Chapter 7

Minor scheme extension and design

7.1 INTRODUCTION

This chapter covers important issues involved in the creation of a new irrigated area, by either extending an existing scheme or designing a new, independent one. Some of the basic problems are considered, and procedures are given for extending an existing scheme.

It is the aim of this chapter to present to the readers some of those issues that they must pay attention to before making any decision to start construction.

The discussion is limited to small schemes - with a command area not greater than 50 ha - as for such an area discharges in new canals would be small, and this limits the size of these canals. When the target area is larger than 50 ha, or where difficult design problems are involved, the irrigation extension officer is requested to contact an irrigation engineer for advice.

It should be emphasized here that the participation of future beneficiary farmers is a very important factor in designing and constructing new irrigation networks. If farmers are encouraged to collaborate from the beginning, then operation and management of the scheme can well be organized, and farmers will hopefully feel an element of personal pride in the scheme. This will be far more difficult if individual farmers are not involved in design and construction, and are arbitrarily assigned to a new scheme.

7.1.1 Minor scheme extension

Land which is adjacent to an existing irrigation scheme could be considered for incorporation into the scheme. When studying such an extension, several questions need to be answered:

- Is the soil suitable for irrigated crop production ?
- Is the topography suitable for irrigation?
- Who owns the area or who controls tenancies, and hence, who will use the new fields?
- How much water will be needed to irrigate the new area?
- Is enough water available from the source?
- Is water supply to the new fields possible by extending the existing irrigation canal network, or will a new one have to be constructed?

7.1.2 New scheme planning

The same questions apply when the creation of a new, independent irrigation scheme is considered. The crucial problem, which should be solved first, is to locate a water source with

good quality and quantity. Another question to answer is "How to get water from the source?" Can the water be extracted by gravity or will it be necessary to install pumps?

Experiences from neighbouring irrigation schemes can be used for the design of a new scheme. For instance, aspects that can be considered when looking at nearby schemes include:

- What are the types of canals in neighbouring schemes, and are they satisfactory?
- What are the sizes of the farmers' fields in those schemes, and should they be larger or smaller in the new scheme?

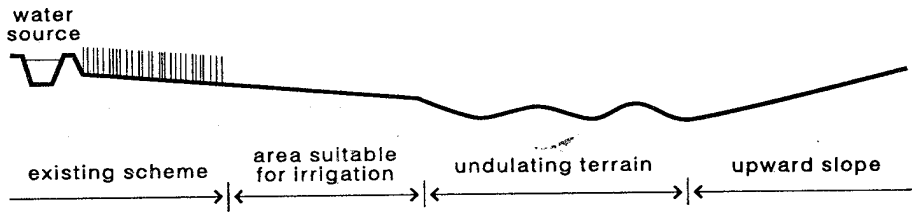
The following sections cannot cover these questions in detail because many factors depend on local circumstances, which of course vary from place to place. This chapter rather tries to give the reader an idea as to how to approach the problems associated with extending an old or constructing a new irrigation scheme. Again it is emphasized that for complicated matters an irrigation engineer should be consulted for help.

The questions about soil characteristics and land ownership will not be discussed here, because they are beyond the scope of this Manual.

7.2 TOPOGRAPHY OF THE AREA CONSIDERED

Any area which is considered for an extension or for a new scheme should not have steep slopes but be rather flat, with a gentle slope downwards from the existing scheme or from the water source. See Figure 46, which shows the profile of the land area along the line from the water source to possible new irrigation areas. Such a land profile map can be used to judge whether extension of a old scheme or construction of a new irrigation scheme is feasible with regard to water delivery.

FIGURE 46
Extension of an irrigation scheme



When it is not certain whether the new area can be irrigated without difficult problems, an irrigation engineer should be consulted. The engineer can make a detailed topographical survey of the area and can give advice.

7.3 WATER REQUIREMENTS

When an area generally suitable for irrigation is identified, the exact area that would receive irrigation water should be determined. Methods of calculating the surface area of a field are presented in Training Manual 2: *Elements of Topographic Surveying*.

After the surface area to be irrigated is determined, the irrigation needs for this area must be calculated. This can be done with the help of Training Manual 6: *Scheme Irrigation Needs and Supply*.

