Small-scale, low-cost, environment friendly irrigation schemes: sites selection and preparation of full work tender dossier
EuropeAid/137393/DH/SER/MK

MINISTRY OF AGRICULTURE, FORESTRY AND WATER ECONOMY

**Component 2:**
**Support for stakeholders involved in planning and implementation of the irrigation sector policy**

# TRAINING MANUAL
# For Institutional Stakeholders

## SUBJECT:

- **Main System Irrigation Management**
  **(Includes Transfer of Irrigation Management Services)**

Date: 02 July 2018

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A project implemented by:

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# 1 EXECUTIVE SUMMARY

According to the Terms of Reference (ToR), the objective of Component 2: "Support for stakeholders involved in planning and implementation of the irrigation sector policy" is to provide capacity building of stakeholders in irrigation management, targeting the Water Management Directorate (WMD) at the Ministry of Agriculture, Forestry and Water Economy (MAFWE), and the Joint Stock Company for Water Management (JSCWM) and farmer's groups at the selected sites.

The support to the institutional stakeholders (WMD at MAFWE and JSCWM) should

1) provide clarifications and transfer necessary knowledge about practical application of the selected standardised methodology used to prepare the outputs under Component 1
2) support to successfully carry out the ongoing policy to transfer the responsibility for water management to water users

This support will be provided through the following trainings subjects:

1) **Methodology used for Pre-feasibility studies**
2) **Strategy to transfer/share water management to irrigation water users (Irrigation Management Transfer - IMT) (Workshop)**
3) **System Irrigation Management**
4) **Methodology to be used for feasibility studies**
5) **On farm irrigation management and participatory methods**
6) **Methodology to be used for Main Designs**

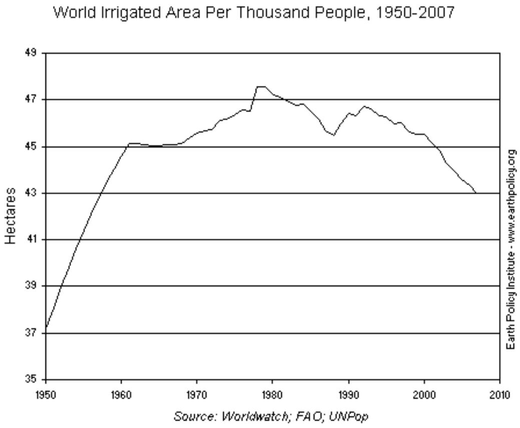
**Capacity needs assessment**

During the training, a capacity needs assessment questionnaire will identify the following subjects of interest for future training. The subjects of interest up to now are:

1) **Methodology used for Pre-feasibility studies**
2) **Strategy to transfer/share water management to irrigation water users (Irrigation Management Transfer - IMT) (Workshop)**
3) **System Irrigation Management**
4) **Methodology to be used for feasibility studies**
5) **On farm irrigation management and participatory methods**
6) **Methodology to be used for Main Designs**
7) **Formation of water users' associations (WUAs)**
8) **Workshop(s) on water tariff methodology.**
9) **Tender Dossier Preparation (following latest EU PRAG rules)**
10) **Application procedures to different donors / multilateral and bilateral org.**

