fees and meeting health needs.

- Job opportunities increased due to widening of the cultivated area. A survey on the project indicated an increase of 50% and 300% for men and women respectively.

1.5 Problems to be Considered

1. Some farmers complain that they are receiving a smaller quantity of water now because their plots are on the outskirts of the main wadi.

2. Some complain that the system of water distribution is inadequate because those nearby receive water before those further away.

3. Expansion of the irrigated area has raised the demand for ploughs. Tractor owners prefer to work for large landholders, making smallholders wait. There is a need for more ploughs.

4. Land preparation before the flooding of the area is a necessity because it helps the infiltration of water into the land more efficiency.

2.0 Azagrfa Water Harvesting Project

Location and Inhabitants: The project area is located near the village of Azagrfa, about 30km north of El Fashir, North Darfur State. Its population is 5,650.
Number of Beneficiaries*:* 500 families.

Amount of Surface Water Produced in Cubic Metres: 250,000 cubic metres.

Irrigated Area in Feddans:
Approximately 500 feddans.

2.1 Problem Statement

TWO wadis, named Khasum Hilla and Mushuk, run from north to south and meet to form Yuma wadi. The water in this wadi is not well exploited. Only sub-surface wells are used to source water during the dry season. People in the area realised the potential benefits of building a dam across this wadi and contacted ITDG to help with planning and construction. ITDG responded positively and worked with the community to design and implement the project.

2.2 Project Goal

THE project plans to construct a water harvesting system at wadi Mushuk, upstream of the confluence, to irrigate an area of about 400 feddans: 250 feddans adjacent to the western bank of the wadi and 150 feddans to its eastern bank.

2.3 Project Description

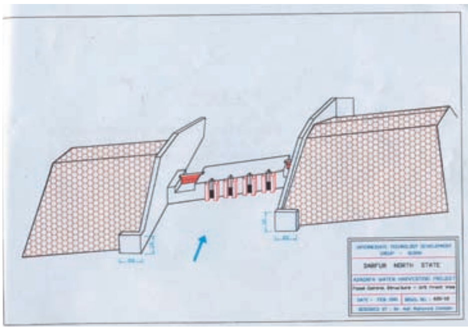
THE project undertook hydrological data analysis and erected earth dam and flood control structures.

The project includes:

a.Hydrological Data Collection Analysis
b.Earth Dam
c.Flood Control Structure

Hydrological Data Collection and Analysis: The results obtained using the Manning formula were as follows:

- Maximum flood discharge [Q][1] = 28.17cu.m/sec
- Estimated flood duration = 7 hours
- Volume of flood per storm = 335,000cu.m
- Potential irrigated area = 710 feddans



Drawing for Azagrfa dam

Three benchmarks have been established at different locations to take the necessary measurements for design and construction purposes:

- TBM 1 reduced level is 100.0m
- TBM 2 reduced level is 98.57m
- TBM 3 reduced level is 99.07m

Earth Dam: The earth dam is dressed with dry and wet pitching for protection against erosion due to rainfall and/or floods. Energy dissipaters are introduced on the upstream face of the earth dam for more protection against erosion.

- Total length of earth dam including flood control structure = 275m
- Maximum cross-section bed width = 13.75m
- Minimum cross-section bed width = 7.00m
- Maximum dam height = 2.35m
- Minimum dam height =1.00m
- Soil fill quantity = 3700cu.m
- Excavation work (for trench cut off) = 275cu.m

Flood Control Structure: The structure is composed of:

i. Spillways
   - Main spillway of length 11.0m, crest level is 99.14m
   - Two side spillways each of length 1.5m; crest level is 98.74m

ii. Sluice gates
   - Four sluice gates of 35cm diameter, each with 35cm diameter steel pipe of length 1.5m.

1. Q = Amount of water in cubic metres per second

- Masonry work quantity = 230cu.m
- Excavation work quantity = 140cu.m

The spillway is designed to pass a maximum discharge of:

- 18.02cu.m/sec, if two side spillways are closed.
- 14.92cu.m/sec, if two side spillways are opened.

The four sluice gates are designed to pass a maximum discharge of 1.51cu.m/sec.

