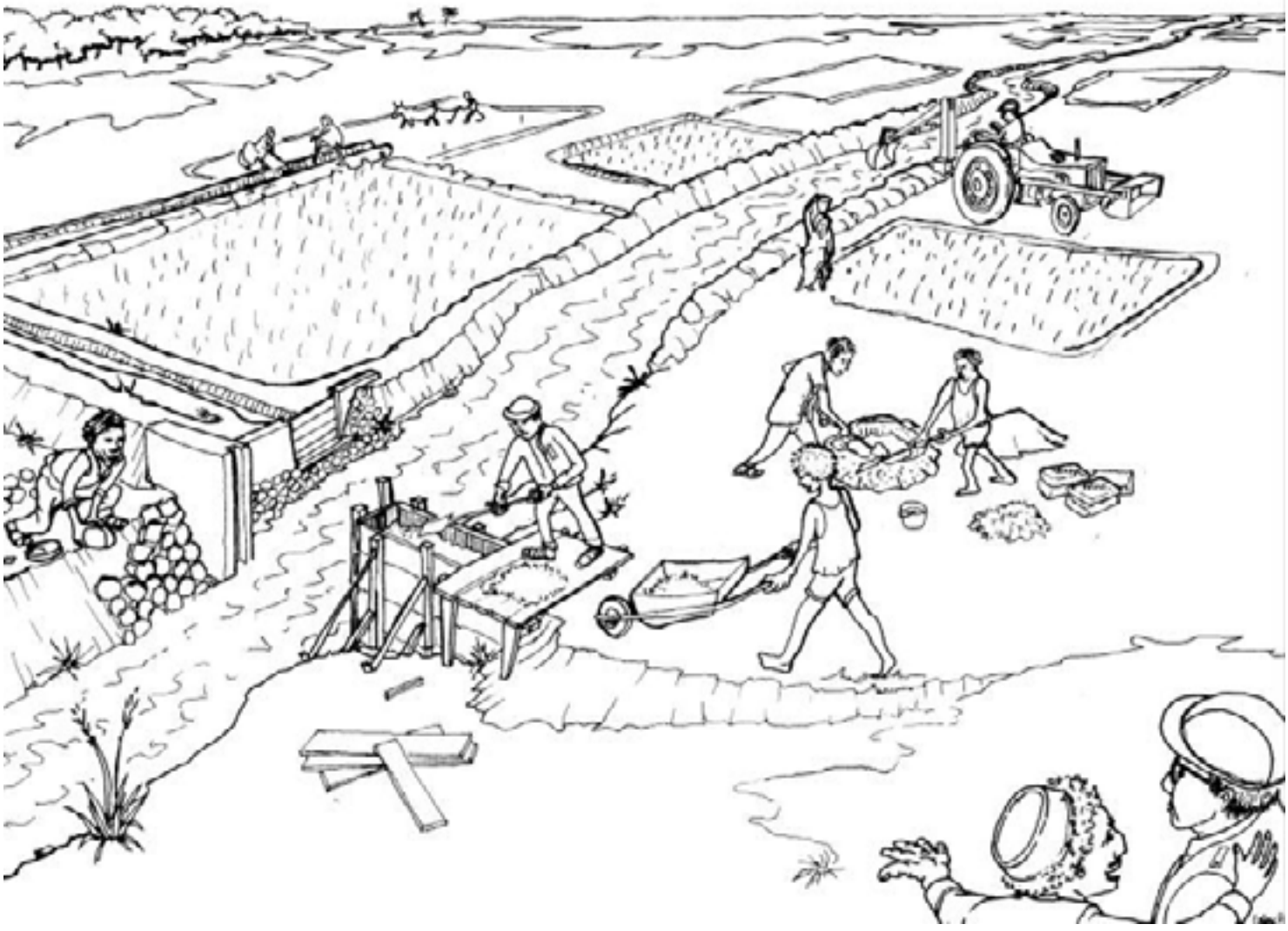
Module 2:
FARMERS' IRRIGATION SYSTEM IMPROVEMENTS



MODULE 2

FARMERS' IRRIGATION SYSTEM IMPROVEMENTS

LAYOUT OF IRRIGATION CANALS AND REGULATING STRUCTURES

Introduction

The conveyance and distribution of water from the main intake to the different farmers and fields is referred to as the farm irrigation system. Much of the losses and inadequacies of irrigation systems occur at this level. The operation and maintenance of the farm irrigation is a main area for improvement. The exercises of this module are aiming on assisting farmers in improving the operation and maintenance of the canals and regulating structures, the irrigation infrastructure.

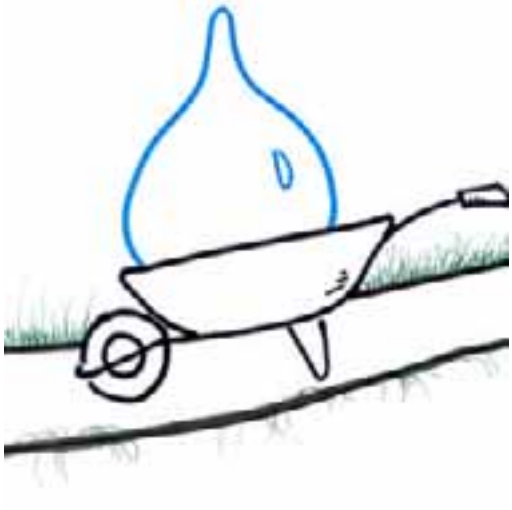
The exercises have been sub-divided in 3 sub-modules.