# 2 IRRIGATION MANAGEMENT

## 2.1 INTRODUCTION




- The world irrigated area has increased from 94 Million (M.) hectares (ha) in 1950 to over 287 M. ha in 2007 (Earthscan/IWMI, 2007)
- The world irrigated area per thousand people has varied relatively little, from 37.3 in 1950 to 43.0 ha/thousand people in 2007
- The world irrigated area per thousand people has declined from a high of over 47 (in the late 1970s) to only 43 ha/ thousand people in 2007. Macedonia in 2007 had 79.638 ha/ 2,065 M = 38 ha/ thousand people.
- Growing populations and pressures on agricultural production have meant increasing food insecurity around the globe. The number of hungry people in the world declined from 878 million in 1970 to 825 million in the mid- 1990s, but it has been rising ever since.
- Food demand will rise to almost twice of present-day levels in the next 50 years, due to rising population, but also changing dietary habits with economic development. (Diets will change to consumption of more cereals, livestock – 25% for grains for livestock feed- and fish products).
- Agriculture continues to be the largest consumer of water, taking 71% of all withdrawals, compared with 18% for industry and 8% for domestic/municipal use.
- Water, rather than land, has become the limiting constraint on development
- Land and water resources are being degraded through erosion, pollution, salinization, nutrient depletion and the intrusion of seawater
- The climate change will affect existing temperatures and patterns of precipitation. Agriculture nearer the equator – where poorest countries are situated – will be affected most.
- The growing demand of cities and industries for water offers possibilities for employment and income, but it also shifts water out of agriculture, puts extra strain on rural communities and pollutes water.
- New investments in irrigation and agricultural water management have the potential to support economic growth within agriculture and other areas.
- An increase in global trade in food products and consequent flows of virtual water, (If 1t of grain requires 2t of water to grow, importing 1t of grain is equivalent to importing 2t of water) offers prospects for better national food security and to relieve water stress.
- More attention to green water resources (water provided by rainfall, stored in the root zone and consumed by natural vegetation and rainfed agriculture), not just to blue water resources (in lakes, rivers and aquifers)
- Water management institutions have been slow to adapt to new issues and conditions.
- The institutional arrangements and management processes change over time as the pressure on the renewable resources increases. To meet the increasing demand will require to:
- use more blue water, but more marginal-quality water for agriculture, more green water by upgrading rainfed agriculture; and import more virtual water in water scarce regions.
- increase the productivity of blue and green water to reduce the abstraction;

- manage demand for agricultural water by changing diets and reducing postharvest losses

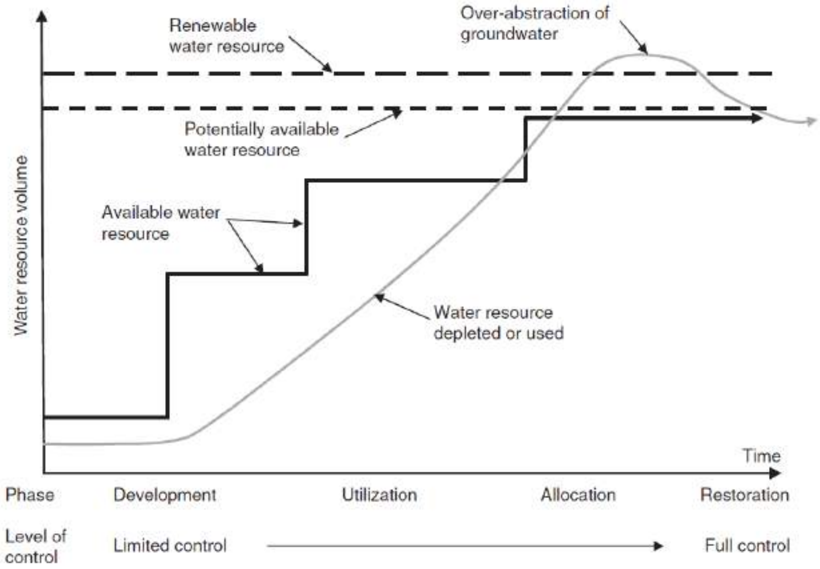



**Figure 2-1 Phases of river basin development. (Molden et al., 2001.)**

## 2.2 THE WAY FORWARD

Water resources and irrigation managers will need to think more broadly, to understand and consider the multiple uses of water and integrate the management and use of these resources.

- Take in account the impacts of their management on the natural environment; (levels of water abstraction impact of agricultural pollutants in drainage wastewater on natural ecosystems.
- Greater appreciation of rainfed agriculture as well,
- Greater understanding of and commitment to the needs of vulnerable groups and the poor.
- Ensuring secure and reliable irrigation water supplies to tail-ends, where these groups are often found,
- Efficiency and productivity need to become keywords for irrigation managers. Efficiency in all operations:
    - Water abstraction kept to a minimum, leaving water in rivers or aquifers for the environment
    - Water is delivered where, when and in the quantity required.
    - Improving scheduling procedures to make better use of rainfall
    - Waste needs to be reduced in all parts of the supply chain: over-irrigation of plots, flows at night poor storage and loss of harvested crops.
    - Understand and accept the concept of service provision, and the need to liaise and work with water users in the provision of a responsible and fair service in return for timely and adequate payment of the service fee;

The focus needs to change from a narrow perspective on, for example conveyance efficiencies, to a broader perspective such that as much as possible of the water abstracted for irrigation is converted into useable product.