Operation Procedures: Most of the floodwater is diverted to irrigate adjacent agricultural land. If the four sluice gates are closed for some period, silt is expected to be deposited upstream of the earth dam. Therefore, these gates should be opened frequently to flush the deposited silt. The sluice gates can also be opened to meet irrigation demands downstream. If flooding is heavy the two side spillways are opened to increase the passing capacity of the main spillway by removing the timber logs. The length of each timber log is 1.90m and its cross section is 15 x 20cm^2. The four sluice gates can also be opened.

2.4 Impact of the Project to date

IN the first year, rainfall in the area was extremely scarce. Nevertheless, the wadi was filled as a result of water channelled down from upstream.

· A total of 300 feddans were irrigated and cultivated with vegetables and sorghum.

· Consequently, 300 farmers benefited from selling the crops.

· Water was stored and used for domestic purposes for two months after the rainy season. The subsurface water was then used for another two months.

· The following year, the same area was cultivated with the addition of approximately 100 feddans more downstream. Now in its third season, the project has resulted in

· Over 600 feddans being irrigated and cultivated with vegetables and sorghum.

2.5 Problems to be Considered

1. Some of the area proposed to be flooded is higher in elevation and requires grading. Canals may be necessary to allow for spreading of water.
2. Land preparation is required before the flooding of the area because it helps the infiltration of water into the land to take place more efficiently.

3.0 Turra Water Harvesting Project

Location and Inhabitants:
The project site is near the village of Turra, 40km north of El Fashir, North Darfur State.

Number of Beneficiaries:
- 4,000 people approx.
- 8,000 goats
- 4,000 sheep
- 1,000 camels
- 1,600 donkeys
- 100 horses

Amount of Surface Water Captured in Cubic Metres: 55,000 cubic metres.

Irrigated Area in Feddans: This project is designed to capture water for domestic use and not for irrigation. However, the spilled water is channelled to a tree nursery to support agro forestry interventions by planting trees within the crops grown in farms and along the terraces.

Turra dam: an upper view of the embankment

Turra dam: view for upstream side

3.1 Problem Statement

IN spite of the big human and animal population, there is a severe shortage of water especially during the dry season. The nearest water sources are wells 12 Km away from the village, and they dry up in summer. People then travel longer distances to fetch water or sometimes buy from tankers that come to sell water in the village.

3.2 Project Goal

THIS is a new project to provide water for domestic use for both people and livestock. The proposed catchment area is about 400m x 300m. To achieve this the project will construct earth embankments and flood control structures.

3.3 Project Description

THE project consists of the following:
Earth Embankments:
- Northern embankment total length = 125m, embankment top level: 103.50m

- Southern embankment total length = 295m, embankment top level: 103.50m
- Eastern embankment total length = 400m, embankment top level: 103.50m

Sluice Gates Structure (masonry work)

- Length = 4.5m, crest level: 102.30m
- Number of steel gates = 3
- Number of 0.5m diameter pipes, of length 2.5m each = 3

Side Spillway (masonry work)

- Total length = 28.0m
- Crest level: 102.30m

Operation Procedure:

Filling of Reservoir: Initially the three sluice gates of the structure are closed. Filling of the reservoir continues to take place up to the level of 102.30m. The maximum stored water in the reservoir is about 55,000cu.m. If the water level upstream of the earth embankment reaches above 102.30m, floodwater starts to flow over the crest of the spillway and the sluice gates structure.

Silt Control: If the amount of silt deposited upstream of the earth embankment becomes significant, the gates can be opened fully or partially to wash out the silt.

3.4 Impact of Project

- In its first year, there was very little water captured, which lasted for a few months. The percolation rate was high due to the porous nature of the soil in the area.

· In its second season, the water captured is much higher in spite of the low rainfall. The percolation rate is lower due to sealing the porosity caused by infiltration of silt particles.