In the case of a scheme extension, the irrigation water needs for the extension area will be added to that of the old scheme, so the calculation must show that the total irrigation water needs will not exceed the capacity of the intake structure or the main canal of the original scheme. When the supply capacity of the intake structure or the main canal is not enough to cover the needs of the extended area as well as of the existing area, the supply capacity of the main canal and the structure will have to be expanded before the extension can become feasible.

7.4 WATER CONVEYANCE TO THE NEW AREA

If enough water is available at the water source and the capacity of the intake and the main canal is large enough (or can be expanded), water for the new area can be supplied by extending the existing canal network. The capacity of the existing canal network should be determined, and should be compared to the discharges which are required for the extended scheme. When the capacity of the network is sufficient to transport the required amounts of water, only the canals in the extension area need to be constructed. If the network capacity is not large enough to transport the required discharges, its capacity should be increased. In this case, not only have new canals to be constructed, but also the existing supply canals will have to be enlarged.

A method for estimating a canal's capacity, as well as a method for increasing it, are given in Annex 1 of this Manual.

If it is for a new scheme, a complete layout of the canal network will have to be established, starting at the water source. A discussion of how to design a network layout is not given here. Since the network layout depends on local circumstances, such as soil type, slopes, crops, etc., only some general remarks can be made here.

It is advisable that feeder canals are placed along ridges or across the main land slope so that the water level in these canals can be kept as high as possible. Furthermore, the layout of a canal network should coincide as far as possible with the boundaries of existing farms, and crossings by roads and natural drains should be avoided.

Attention must be paid to the water level in the new canals. In order to supply a field with water, the water level in the supply canal should be at least 10 cm higher than the highest part of the field to be irrigated.

The method for constructing new irrigation canals is described in Annex 2.

7.5 MINOR SCHEME EXTENSION - AN EXAMPLE

An example of a minor scheme extension is presented in this section. After general description of the scheme, the procedure to follow in extending the scheme is given.

Description of the irrigation scheme

An existing irrigation scheme is located along a small river and the area of the scheme is 80 ha (800 m wide by 1000 m long). The terrain has a slope to the east and to the north, although the slope to the north is relatively flat. The scheme is divided into 8 blocks of equal size, with a tertiary canal supplying water to each block. Irrigation water is diverted from the river at a rate of 200 l/s. This flow is divided over the canal network in such a way that each block receives 25 l/s. An area which is located immediately north of the scheme is being considered for incorporation into the scheme. See Figure 47.

The farm ditches each have a length of about 100 m. See Figure 48.

The procedure for extending the scheme concerned involves the following steps:

Step 1 Mark the area for extension and measure the size of the new area.

Step 2 Mark the alignment of the canals in the extension area.

Step 3 Check the slope of the proposed canal alignments.

Step 4 Calculate the required discharges in the new canals.

Step 5 Add the irrigation needs of the extension to the water needs of the existing scheme, and check the capacity of the water intake structure and the availability of water at the source.

Step 6 Determine the required discharges of the existing canals which will supply the new area and check their capacities.

Step 7 If necessary, enlarge the capacities of the intake structures or existing canals.

Step 8 Determine the dimensions and elevations of the new irrigation canals and construct them.

FIGURE 47
Existing irrigation scheme and location of possible extension

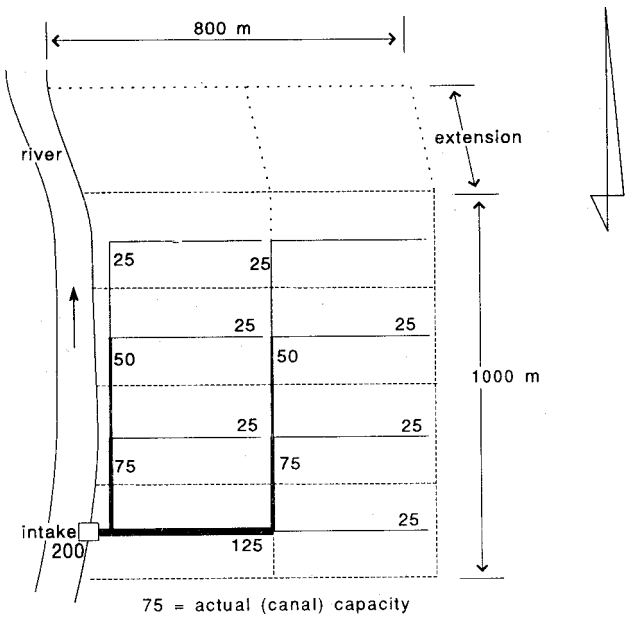
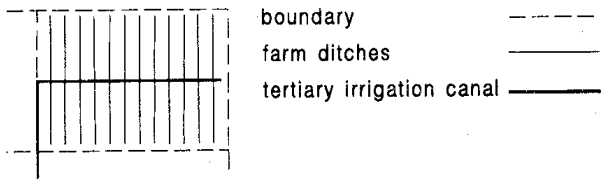