Productivity will need to improve, though irrigation scheme managers will need to focus on more than just the physical productivity but focus on the economic water productivity (the value of agricultural water production per unit of water) and the agricultural water productivity (the net gains from all uses of water for agriculture, including crops, fisheries, livestock, forestry, firewood, etc.).

Water resources and irrigation managers will need to understand the wider dimensions of irrigated agriculture, from catchment management through to marketing, and work towards enhancing efficiency and productivity in all parts of the supply chain;

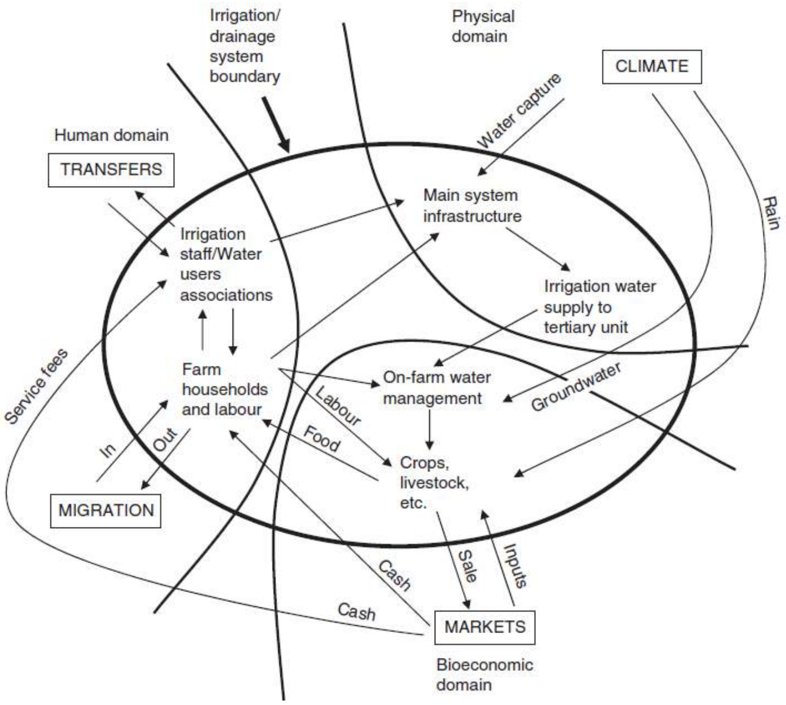
They should understand and treat irrigated farming as a business, to which the supply of irrigation water and removal of drainage water in a reliable, timely and adequate manner makes a significant contribution to the success or failure of the enterprise.

Improving these facets of productivity will involve improving the support given for inputs and supporting processes other than irrigation water and drainage water removal, such as credit, input provision, agricultural machinery and marketing.

Better educated, informed and motivated managers are needed in the irrigation sector (head of an irrigation district, the manager of an irrigation scheme, the executive director of a water users association (WUA) or a farmer.)

Reforms are taking place in many countries through the process of irrigation management transfer, giving more rights and responsibilities to water users for the management, operation and maintenance of all, or parts of, their irrigation and drainage systems. In many countries these changes need to be matched by reforms to state agencies responsible for water resources and irrigation development and management, and correspondingly in the education and training institutions that feed young professionals into these agencies and the sector in general.