References

In the preparation of the exercises in the module use is made of the following publications:

- Irrigation water management training manual No. 1, Introduction to irrigation, 1995, FAO
- Irrigation water management training manual No. 3, Irrigation water needs, 1986, FAO
- Irrigation water management training manual No.4, Irrigation scheduling, 1989, FAO
- Irrigation water management training manual No. 7, Canals, 1992, FAO
- Irrigation water management training manual No. 8, Structures for water control and distribution, 1993, FAO
- Irrigation water management training manual No. 10, Irrigation scheme operation and maintenance, 1996, FAO
- Photo album on Problems and Solutions

Additional technical information can be obtained from the above mentioned publications



Sub-module 2.1: Canals

Through observations and small group discussions on the conditions of the canal systems farmers will identify in exercise 2A (phase: planning) canal parts where rehabilitation activities are needed and will prepare a planning of the repairs and rehabilitation. The follow up on the planning will take place in exercise 2B (phase: construction).

Sub-module 2.2: Irrigation structures

During exercise 2C (phase: planning) farmers will review the existing irrigation structures. Repair of the structures and construction of additional ones will be planned during a field visit in exercise 2D (phase: construction). The follow up on the planned repairs on the structures takes place in exercise 2E (phase: maintenance).

Sub-module 2.3: Water distribution and system maintenance

During exercise 2F (phase: planning) farmers will discuss and determine in the field how the distribution schedule and the timing of water supply can be improved. Finally the farmers will discuss in exercise 2G (phase: operation) the organisation required for the operation and maintenance of the irrigation system and how it can be strengthened through the Water Users Association.

SUB-MODULE 2.1

CANALS

EXERCISE 2A: PLANNING OF CANAL REHABILITATION

Introduction

A common problem in many irrigation schemes is the poor condition and inefficient way of water conveyance in the farm canal network. To improve the exploitation of the canal system it is important that farmers do understand the functioning of the canal system, the different problems that may occur in irrigation canals, their causes and how to avoid or overcome these problems. This will be discussed in the field and in small groups when farmers identify canal sections for repair, rehabilitation and/or areas for extension of the canal system. In addition to the identification farmers will decide on how to repair or rehabilitate the canal parts selected, taking into account the cause of the canal damage. Further, areas which are not or inadequately irrigated will be identified and the need or potential for extending the canal system evaluated. Finally, a plan of action will be developed.

Objectives

- To improve layout and functioning of the canals ensuring efficient conveyance of water to all areas, reducing water losses, frequent repair and maintenance.

Expected outputs

- Map and list of identified problems restricting functioning of the canal systems
- Detailed plan for realignment and extension of canal sections, rehabilitation to be done as well as short term repairs, resources (labour, materials, cost) and time schedule.
- Assignment of tasks to each farmer for the canal reconstruction per irrigation block.

Preparations required

- Carry out topographical survey of the canal system (length profile)
- Investigate all canal parts that need to be improved, identify how repairs need to be carried out, and the materials and tools needed.
- Select a canal section where different problems can be observed for the field visit

Materials required

- Irrigation map prepared by the farmers during exercise 1A of FSP.
- Large sheets of paper and markers.

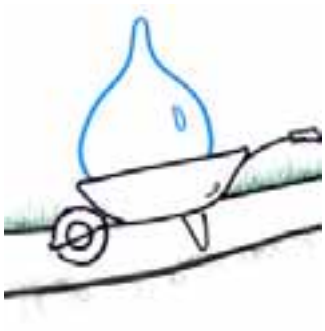
Time required

- Four hours.

Timing

- Well before the irrigation season

Procedure (Steps)



Plenary Introduction (10 min)

1. Explain the specific objectives and expected output.

Field visit (1 hour and 20 min)

2. Visit with the farmers an irrigation-block where different canal problems have been identified. Follow the canal system and discuss the condition of the canals.

3. Discuss the problem, the cause and what can be done to avoid or overcome it (repair, rehabilitation or extension of canal). Identify where the canal system needs to be repaired, rehabilitated or be extended and how it should be done.

Small group activity/discussion (40 min)

4. Split the farmers up in small groups according to irrigation blocks and ask them to draw on a large sheet of paper a map of the canal system in their irrigation block.

5. Ask the groups to indicate on the map for each section of the canal system a short description of the condition of the canal (size, lining). Distinguish main, tertiary and quartair canals.

6. Ask the groups also to indicate on the map the sections where they experience problems in the canal system and areas that can not be reached adequately for irrigation, and to describe the problems listed and their causes.

Plenary discussion (40 min)

7. Ask each group to present their map and identified problems. Discuss the presentations and list down the different problems identified and their causes.

8. Discuss how to avoid or overcome the identified problems (repair, rehabilitation or extension of canal) and how it should be carried out.

Small group discussions (40 min)

9. Back in their small groups, ask the farmers to prepare a list of repairs and improvements (to be achieved before start of irrigation season) and long-term (several seasons) rehabilitation plan for its block. The plans have to include resources needed (labour, materials, costs), time schedule and assignments of tasks to each farmer.

Plenary discussion (30 min)

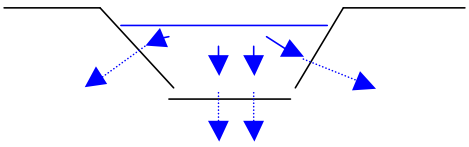
10. Ask the groups to present their plans. Discuss and agree on the plans.

11. Summary and Closure (Exc. 2, Part C).

Guidelines for (technical) preparations / questions for discussions

Overview of possible problems and causes in earthen canals resulting in excessive water losses

Seepage
Seepage of water through canal banks and canal bed (see drawing) is an invisible loss of water.



Seepage loss through canal bank and canal bed

Serious seepage appears when: (A) Coarse materials (sand) are used for the construction of canal bank and canal bed and (B) because of bad compaction of the canal banks.