3.5 Problems to be Considered

1. The water is being used directly from the reservoir without any kind of treatment. A water treatment intervention such as a sand filter is recommend

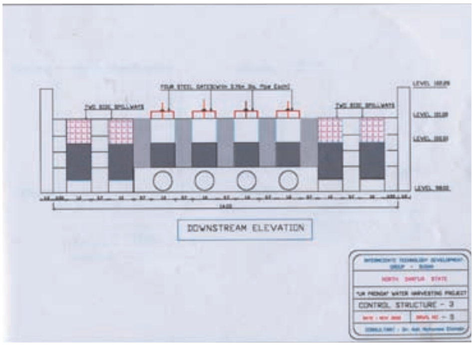
4.0 Umpronga Water Harvesting Project

Location and Inhabitants: The project site is located 60km south west of El Fashir and 3km east of Taweela locality, North Darfur State.

Number of Beneficiaries:
2,617 families.

Amount of Surface Water Captured in Cubic Metres: 600 000

Irrigated Area in Feddans:
5,000–10,000 feddans.



Drawing for Umpronga dam

4.1 Problem Statement

THE people of Umpronga are farmers and they mostly depend on selling cash crops such as Tobacco and vegetables, which they grow after the rainy season on the bed of the Wadi. The flood-land of the wadi was not enough for everyone, so they tried to build an earth embankment across the wadi course, but it was washed away. They have contacted ITDG to help them build a dam so that more area is flooded and more crops can be grown.

For domestic water use, the people of Umpronga get their water from Tawila 7 km away. The new dam will help them access water from closer sources at least during the rainy season and for a few months after it.

4.2 Project Goal

THE aim of this new project is to irrigate an area of about 5,000–10,000 feddans up and downstream of a khor[2], by constructing a dam and flood control system.

4.3 Project Description

THE project consists of the following structures:

Earth Embankment

Northern embankment:

- Length = 1,215m, embankment top level: 102.00m
- Number of openings = 5 each is 21 metres long

Southern embankment:

- Length = 1,120m, embankment top level: 102.00m
- Number of openings = 5 each is 21 metres long

Control Structure:

- Spillway length = 14.00m, spillway crest = 101.00m
- Number of sluice gates (0.76m in diameter) = 4
- Number of side spillways (1m x 1m each) = 4
- 4 terraces, 2 in each side with openings for better water distribution

Operation Procedures:

The procedures apply to the irrigation process, flood control and silt control. If the water level upstream of the earth embankment is below the level 101.50m and above the level 100.50m, and all four sluice gates are closed, water will flow through the openings of the northern embankment and the southern embankment to irrigate the agricultural land.

If the water level upstream of the earth embankment is above the level 101.50m the four side spillways and the four sluice gates should be opened to reduce the extra amounts of floodwater and lower the upstream water level. If the amount of silt deposited upstream of the control structure becomes significant, the sluice gates can be opened partially or fully to wash out the silt.

4.4 Impact of Project

IN its first season and even before the completion of the construction and erection of the gates, the dam managed to irrigate 2,000 feddans. 2000 families who acquired land in that area have benefited from the

2. Khor is a water course also know as wadi

dam. Crops cultivation includes: Snuff tobacco (90%), Okra (5%), Tomato, Watermelon, Pigeon peas and Karkhadeh (Hibiscus) (5%). In addition, 11000 people came from other villages settling around the project, providing casual labour, at 5-6 workers per acre. An additional 1000 shuttle there daily, from Tawila town (7 Km away). They earn money and are supplied with fresh vegetables to eat. This seasonal job opportunity lasts for about 7 months after the rainy season.

The farmers are planning to increase the length of the earth embankment to increase the size of area flooded.

4.5 Problems to be Considered

LAND preparation before the flooding of the area is a necessity because it helps the infiltration of water into the land more efficiently.

5.0 Idd Elbeida Water Harvesting Project

Location and Inhabitants:
Idd Elbeida village, east of El Fashir, North Darfur State.
Number of Beneficiaries: 300 families.
Amount of Surface Water Captured in Cubic Metres: 150 000
Irrigated Area in Feddans: 300 feddans.

5.1 Problem Statement

A DAM was built in this area under a previous project. However, about 40m width was washed out by flooding in 1998. Consequently the community were not able to benefit from the dam.

5.2 Project Goal

THE aim of this project was to rehabilitate the existing project and add flood control and hafir systems as a first phase and a water-harvesting project was designed and executed.

5.3 Project Description

THE project consists of three separate structures.