# 3 COMPONENTS OF IRRIGATION AND DRAINAGE SYSTEMS (I&DS)




Irrigation and drainage is a complex mixture of technical, institutional, economic, social and environmental processes.
Chambers (1988) identified irrigation and drainage schemes as a complex mixture of physical, human and bioeconomic domains. In the human domain we are dealing with the irrigation agency personnel and with farmers, their families and other stakeholders. In the bioeconomic domain we are dealing with the crops, livestock and markets. Overlying these three domains are the political, economic and legal domains.
Building on the above and other work, a useful categorization of domains in relation to irrigated agriculture is:

• **technical:** physical infrastructure related to I&D systems, the canals, drains, roads, field layouts, etc.,

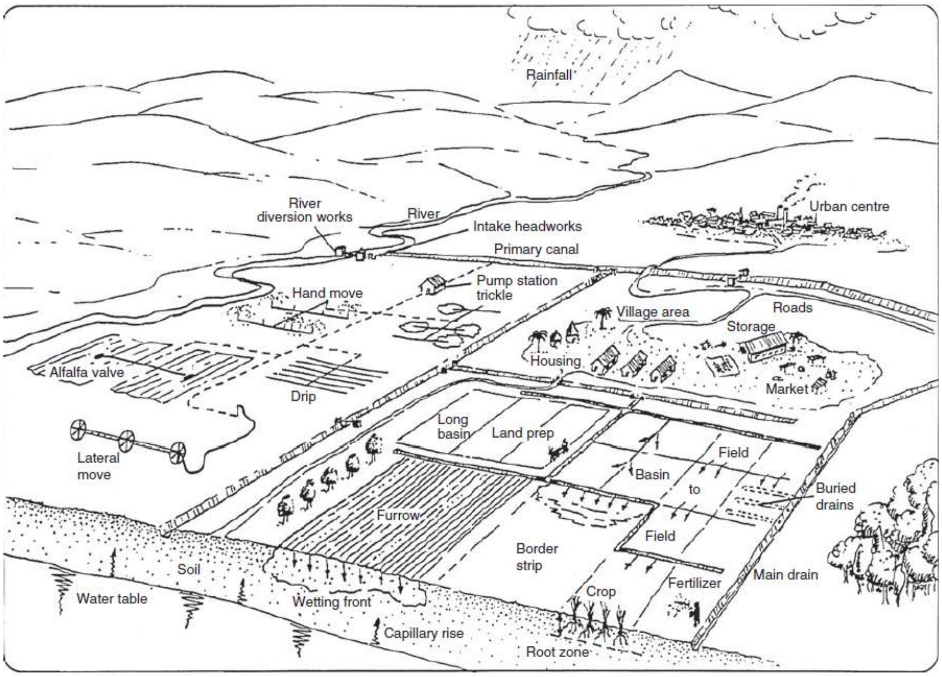



**Figure 3-1 Physical components of an irrigation and drainage scheme.(Burton, 2010)**

• **Institutional:** political, legal and organizational frameworks influencing irrigated agriculture
Politics and politicians play a large part in irrigation development and irrigated agriculture, as agricultural production and rural livelihoods are key areas of political interest. This interest can be either beneficial or harmful depending on the context

| Beneficial | Harmful |
|---|---|
| • improve availability of inputs, access to markets and market prices.<br>• Allocating funds for investment for new or rehabilitation of existing schemes, or for scheme management, operation and maintenance.<br>• introduce, revise or update legislation, particularly in relation to the transfer of the management of I&D systems to water users' associations (WUAs).<br>• strong and consistent political support | • interfere in the setting and levying of irrigation and drainage service fees,<br>  ○ either by setting an unreasonable cap on the service fee that can be levied,<br>  ○ or by suggesting during election periods that water users need not pay such service fees |

**Legal frameworks**: all legislation related: Water Resources, Irrigation and Drainage, Water Users Association, Public Health, Environment, Tax Code, Civil Code and Employment Laws.