What to do?
- Compaction and sealing of the canal banks
- Lining of the canal on highly pervious sections

Breakage and Leakage
Leakage is the loss of water through cracks and fissures openings of the canal bank. Breakage is the frequent rupture of canal banks.

Breaks and leaks develop because of (A) rat holes, (B) organic material (roots) in canal bunds, which eventually leads to holes and piping, (C) eroded sections along canal banks, (D) tunnelling in bad compacted canal sections, (E) piping around hydraulic structures and (F) cracks in concrete canal linings.

What to do?
- Rehabilitation of the canal bank addressing the specific cause of the problem.

Overtopping of canal banks
Inundation and overtopping of canal banks will result in excessive bank erosion and the eventual collapse of the canal bank.

Overtopping happens: (A) When canal bed have been insufficiently raised (canal passing depression). (B) Because of a bad upstream control; Hydraulic control structures are not available, not working or in-correctly operated. (C) Obstruction of the canal by plants, stones or blocks. (D) Hand made weirs from farmers downstream which raises the water level and blocks a free water flow. (E) No drainage facilities are available nor outlets towards the drains. (F) Drainage capacity of drains is too low. (G) Sedimentation of the canal bed, reduces the discharge capacity of the canal. (H) When canal banks are too low.

What to do?
- Construction of appropriate canal dikes
- Improvement of the upstream control; Put control structures in place to secure excessive flows, improve the operation capabilities of the gate operator
- Provide drains along canal banks to stabilise the canal banks
- Provide spillways along the canal banks
- Cleaning of canals
- Deepening and widening of the canals
- Instead of using weirs to raise the water level use moveable siphons

Canal erosion
Erosion of the canal bed and canal banks: Excessive water velocity will weaken the canal banks enhancing breakages; Sedimentation downstream the eroded canals nearby structures will cause a malfunctioning of these structures

Canal erosion happens when: (A) The canal slope is too steep. (B) Discharge in the canal is too high. (C) Unstable soil materials are used.

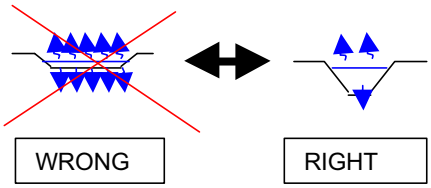
What to do?
- Installation of drop structures
- Compaction of canal banks
- Lining of certain sections

Overview of repair procedures of canal damage

a. <u>Reduction of the permeability of the bank</u>
The permeability of a canal bank can be reduced by compacting the centre, or core of the embankment. The core is first excavated by digging a narrow trench, and then replaced with soil in layers, compacting each layer. The compacted core should extend above the water level.

b. Reduction of the width of the canal bed

Earthen canals are often wide and shallow due to collapsing banks, resulting in high water losses due to evaporation and seepage. Canals should be constructed (see drawing) preferably by digging its profile into slope or on well-compacted embankment.



c. Repair of a leak

1. Determine the place of leakage with pegs
2. Empty the canal
3. Remove the vegetation
4. Excavate the canal bank below the leak
5. Rebuild the canal bank by filling the bank in layers with moist soil and compact well each layer

d. Repair damage due to overtopping of the canal bank

1. Remove the vegetation
2. Hammer pegs in the canal section at both sides of the section. Check the level with these pegs and a rope
3. Excavate the top and sides of the bank like stairs
4. Rebuild the bank by filling the excavated portion with clayey soil and compact it in wet condition
5. Trim the sides and lay grass sods on the bank when the top is reached

When it is impossible to avoid high water levels an emergency outlet or spillway can be installed along the canals.

e. Reshaping an eroded cross-section

1. Construct a wooden template. Slope of the wooden frame must be the same as the slope of the canal bank to repair If the material of the bank is unstable, use a flatter template
2. Hammer in reference pegs to indicate the original level of the canal banks on each side of the canal. Excavate the bed and sides of the eroded canal section in steps until they reach slightly under the actual bed level
3. Fill and compact moist soil, layer by layer
4. Check the cross-section and bank levels with the template and the reference pegs

f. Repair of cracks and gullies in a canal embankment

1. Remove any plants from banks which show cracking and in which small gullies have been formed by overtopping water or by heavy rainfall
2. In the case of deep cracks and gullies, excavate the banks partly. Small cracks are to be filled with fine- textured soil, moistened and compacted
3. Rebuild the bank by filling in the layers and compacting the moist soil

g. Reducing the flow velocity to reduce erosion

If the canal bed slope is too steep, cuts and fills can change the slope. If this involves too much earth moving, drop structures have to be built. If the canal discharge has to remain constant, the cross section of the canal after the drop structure has to be enlarged. Sometimes a series of check structures needs to be installed along the canal. Type of possible drop structures: Bamboo, Stones, Pipe drops and Concrete structures.

h. Lining of the canals

Canal lining increase of the flow velocity, decreases seepage and maintenance. The most commonly used types of lining are concrete lining, concrete block, bricks or stone masonry lining and compacted clay or soil cement lining.

Since the costs of concrete and masonry lining are very high, lining of canals with compacted clay can be considered although it will be labor intensive. The clay is moistened and placed in layers on the canal bed. Each layer needs compaction.

i. Extension of the canal system

To increase the distribution area an extension of the canal system with additional irrigation canals can be considered.