FIGURE 48
Block with tertiary canal and farm ditches



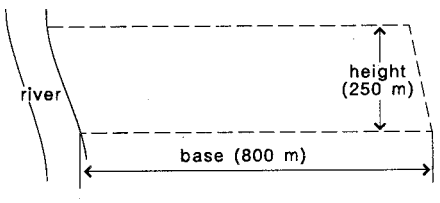
Step 9 Construct the new structures and, if necessary, enlarge the capacities of the existing structures.

The first eight steps are described in detail below, but Step 9 is beyond the scope of this manual and is discussed in Training Manual 8: *Structures*.

Step 1 *Mark the area for extension and measure the size of the additional area*

The boundaries of the area concerned are marked. Check the field slope: the area for extension should have good soil and a gentle slope downwards from the existing scheme. This information can be obtained from observations in the field. For example, runoff during the rainy season shows the direction of the slope.

FIGURE 49
Determining the surface area of the extension



The new area is measured and its surface area is calculated (See Figure 49).

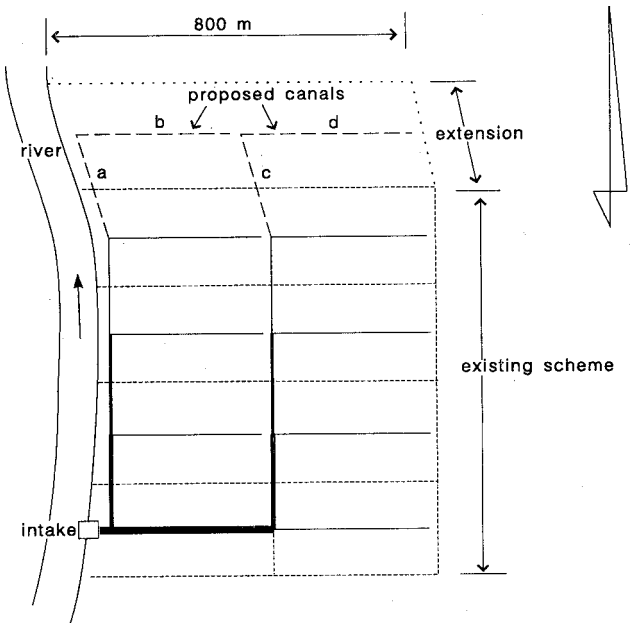
The new area has the shape of a parallelogram. The length of the area, or base of the parallelogram, is 800 m. The width of the area, or height of the parallelogram, is 250 m. So the surface area is 800 x 250 = 200 000 m^2. (See also Section 1.1.3 of Training Manual 1: *Introduction to Irrigation*).

The new area is divided into two blocks of 100 000 m^2, i.e., 10 ha, each. The new blocks thus have a similar surface area to the blocks in the existing scheme.

Step 2 *Mark the alignment of the canals in the extension area*

When studying the alignments of new canals, attention should be paid to the size of irrigation block to make. The block size should be equal to that in the existing scheme so that the farm ditches can have about the same length as the existing farm ditches. The new area in this example is divided into two blocks. (See Figure 47). Figure 50 shows the alignment of the new canals.

FIGURE 50
Proposed alignments of new irrigation canals



Step 3 *Check the slopes of the proposed canal alignments*

Determine the slopes of the proposed canal alignments. When the slope of the terrain is between 0.05% and 0.15%, the canals can follow the same slope as the terrain. If the slope is less than 0.05%, the cross-section of the new canal needs to become rather large, and if it is steeper than 0.15% then it may be necessary to construct the canal partly in cut and partly in fill, with drop structures to slow down the flow velocity. (See also Figure 38 in Section 5.6.2). When the field slope of a proposed canal alignment is not between 0.05% and 0.15%, it is advisable to consult an irrigation engineer for guidance.

A method to determine the slope of a canal alignment is given in Annex 3.

Canals a , b and c , d are the proposed new canal alignments. The slopes of these four alignments are between 0.05 and 0.15%, and the canals to be constructed can have the same slope as that of the terrain.