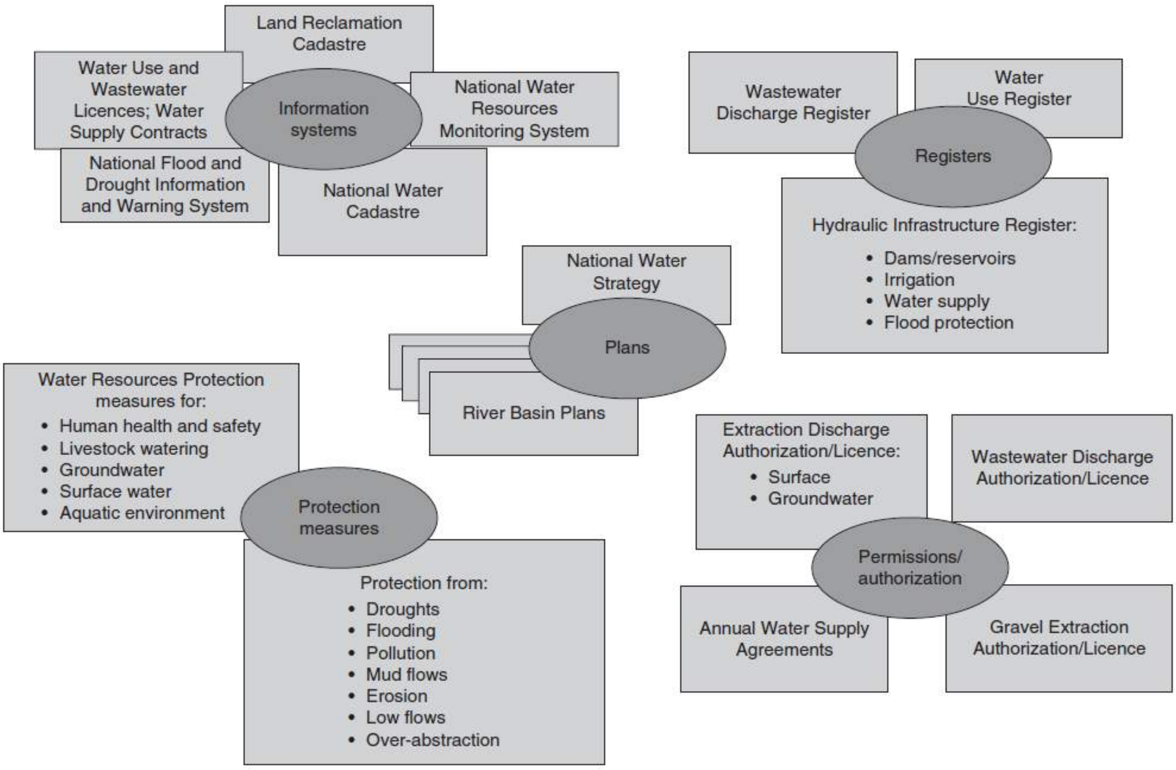



**Figure 3-2 Typical elements of water resources legislation (Burton, 2010)**

**Institutional or organizational framework**: all organizations involved in irrigated agriculture: Ministry of Agriculture Forestry and water economy, Joint Stock Company of Water Management, Ministry of Local Self-government, Ministry of Environment and Physical Planning, Ministry of Finance, Ministry of Economy, Ministry of Transport and Communications, Local Government, Association of Local self-governments (ZELS), Farmers organizations, etc.

• **Economic:** the financial and economic aspects of irrigated agriculture, the cost and value of inputs, resources and outputs.
Irrigation and drainage development in general contributes to improved livelihoods and economic development. Irrigated agriculture requires more labor than rain fed agriculture, resulting in increased employment opportunities for landless labor. As a result of the increased productivity, secondary industries develop, including traders, shopkeepers, agricultural machinery repair workshops and the like.
Increased costs to cover the expenditure required to manage, operate and maintain the I&D system. Unfortunately, governments and farmers in many countries are still reluctant to cover the real costs of managing, operating and maintaining these systems (MOM costs) despite the obvious financial and social benefits arising from them.
After the rehabilitation of I&D systems usually they fail again several years later due to inadequate investment in maintenance. Governments have transferred the management of the schemes or parts of the schemes to the water users, in the belief that as the direct beneficiaries they will be willing to cover the real MOM costs. However, despite being prepared to cover the costs of seeds, machinery hire, fuel and the like, farmers in some countries still have difficulty in accepting that they should pay the real cost for providing irrigation water and drainage water removal. This is one of the biggest challenges facing the irrigation and drainage sector.

• **Social**: the interaction of people within the irrigation schemes and the ways that they live and work together.