- The first was a spillway on the right side of Idd Elbeida earth embankment, as the location is relatively high and suitable for the spillway function.
- An emergency structure was built in the middle with a small spillway and sluice gate.

- The third structure, a sluice gate and spillway system, was located on the khor stream for silt control.

Operating Procedures:
As the control structure was built in the main stream of the watercourse, silt deposits were expected. When there is a significant amount of silt deposit, the sluice gate should be opened to allow the silt to wash away.

5.4 Impact of Project in First Year

OVER 200 feddans were irrigated and cultivated with vegetables.

Most of the remaining area is left fallow to form wide pasture areas for grazing animals.

5.5 Problems to be Considered

SIMPLE canalisation is needed to allow for more water spreading and to reduce the water load on the earth embankment, which could cause damage to the embankme

IV. PROPOSED PROJECTS

(Projects designed and awaiting implementation)

1.0 Abu Delieg Water Harvesting Project

***Location**:* 45 km south east of El Fashir, North Darfur State.

1.1 Problem Statement

AN initial project was constructed by the Rural Water Corporation in 1972. The project consisted of the following:

- An earth embankment of total length = 4,040m
- Spill way water structure (masonry work), length = 26.40 m

However, the earth embankment was washed out at different sections along the western, eastern and southern sides. The total length of the washed out sections is about 250m. The project is no longer functioning because of this damage and crops of sesame, groundnuts, vegetables and watermelons that were grown there have suffered.

1.2 Project Goal

THE goal of the project is to rehabilitate the current, damaged structures.

1.3 Project Description

THE project will involve the following activities:

i. Remodelling and raising the existing earth embankment to the level of 101.60m.

ii. Raising the existing old spillway crest by 25.0cm and erecting 3 pipes (8in each in diameter) at the spillway wall to control the silt upstream of the structure.

iii. Building 4 new structures to support the original design and 3 of them to be used to distribute the water harvested through a system of canals while the 4th is for draining part of the floodwater.

Canals: For proper water spreading to be achieved, three canals are proposed:

- Canal A: Fed by New Structure No. 4
- Canal B: Fed by New Structure No. 3
- Canal C: Fed by New Structure No. 1

Field watercourses take water from the canals, through pipes, to flood the agricultural land.

Construction:

New Structure No. 1: The structure has four gates, all 0.50m in diameter, for silt control, flood control and water regulation to Canal C.

- Spillway crest level = 100.00m
- Spillway crest length = 21.0m

New Structure No. 2: The structure has one gate, 0.76m in diameter, for silt control and flood control.

- Spillway crest level = 100.00m
- Spillway crest length = 7.0m

New Structure No. 3: The structure has two gates, 0.35m in diameter each, for silt control, flood control and water regulation to Canal B.

- Spillway crest level = 100.40m

- Spillway crest length = 7.0m

New Structure No. 4: The structure has two gates, 0.35m in diameter each, for silt control, flood control and water regulation to Canal A.

- Spillway crest level = 100.40m
- Spillway crest length = 14.0m

Operation Procedures

Flood Control: Initially all gates of the four new structures are closed. Only the spilled water from the four structures and from the old spillway passes through the earth embankment.

If the water level upstream of the earth embankment reaches 100.75m, 75cm above the old spillway crest level, all gates can be opened to increase the passing capacity of the earth embankment. This must include all gates of New Structure No. 2.

Silt Control: Initially all gates of the new structures are closed. If the amount of silt deposited upstream of the embankment becomes significant, the gates can be opened fully or partially to wash out the silt. The 3 open pipes erected at the old spillway are used to wash out silt deposited upstream

Controlled Flood Irrigation: The spilled water from New Structures No. 1, 3 and 4 is used to feed Canals C, B and A respectively. To protect the canal system against high floods, exits located at the end of each canal are used to control the water supply levels of the three canals. Field watercourses then take water from the canals through pipes allowing it to flood the agricultural land.

If the water level upstream of the earth embankment drops to a level below 100.00m, it means that no spilled water is released to Canal C. In this case, the gates of New Structure No. 2 can be opened to release excess water.

If the water level upstream of the earth embankment drops to a level below 100.40m, no spilled water can be released to Canal A or Canal B. In this case, the gates of New Structure No. 3 and New Structure No. 4 can be opened to release water to Canals A and B respectively.