For more technical information, see also:

- Irrigation water management training manual No. 7, Canals, 1992, FAO
- Irrigation water management training manual No. 8, Structures for water control and distribution, 1993, FAO
- Photo album on Problems and Solutions

Questions for discussions

- Are there water losses from the canals through seepage, leakage or overtopping?
- What soil texture is used for the construction of the canals?
- Is there a lot of vegetation present on and around the canals?
- How is water flowing in the canals? Are there blockages in the canals formed?
- Is it still possible to distribute water equally to all fields along the canal system?
- Is there a need to construct additional canals to improve water distribution?
- What is the impact of the identified canal problem on the water availability?
- Will everybody help in the repair, financially and/or through contributing labour?
- Where will you get the materials and tools for the repair?
- How will you transport the materials to where they are needed?
- How will the costs for materials, use of tools and hired labour be financed?
- Will you all work together, finishing one repair after the other?
- Or, will each irrigation block be responsible for its own repairs?
- Could it be a better idea to organise the repairs through a WUA?

EXERCISE 2B: FOLLOW UP ON CANAL REPAIRS, REHABILITATION AND EXTENSION

Introduction

Repairs and rehabilitation works will be carried out by farmers according to the schedule determined in exercise 2A in which each farmer or household of the WUA was allocated a well-defined task. During the subsequent FST sessions follow up will be given to the progress of work, when delays occur causes will be discussed and rectified.

Objectives

- To monitor the progress of canal repairs and rehabilitation.
- To adjust plan and tasks of canal repairs and rehabilitation

Expected outputs

- An updated list of activities and assignments which need to be carried out during the following weeks.

Preparations required

- None

Materials required

- The repair and rehabilitation plan for the canal systems prepared during exercise 2A

Time required

- One hour

Timing

- Prior to start irrigation season

Procedure (Steps)

Plenary Introduction (15 min)

1. Review of the previous training session (Exc. 1, Part C).
2. Explain the specific objectives and expected output.

Field visit (50 min)

3. Go with the farmers to the location where the canal is under repair.
4. Recall the planning prepared for the repair of the canal systems and ask the responsible farmers to report on the progress made.
5. Discuss the problems encountered and identify solutions how they can be solved.
6. Discuss and decide on what needs to be done during the following weeks as well as who will be responsible for those activities.
7. Summarise the plan of action for the following weeks.
8. Summary and Closure (Exc. 2, Part C).

Guidelines for (technical) preparations / questions for discussions

For more technical information, see also:

- Irrigation water management training manual No. 7, Canals, 1992, FAO
- Irrigation water management training manual No. 8, Structures for water control and distribution, 1993, FAO
- Photo album on Problems and Solutions

Questions for discussions

- What progress has been made in (the preparation of) the repair and rehabilitation of the canal systems?
- Is the repair and rehabilitation of the canal systems still on schedule?
- If not, why not?
- Why were some activities not carried out?
- What were the problems that you had? And will that delay further progress?
- Are the financial arrangements for the canal repairs functioning well?
- What needs to be done to make some further progress?
- What needs to be done during the following weeks?
- When shall we discuss again the follow up on the rehabilitation of the canal

SUB-MODULE 2.2

IRRIGATION STRUCTURES

EXERCISE 2C: INVENTORY OF EXISTING IRRIGATION STRUCTURES

Introduction

Different hydraulic structures are regulating and distributing the flow of water to the various parts of the irrigation system. They can be simple temporary constructions (earth plugs, stones, branches) or more permanent-durable structures with gates or other regulating devices. The structures play a very important role in the effective control of water flow in the right quantities. If farmers like to improve the operating and control of the distribution of the irrigation water it is therefore important that they understand the functioning of the different structures.

Objectives

- To understand the functioning of the different hydraulic structures in the distribution of irrigation water
- To define weak points and inadequate functioning and distribution of water
- To define criteria for the proper distribution of water to the irrigation blocks and sub blocks.

Expected outputs

- Inventory of the distribution and regulation structure in the canal systems.
- Definition of the operational system.
- Identification of the need for repair and/or construction of additional hydraulic structures.

Preparations required

- Conduct a short survey in the area to identify the different hydraulic structures present.
- Prepare drawing of the distribution network and identify the key distribution points and corresponding areas.
- Select an area for a field visit where different hydraulic structures can be studied.

Materials required

- Irrigation maps prepared by the farmers in exercise 1A (of FSP) and 2A (of FST).
- Large sheets of paper and markers.

Time required

- two and half hours

Timing

- Before start of irrigation

Procedure (Steps)

Plenary Introduction (15 min)

1. Review of the previous training session (Exc. 1, Part C).
2. Explain the specific objectives and expected output.

Brainstorming (20 min)

3. Put the irrigation map up prepared by the farmers in exercise 1A. Ask the farmers to locate all the different hydraulic structures in the scheme, to describe their functions and to categorise the structures according their functions in (a) distribution structures, (b) water-height regulation structures, and (c) crossing structures.

Field visit (30 min)

4. Visit the hydraulic structures present in the area and discuss the functioning of the structures.
5. Ask the farmers also to identify the simple temporary devices farmers use to regulate and distribute the water as well as to identify illegal or uncontrolled off-takes.

Small group discussion (40 min)

6. Ask the farmers to split up in small groups according to irrigation blocks.
7. Ask the groups to indicate on the map of their irrigation block, prepared during exercise 3A, the distribution network, key division points and the locations and types of temporary and permanent hydraulic structures.
8. Ask the groups to discuss the operation and control possibilities and limitations of the distribution of water through the canal system with the use of the different structures present.
9. Ask the groups to summarise the discussion results in two columns on a large sheet of paper, one for the possibilities and one for the limitations.

Plenary discussion (50 min)

10. Ask each group to present the map and the results of their discussions.

11. Discuss the presentations and identify where the operation and control of water distribution can be improved through the repair and/or construction of additional hydraulic structures in the irrigation system.

12. Agree on a tentative plan for short (repair) and long term (construction) of regulating structures. Summarise the results of the discussions.