Farming within I&D schemes requires more social cohesion, cooperation and discipline than rainfed farming. In general, where the social cohesion is strong irrigation is productive, while where the social cohesion is weak irrigation suffers. This ability to work together and enforce compliance with a set of agreed rules is not apparent in all I&D schemes and becomes more difficult to engender the and becomes more difficult to engender the and becomes. In the larger schemes the social domain will encompass

- the management and staff of the organization responsible for managing the main system, and
- the farming community.

The nature of the relationship between these two social groups will have a direct bearing on the nature and quality of the service provided.

- Where there is corruption and/or lack of transparency the service delivery may be good to some farmers but poor to others, with high levels of distrust between the two groups.
- Where there is accountability, openness, trust and communication between the two groups service delivery will be measurably better, and productivity consequently higher

• **Environmental**: the physical environment impacted by the scheme and the health issues related to I&D systems

The main environmental impacts include land degradation within the scheme; degradation of water quality, both in surface and groundwater; groundwater depletion; ecological degradation, health risks, such as areas of standing water (breeding places for mosquito, vector of many illnesses.)

## 3.1 PHASES OF DEVELOPMENT OF AN I&DS

Six relatively distinct phases can be identified in the development of I&D schemes:

- planning;
- design;
- construction;
- operation;
- maintenance and asset management;
- rehabilitation.

In order for an I&D scheme to be developed some form of organization needs to exist to conceive of the idea and follow it through to completion. This can be a group of leader farmers or a government agency.
It is useful to look at the activities involved in these different phases as they can have a significant bearing on how the scheme is managed, operated and maintained.

**Planning:** identification of the potential for irrigation and selection of the best approach for its development. A feasibility study will be carried out to ascertain the feasibility and likely cost and benefits of the development.
**Design:** Once the development has been planned full designs will be prepared
**Construction:** Once finances have been secured, designs completed, and contracts tendered and awarded, construction can commence.
**Operation:** can be by the beneficiaries, a government agency or a private enterprise. Size often determines who operates the system; small systems are easier for farmers to run, government often runs the larger-scale systems.

**Maintenance and asset management:** asset management relates to the management over time of the system's assets. It looks at the short-, medium- and long-term maintenance, repair and replacement of the system's physical assets and the income stream required to <u>sustain the system at the required service level</u>
**Rehabilitation:** it arises from the failure to properly operate and maintain schemes. Rehabilitation is to repair the system to its original designed state, and modernization is to upgrade components of the system, (automatic control, automated flow measurement, changes in field irrigation methods, etc).

## 3.2 IRRIGATION METHODS

There are four principal methods

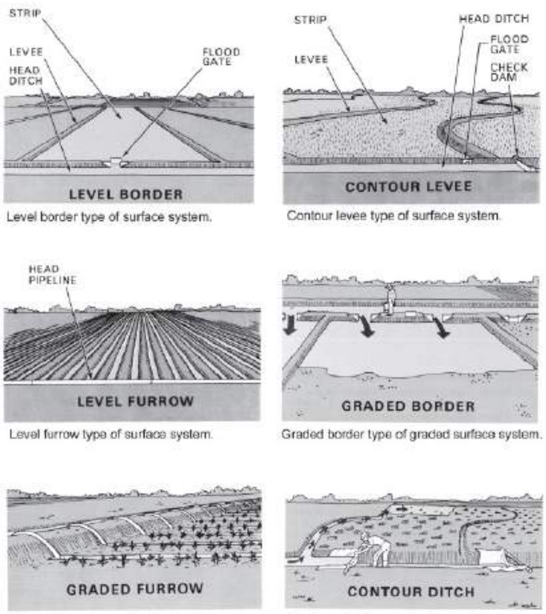
1. Surface irrigation:
2. Sprinkler irrigation.
3. Trickle (drip) irrigation
4. Subsurface irrigation.

Each of these irrigation methods has its own advantages and disadvantages, and is suited to particular physical conditions such as crop type, soils, land slope, water availability, availability of funds, labour costs, labour availability, etc.