Step 4 *The irrigation water needs for the new blocks can be calculated*

Calculate the discharge required in the new canals. The peak irrigation flow for the existing scheme was 2.5 l/s/ha. (For the method of calculation, see Training Manual 6: *Scheme Irrigation Needs and Supply*). The water requirement for the extension area will be the same if the same crops are grown, and thus 2.5 x 10 = 25 l/s is required for each new block. So, canals a , b and c , d should each have a capacity of 25 l/s.

Step 5 *Add the irrigation water needs of the extension area to the needs of the existing scheme, and check the capacity of the water intake structure and of water availability*

The irrigation requirements for the new area are 2 x 10 x 2.5 l/s, or 50 l/s.

The irrigation needs for the existing scheme are 80 x 2.5 = 200 l/s.

The irrigation water needs for the extended scheme are thus 200 + 50 = 250 l/s. The capacity of the intake structure should thus be equal to or larger than 250 l/s.

In this example, let us assume that the intake structure of the existing scheme has enough capacity to supply the additional water demand of the new area.

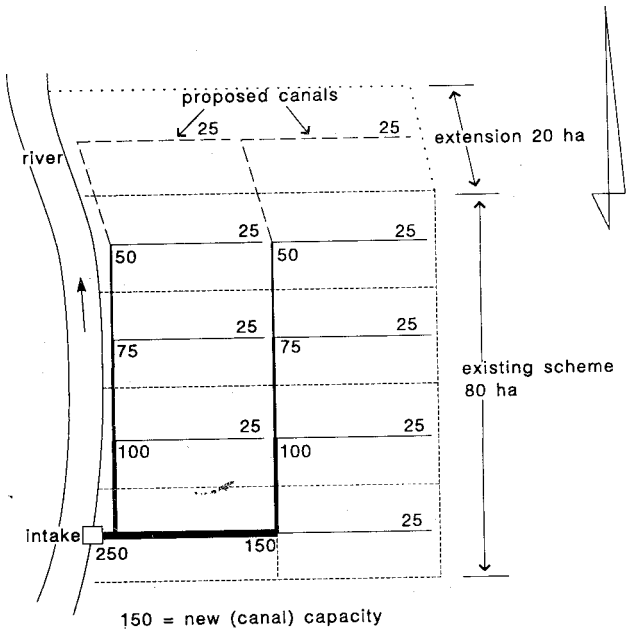
Step 6 *Determine the required discharges of the existing canals which will supply the new area and check their capacities*

The discharges required in the new canals are added to the actual discharges of the existing canals which supply the new blocks. See Figure 51, where the new discharges in the canal system are given.

Having determined the new discharges required, the capacity of the existing canals should be verified. The procedure for estimating canal capacity is given in Chapter 2 of Annex 1 of this Manual. The estimation for canal section **e** in Figure 50, for example, shows that Q_{max} = 33 l/s for that canal section.

The capacity of this canal section will have to be 50 l/s (See Figure 51) so this section will need to be enlarged.

FIGURE 51
Extended scheme and required discharges



Step 7 *If necessary, enlarge the capacities of the existing canals*

The capacities of the existing canal sections concerned should be enough to transport the new discharges. When they are too small, the canals should be enlarged.

A canal's capacity can be enlarged by raising the canal embankments or by widening the bed width. For the procedures to do this, see Section A1.3 of Annex 1.

Step 8 *Determine the dimensions and elevations of the new canals and construct them*

Since the slopes of the new irrigation canals are between 0.05% and 0.15% (from Step 3), Table 1 (in Chapter 3) can be used to determine the dimensions of the canals. The canals will be made with earth. For a discharge of 25 l/s the table gives a bed width of 20 to 25 cm and a water depth of 15 to 25 cm. The minimum required free board for such a canal is 20 cm (see Chapter 3). The cross-section of gently sloping canals can thus be given a bed width of 25 cm and a height of 45 cm. The clay-rich soil in the area allows a side slope of 1:1 to be used safely.

Attention should be paid to the water level in the canals. To supply a field with water, this level should be at least 10 cm higher than the field level. If necessary, the water level can be raised by installing checks in the canal, but then care must be taken to ensure that the embankments of the canal are high enough to maintain the minimum required free board above this higher water level.

Having determined the dimensions of the cross-sections of the new canals, their construction can start. See Annex 2 of this Manual for construction of canals.