13. Summary and Closure (Exc. 2, Part C).

Guidelines for (technical) preparations / questions for discussions

Irrigation structures:

a. **Water intake**
- Breaches: A temporary opening in the embankment of a field canal, made by a farmer whose field is to be irrigated.
- Gates: A gate of wood, masonry or concrete which the farmer opens to let water flow from the field canal into the field.
- Spills: A short pipe of PVC or concrete buried in the canal embankment. By removing the plug water from the field canal will flow into the field.
- Siphons: Curved pipes of PVC are filled with water and laid over the canal bank at every irrigation.

b. **Drop structures** (water height and slope regulating)
In order to create a gentler slope to prevent erosion of canal bed and canal banks the canal is split into sections. Part of each section is constructed in cut, and part in fill, with each section having a bed level which is lower than the canal section upstream of the section concerned.

c. **Bridges** (crossing)
A bridge is a structure that enables people or traffic to cross a canal

d. **Aqueducts** (crossing)
Aqueducts are self-supporting canal sections used to carry water across drainage canals, gullies or depressions.

e. **Culverts** (crossing)
Culverts and inverted siphons are buried pipes used to carry irrigation water underneath roadways, drainage canals, natural streams or depressions.

f. **Stilling basin** (velocity regulating)
A basin with protected walls and floor and which is filled with water. Its function is to convert fast flowing water into turbulence, so that the flow enters at low speed into the canal downstream of the basin.

g. **Spillway** (excess regulating)
A spillway is a structure that guides excess water safely to the drainage system.

h. **Off takes** (distribution)
Canal offtakes are usually sited just upstream of a structure for water-level control.

i. **Weirs** (water height regulators)
Weirs are sharp-crested, overflow structures that are built across open canals. Weirs can be used to measure water flow.

j. **Division boxes** (distribution)

- Proportional flow Division box with a constant proportional delivery: water remains proportional whether the water rises or falls in the source canal.
- Rotational flow Division box with gates; the total discharge of the source canal flows into a branch canal.
- Delivery on demand Use of cross regulators. The flow can be adjusted in function of the demand by regulating the opening of the gates.

Common problems in and around structures

Leakage The water upstream of a structure is higher than the downstream water level. Therefore water may search for another way underneath or along the structure, or even through a crack in the bottom or sides of the structure to this lower level. The moment that water has found a small path there is a leakage problem, and at the same time the beginning of an erosion problem. Leaking water will enlarge the path by washing out the soil and so the leakage will increase. Finally the structure will collapse if the process is not stopped. To avoid such problem, the structure can be equipped with vertical cut-offs. They hinder the water flow along and underneath the structure. The cut-offs are part of a structure and can be driven into the bed and the embankments of a canal.

Erosion Sections of an unlined canal immediately downstream of a structure or downstream of a lined canal section often suffer from erosion. Downstream of a structure the canal bed may suffer from a water jet that flows through a gate or pipe, or it will be caved in by water that spills over a weir. In both situations a stilling basin is needed to dissipate the energy of the incoming water. The basin should be constructed immediately downstream of the weir or pipe.

Siltation The deposition of soil and debris can effect the functioning of a structure. If, for instance, a stilling basin collects soil deposits the available water mass diminished and energy dissipation will be less effective. Similarly in the case of soil deposits in a flow division box, the division of the flow will be less accurate due to the changes in flow velocities and water levels. Siltation is difficult to avoid. Depending on the local conditions, large sand traps could be constructed at the upper end of the main canal.

Rot and rust Wooden and steel parts in structures suffer from being alternately wet and dry. The wooden parts will rot and disintegrate, while steel parts will rust, expand and get jammed in the slides. Routine maintenance is necessary to avoid these problems, or to reduce their effect to a minimum.

For more technical information, see also:

- Irrigation water management training manual No. 8, Structures for water control and distribution, 1993, FAO
- Photo album on Problems and Solutions

Questions for discussions

- What do you use for the intake of water from the field canal into the field?
- What is the effect of the different methods used for water intake on the condition of the field canal banks?
- Which structures are used in the distribution of water to all the fields?
- What kind of water distribution system do you have?
- How is the water flow control carried out?
- Do special gate operators operate the gates?
- Who is responsible for the maintenance of the structures?
- Are all structures still functioning well?
- Does the condition of (some of) the structures influence a proper water distribution?
- Are more structures needed to improve the water distribution?
- Who is going to construct those additional structures needed?
- Could it be a better idea to organise the construction of additional structures through a WUA?

EXERCISE 2D: PLANNING FOR REPAIR AND/OR CONSTRUCTION OF ADDITIONAL IRRIGATION STRUCTURES

Introduction

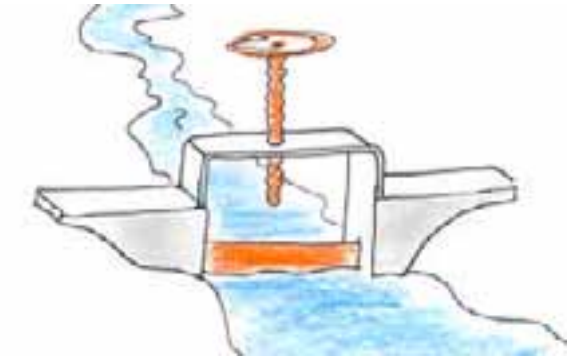
After having identified where the operation and control of water distribution can be improved through the repair and/or construction of additional hydraulic structures (exercise 2C), farmers need to decide on how to carry out the repairs and additional constructions. Farmers will investigate the condition of the structures and identify proper repair methods. They will discuss how to organise the construction of the additional structures and, finally, a plan of action for the repairs and/or constructions will be developed.

Objectives

- To prepare a plan of action for the repair (short term) and construction (long term) of additional irrigation structures.