2.0 Abu Degaise Water Harvesting Project

Location*:* The project site is located about 18km north west of El Fashir.

1.1 Project Description

THE project has the potential to irrigates an agricultural area of about 1,000 feddans.

The new project consists of the following:

Control Structures:

Structure 1:

- Length = 7.0m
- Crest Level = 101.00m
- Height of Spillway Masonry Wall = 1.0m
- Number of sluice gates (0.50m Dia.) = 4

Structure 2:

- Length = 7.0m
- Crest Level = 100.00m

- Height of Spillway Masonry Wall
= 0.75m
- Number of sluice gates (0.35m Diameter.) = 4

Earth Embankments:

Embankment 1:
- Length = 1600m
- Embankment Top Level = 102.00m
- Number of Openings = 5 (Each of 40m width and crest level of 100.40m)

Embankment 2:
- Length = 1130m
- Embankment Top Level = 101.00m
- Number of Openings = 5 (Each of 30m width and crest level of 99.65m)

Operation Procedures

Irrigation Process:

Initially the sluice gates of the two control structures are closed. During the flood season water starts to rise and spreads out on the agricultural area upstream of embankment 1, until it reaches the crest level, 100.40m. When the water level rises above 100.40m, the water starts to flow downstream of embankment 1 and spreads out on the agricultural area upstream of embankment 2.

The floodwater continues to flow until the water level upstream of embankment 2 reaches the crest level, 99.65m. When the water level rises above 99.65m, water starts to flow downstream of embankment 2 and spreads out through the agricultural area downstream of embankment 2.

Hafir System: Part of the floodwater upstream of embankment 2, is diverted to fill a hafir, which is used as a source of drinking water for people and livestock.

Silt Control:

Initially all the sluice gates of both control structures are closed. If the amount of silt deposited upstream of the control structures and embankments becomes significant the sluice gates can be opened fully or partially to wash out the silt.

V. INSTITUTIONALISING THE EXPERIENCE

LOCAL engineers were trained in surveying, designing and implementation of dam construction.

The University of Khartoum has incorporated this new dam building approach into its curriculum for civil engineers, mainly hydrology section of civil engineering for both graduates and postgraduate students. One of the Master's students, who is originally from Darfur is now working for ITDG as construction engineer responsible for water projects.

A number of departments at El Fashir University are also involved in studying the impacts of ITDG interventions on the environment, farmers livelihoods, gender impact, etc.

ANNEX -1

Criteria for Future Water Harvesting Projects

A survey will be undertaken to decide on new locations for design and construction. ITDG's criteria for selection is set along the following lines:

- The appropriate topographic location

- The multi-purpose uses and benefits of building a dam, e.g. providing surface and sub-surface water for domestic use and irrigation

- The number of people and animals benefiting from the dam

- The cost-effectiveness which refers to the total cost of the dam versus the benefits and number of beneficiaries

- The simplicity of the design

- The proximity to a water source to ensure access to water for construction. This point requires careful thinking. It is known that a water source may be scarce where water is badly needed, but we have experienced that in such cases, the cost of transporting water is sometimes prohibitive. So, it is important to work out a way of balancing the contradicting demands.

- The capacity of the dam to meet the interests of communities living up and down stream of the location

- Widespread community acceptance and support

ANNEX -2

Hydrological Analysis

This procedure is used throughout the calculation of maximum flood discharge, [Q], for all the projects:

Survey work was carried out to determine the maximum flood discharge, [Q], which occurred in the past years. This was achieved by finding:

i. The maximum area of flow across the khor, [A], and its wetted perimeter, [P], at a point about 1,200m upstream of the existing control structure.
ii. The longitudinal slope of the khor.

Using Manning Formula to find Q:

$$Q = \frac{A.[R].[S]}{N}$$

Where:

A: area of maximum flow
P: wetted perimeter
R: hydraulic radius [A/P]
S: khor slope
N: manning coefficient, [1/N = 33 for sandy soil]

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Practical Action is the new name for ITDG – the Intermediate Technology Development Group. The name may have changed, but the organisation and the values that we represent remain – practical answers to poverty, sustainable solutions and people focused.

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