**Surface irrigation:** oldest and most widely used method of water application. uncontrolled flooding,

- wild flooding;
- controlled flooding;
    - basin or level border,
    - contour levee,
    - graded border or border strip,
    - furrow,
    - corrugation (small furrows pressed in the soil for cereals.

      Characteristics:
- not recommended for highly permeable soils or steep slopes.
- Least expensive of the possible systems, though costs rise if land-forming or land levelling are required.
- land preparation is relatively straightforward,
- easy to operate and maintain,
- not affected by wind conditions,
- low energy costs,
- can be highly efficient (up to 60%) but require more skilled operation to apply water uniformly to the land surface without undue losses.



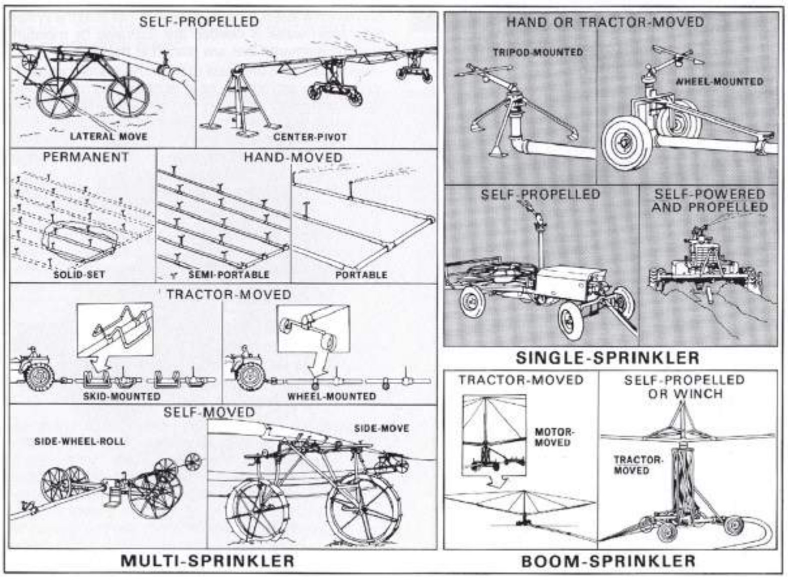
Level border type of surface system. Contour levee type of surface system. Level furrow type of surface system. Graded border type of graded surface system. Graded furrow type of graded surface system. Contour ditch type of graded surface system.

- The efficiency of the water application is highly dependent on the knowledge and skill of the farmer.
- It is often thought that farmers are very experienced in surface irrigation methods simply because they have been practicing them for years. However, it is rare for farmers to evaluate their irrigation application by assessing the soil moisture status in the root zone before and after irrigation. It is therefore difficult to know if an excessive quantity of water has been applied and lost to deep percolation below the root zone; a farmer may well have been over-irrigating for many years without knowing it.

- Significant improvements in water-use efficiency and productivity can be gained through assessment of farmers' actual application practices followed by training.

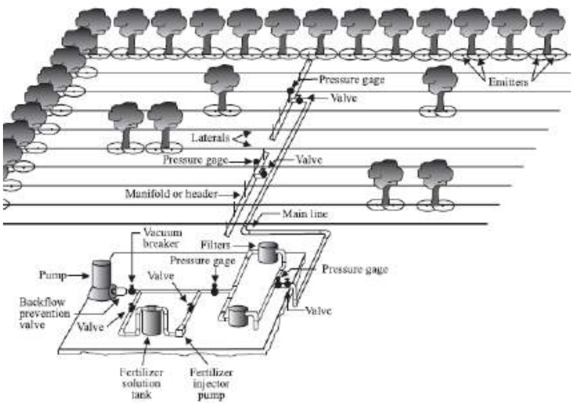
**Sprinkler irrigation:** (5% of the irrigated land worldwide). (up to 75% application efficiency)

- suit most soil types and terrains,
- does not function well under windy conditions.
- can be used for frost protection, fertilizers and pesticides application.
- High initial cost of the equipment and the energy costs required for pumping.
- Need for good-quality water, particularly with sodium and chloride
- PRICE: rootcrops, (1.600-2.300 Eur/ha), potato, rice, tobacco, cabage (3.100-3.500 Eur/ha). 40-50% reduction if the systems are without second filtration