Expected outputs

- Detailed workplan for repair and construction of additional irrigation structures (including procedures, who will do what, materials and tools, and financial contributions).



Preparations required

- Investigate the irrigation structures identified for repair in exercise 2C and identify how those structures can be repaired.
- Work out the different steps in repairing those structures, materials and tools needed.
- Select an irrigation block for a field visit, where different kinds of needed repairs and construction have been identified.

Materials required

- Irrigation maps prepared in exercise 2A and 2C.

Time required

- Three and half hours

Timing

- Before the fields need to be irrigated

Procedure (Steps)

Plenary Introduction (15 min)

1. Review of the previous training session (Exc. 1, Part C)
2. Explain the specific objectives and expected output.

Plenary discussion (20 min)

3. Recall the selection made of irrigation structures for repair or improvements (exercise 2C) and discuss where to go for a field visit and to develop the planning for the repair and construction activities.

Field visit/activity (2 hours)

4. Visit with the farmers the irrigation block selected. Ask the farmers to observe the structures identified for repair or improvement before the irrigation season and which need to be rehabilitated over time. Identify and discuss the problems, needed repairs and constructions.
5. Explain and discuss the procedures (steps, materials, tools needed) how each structure can be repaired or constructed in a proper way.

Plenary discussion (1 hour)

6. Summarise all the planned repairs and constructions. Discuss the materials, tools and labour skills needed.
7. Discuss the planning for the repairs and constructions to be carried out before the season and over the season, including who will be responsible for the materials and tools needed, who will help in the repair, when will the repairs be carried out and how it will be financed.
8. Discuss the role of the WUA in organising the repairs and constructions
9. Summarise the decisions taken on the planned repairs / rehabilitation of the irrigation structures and prepare a plan of action with specifications on materials, tasks for each farmer, labour, time schedule, etc.
10. Summary and Closure (Exc. 2, Part C).

Guidelines for (technical) preparations / questions for discussions

For more technical information, see also:

- Irrigation water management training manual No. 8, Structures for water control and distribution, 1993, FAO
- Photo album on Problems and Solutions

Questions for discussions

- What kinds of problems do we have, leakage, erosion, siltation or rot and rust?
- What has caused these problems and how could it have been prevented?
- Will everybody help in the repair, financially and/or through contributing labour?
- Where will you get the materials and tools for the repair?
- How will the costs for materials, use of tools and hired labour be financed?
- Will each irrigation block be responsible for their own repairs?
- Could it be a better idea to organise the repairs through a WUA?
- Do you think you can carry out the construction of the structures yourselves or do you need assistance? And where can you get it?

EXERCISE 2E: FOLLOW UP OF PLANNED REPAIRS AND LONG-TERM REHABILITATION WORKS ON IRRIGATION STRUCTURES

Introduction

In most cases the planned repairs and long-term rehabilitation works on irrigation structures will not be carried out during the sessions of the FST. It is more practical to complete the repairs in, for example, one-week time than to spread it out over a large number of half-day FST sessions. But during the sessions it is important to pay regularly attention to the follow up of the (planned) repairs and long-term rehabilitation works on the irrigation structures.

Objectives

- To monitor the progress of the planned irrigation structure repairs and rehabilitation works.
- To adjust plan and tasks of repair and rehabilitation of irrigation structures

Expected outputs

- An updated list of activities and assignments which need to be carried out during the following weeks.

Preparations required

- None

Materials required

- The rehabilitation plan for the irrigation structures prepared during exercise 2D

Time required

- One hour

Timing

- Prior to start irrigation season

Procedure (Steps)

Plenary Introduction (15 min)

1. Review of the previous training session (Exc. 1, Part C).
2. Explain the specific objectives and expected output.

Field visit (50 min)

3. Visit with the participants of the FST the location where an irrigation structure is under repair.
4. Recall the planning prepared for the repair of the irrigation structure and ask the responsible farmers to report on the progress made.
5. Discuss the problems encountered and identify solutions how they can be solved.
6. Discuss and decide on what needs to be done during the following weeks as well as who will be responsible for those activities.
7. Summarise the plan of action for the following weeks.

Guidelines for (technical) preparations / questions for discussions

For more technical information, see also:

- Irrigation water management training manual No. 8, Structures for water control and distribution, 1993, FAO
- Photo album on Problems and Solutions

Questions for discussions

- What progress has been made in (the preparation of) the repair of the irrigation structures?
- Is the repair of the irrigation structures still on schedule? If not, why not?
- Why were some activities not carried out?
- What were the problems that you had? And will it delay further progress?
- Are the financial arrangements for the irrigation structure repairs functioning well?
- What needs to be done to make some further progress?
- What needs to be done during the following weeks?
- When shall we discuss again the follow up on the repair of the irrigation structures?

SUB-MODULE 2.3

WATER DISTRIBUTION AND SYSTEM MAINTENANCE

EXERCISE 2F: DISTRIBUTION SYSTEM

Introduction

The effective operation of the irrigation system will be to a large degree determined by the appropriate distribution of water, timely and in sufficient quantities, to each block and farm. The needed water supply depends on two basic factors (size of serving area and, crops to be irrigated). The distribution of water is determined by discharge, duration and the interval between irrigation.

Objectives

- To evaluate and, where possible, improve the water distribution.

Expected outputs

- A plan of actions to improve the water distribution.

Preparations required

- none

Materials required

- Measuring tape at least 5 meters long, 4 stakes, stopwatch or watch capable of measuring time in seconds, floating object (bottle or coconut).
- Maps prepared by the farmers of their own irrigation blocks during exercise 2A.
- Large sheets of paper and marker.

Time required

- Three hours

Timing

- No timing requirements

Procedure (Steps)

Plenary Introduction (15 min)

1. Review of the previous training session (Exc. 1, Part C).
2. Explain the specific objectives and expected output.

Field visit (2 hours)

3. Go with the farmers to the water source or where the main irrigation canal enters the area. Ask the farmers to indicate on the irrigation map (exercise 1A of FSP) how the water is distributed to the blocks, sub-blocks and farmer's fields.
4. Walk with the farmers the entire distribution system from where the water enters the area, flows into an irrigation block, sub-block and farmer's fields.
5. Discuss at each distribution point, water offtakes and water inlets, how the water distribution takes place (functioning), who is responsible and if there are any problems (unequal distribution between areas (head/tail problem) and in time, illegal or uncontrolled water uses, etc.).
6. Discuss, at a point where water is canalled to a block or sub-block, how to measure the quantity of water (discharge) available for the block.
7. Explain how the discharge can be measured and practice this with the farmers. Ask the farmers to estimate the total irrigated area in the block and the available water per hectare.

Plenary discussion (50 min)

8. Summarise the functioning of the water distribution system, using the irrigation map (exercise 1A, FSP). Ask the farmers to recall the problems observed and discussed in the field and to locate them on the map.
9. Discuss with the farmers how the distribution system could be further improved and better managed to obtain a more equal distribution of the water over a larger area. Include in the discussions the roll of the WUA.
10. Recall the estimated available water per hectare. Discuss with the farmers if this is enough, too much or too little.
11. Ask the farmers how they determine the amount of water / the irrigation time needed to irrigate their fields and discuss the different methods mentioned.

12. Explain and demonstrate on a large sheet of paper how the water demand of a one-hectare sized field can be calculated. Compare the results of the calculation with the estimated water supply and discuss the result(s) with the farmers.

13. Discuss and prepare a plan of action to improve the water distribution in the irrigation system.

14. Summary and Closure (Exc. 2, Part C).

Guidelines for (technical) preparations / questions for discussions

Calculation of the peak water demand

The peak scheme water demand is the discharge in litres per second (l/s) required to meet the peak crop water requirements, plus the losses which occur in the field application and the distribution system (irrigation efficiency).

Table: Indicative values for crop water requirements and growing periods

Crop	Seasonal crop water requirement (mm)	Crop duration (Days)	Average crop water requirement* (m^3/d/ha)	peak crop water requirement** (m^3/d/ha)
Cereals	450-650	120-140	38-46	75-93
Vegetables	400-600	90-120	44-50	89-100
Rice (paddy)	800-**1500**	90-**120**	89-125	178-250

* The average crop water requirement (m^3/d/ha) = Seasonal crop water requirement (m^3/ha) X 10 / Length of crop duration (days)
** The peak crop water requirement (m^3/d/ha) = average crop water requirement (m^3/d/ha) x 2

Table: Indicative values of distribution efficiency (%) in small schemes (<200 ha)

		Earth canals			Lined canals	Pipes
		sand	Loam	clay		
		80	85	90	95	95
Surface	60	**48**	**51**	**54**	**57**	**57**
Sprinkler	75					**71**
Drip	90					**86**

Example: calculation peak water supply of one-hectare paddy (rice, 120 days) field.

The peak crop water requirement (m^3/d/ha) = 125 m^3/d/ha X 2 = 250 m^3/d/ha
The distribution efficiency (%) in a small irrigation schedule with clay canals and surface irrigation = 56 %
Peak water supply is 250 m^3/d/ha / 0.56 = **463** m^3/d/ha. (m^3/d/ha X 0.0116 = l/s/ha).

Flow estimation procedure

The following presents the procedure for measuring the discharge using a floating object Equipment: a) Measuring tape at least 5 meters long, b) Stakes, c) Stopwatch or watch capable of measuring time in seconds, and d) Floating object such as a bottle or coconut.

Procedure (steps)

1. Select a straight section of the canal at least 10 meters long. The shape of the canal along this section should be as uniform as possible.
2. Place two stakes, one each side, at the upstream end of the selected portion of the canal. They should be perpendicular to the centreline of the canal (A). Measure 10 meters or more along the canal.
3. Place two stakes at the downstream end of the selected section of the canal, also perpendicular to the centreline of the canal (B).
4. Place the floating object on the centre line of the canal at least 5 m upstream of point A, and start the stopwatch when the object reaches point A.
5. Stop the stopwatch when the floating object reaches point B, and record the time in seconds.
6. Repeat steps 5 and 6 at least four times in order to determine the average time necessary for the object to travel from point A to point B. The object should not touch the canal embankment during the trial. But if it does, the operation must be repeated and the time for the bad trial must not be included when calculating the average time.
7. Measure the following in the selected canal section: the canal bed width (b), the surface water width (a), and the water depth (h). The cross-section within the selected portion of the canal will usually not be regular, and so b, a and h need to be measured in several places to obtain an average value. If working with a canal with a rectangular cross-section the surface water width a will equal the bed width b.
8. Calculate the average flow velocity (V): $V = 0.75 \times L/t$, where t is the travel time in seconds and 0.75 a reduction factor for subsurface which flows slower.
9. Calculate the wetted area of the cross-section A, using the following formula: $A = (b + a)/2 \times h$ (b, a and h are average values)
10. Calculate the discharge, Q in the canal, using the following formula: $Q = V \times A$ m³/s or $Q = 1000 \times V \times A$ l/s.

For more technical information, see also:

- Irrigation water management training manual No. 1, Introduction to irrigation, 1995, FAO, Chapter 1
- Irrigation water management training manual No. 3, Irrigation water needs, 1986, FAO
- Irrigation water management training manual No.4, Irrigation scheduling, 1989, FAO, Chapter 3 and 4
- Irrigation water management training manual No. 7, Canals, 1992, FAO, Chapter 3
- Irrigation water management training manual No. 8, Structures for water control and distribution, 1993, FAO

- Irrigation water management training manual No. 10, Irrigation scheme operation and maintenance, 1996, FAO, Chapter3
- Photo album on Problems and Solutions

Questions for discussions

- How and who is controlling the distribution of water?
- What influence do the farmers have on the distribution of water?
- With a better distribution, would it be possible to irrigate more land?
- Does every body get enough water during all periods?
- Who gets first water, who gets last?
- Are there conflicts, fights on water distribution?
- Could it be possible for the farmers to increase their influence on the distribution of water through a WUA?
- How do you plan the time needed to irrigate your fields?
- Are there many water losses when you irrigate? What kind of losses?
- Does the water level in the (field) canal fluctuate a lot?
- Is every body irrigating at the same time or on rotation?
- Is there often not enough water for a proper irrigation of you field(s)?
- Do all farmers respect the rotation schedule?
- Are some farmers receiving more water then others?
- Do some areas receive more water then others?
- Do you have to pay a water-fee for the irrigation water?
- How does the irrigation office measure the amount of water used?
- Do they use measuring tools/structures?

EXERCISE 2G: REVIEW OF OPERATION AND MAINTENANCE OF THE IRRIGATION SYSTEM

Introduction

A properly designed and constructed canal system and hydraulic structures will functioning well for as long as they are operated well and maintained with care. That means that the irrigation system needs to be operated in an optimal way. That there is neither leakage nor erosion, that the canals and structures are clean, and that there are no rusty or rotten movable parts in the structures. A good properly organised operation and maintenance can optimise functioning and prolong the life of canals and structures.

Objectives

- To monitor operation and maintenance of canals and structures.

Expected outputs

- An up-dated operation and maintenance plan.

Preparations required

- None

Materials required

- Large sheets of paper and markers.

Time required

- two and half hours

Timing

- Before the end of the irrigation season

Procedure (Steps)

Plenary Introduction (15 min)

1. Preview of the previous training session (Exc. 1, Part C).

2. Explain the specific objectives and expected output.

Field visit (30 min)

3. Visit with the farmers one or two distribution structures and recall the operation rules for the water distribution. Ask the responsible farmers to report on the operation.

4. Discuss the problems encountered and identify solutions how they can be solved. Discuss and decide on what needs to be done to improve operation. Update the plan of operation.

Brainstorming (20 min)

5. Ask the farmers to mention all the activities needed to properly maintain irrigation canals and structures. List the maintenance activities on a large sheet of paper in two columns, for canals and structures one each.

6. Summarise and complete the list of maintenance activities. Discuss shortly the final list of maintenance activities.

Small group discussions (40 min)

7. Split the farmers up in small groups of 4-5 persons and ask each group to discuss, for each of the listed maintenance activities:
   - Why it should be done (reason),
   - Who is responsible for the implementation (farmers, irrigation department, etc.,
   - Who carries out,
   - Which part of the season/year is it normally carried out.

8. Ask the groups to summarise the results of their discussion in a table on a large sheet of paper.

Plenary discussion (50 min)

9. Ask the groups to present the results of their discussions. Compare and discuss the results of the group presentations.

10. Discuss if, and if so, how maintenance should be improved, how that can be organised and what the role of the WUA could/should be in this. Prepare with the farmers a maintenance plan for the coming season.

11. Summary and Closure (Exc. 2, Part C)

Guidelines for (technical) preparations / questions for discussions

Maintenance of the canal and structures

Maintenance is usually carried out in between two irrigation seasons, or at times of low water demands. It consists of Inspecting, cleaning, weeding, de-silting, re-shaping, painting, lubricating and executing minor repairs.

- A Canal system, and in particular the structures, can be safeguarded from problems such as leakage, erosion, rot and rust by regular inspection and immediate repair action.
- Bushes or trees on canal embankments should be removed. They may obstruct the water flow and their roots will open the compacted soil in the banks and cause the development of leakage.
- Plants, silt and debris in the canal and structures should be removed. While cleaning the canal bed, care must be taken that the original shape of the cross-section is kept. For this, a wooden frame, or template, with the exact dimensions of the designed cross-section of the canal being cleaned, can be of great help.
- Breaches and rat holes in the embankments should be filled with compacted soil, inside as well as outside of the embankment. For compacting, the soil should be wetted.
- Structures are alternately wet or dry, and this causes rot in wooden parts and rust to form on iron parts. Frequently painting preserves these parts from rot or rust.
- To prevent movable iron parts like sluice gates and valves from being jammed, regular lubrication is essential.
- Weak sections and sections of canal embankments where people or animals cross the canal should be strengthened with compacted soil or with bricks.
- Eroded sections of a canal should be rebuilt to the original shape.

For more technical information, see also:

- Irrigation water management training manual No. 7, Canals, 1992, FAO
- Irrigation water management training manual No. 8, Structures for water control and distribution, 1993, FAO
- Irrigation water management training manual No. 10, Irrigation scheme operation and maintenance, 1996, FAO, Chapter 4
- Photo album on Problems and Solutions

Questions for discussions

- Is everybody happy how the irrigation system is operated?
- What could be improved in the operation of the irrigation system?
- What needs to be changed in the operation to improve the water distribution?
- Is everybody assisting in the maintenance of the canal system?
- Is there a formal organisation structure and plan for maintenance?
- Who organise and mobilise all farmers for maintenance?
- Are regular inspections of the canals and structures carried out?
- Who is responsible for the inspections?
- Do you report maintenance problems to the person/office responsible?
- What could be the role of a WUA in organising maintenance?