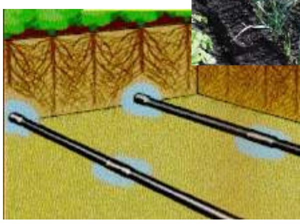

There are different sprinkler devices: revolving head, multiple-nozzle, fixed head, etc. According to their mobility, they can be classified in Permanent, semi portable, portable, (hand moved, tractor moved, self-moved, lateral moved (center pivot, side move), Mobile raingun systems (hose-pull system; hose-reel system), etc.

**Trickle (drip) irrigation**: 0.1% of irrigated land. Up tp 90% efficiency. The method comprises trickling or dripping small quantities of water from a pipe onto the soil surface next to the plant, so almost all the water is absorbed into the soil, there is little or no runoff can be used to apply fertilizers.




- High equipment and setting up costs can be high,
- problems with blocking of the emitters from sand and silt, chemical precipitation and algae.

**Subsurface irrigation:** irrigation water is applied below the ground surface, through buried pipes or drains. It is successfully practiced



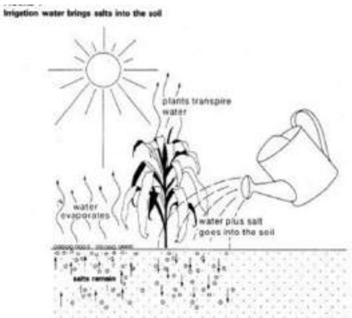
- in some humid areas, for example in the Netherlands.
- in arid regions can cause serious salinity problems.

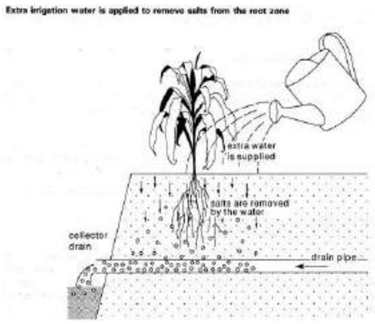
## 3.4 DRAINAGE SYSTEMS

**Drainage Systems:** if and adequate drainage is not provided to an irrigation system, its absence can result in loss of agricultural production and potential failure of the scheme.

Drainage is needed:

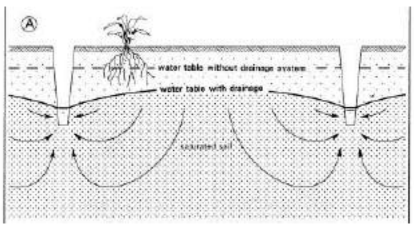
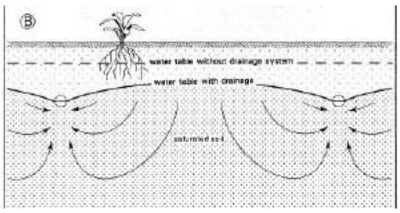
- to make new lands available for agriculture;
- to remove excess surface water following irrigation or rainfall; (improved aeration of the soil, permitting optimum agricultural production)
- to prevent or reduce waterlogging;(improved soil structure resulting from drier soils)
- to control salinity levels, leaching of unwanted salts from the root zone.




There are three main types of drainage system:

- surface drainage: open drains to remove excess irrigation or rainfall;
- subsurface drainage, (horizontal buried pipes set at 1–2 m below the surface and connected to deep open drains); designed to prevent the groundwater table rising into the crop's root zone

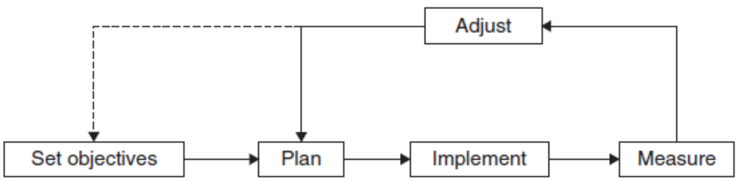
| | | |
|---|---|---|
| <br>Field drain for surface drainage | <br><br><br> | A Subsurface dreinage with open drains<br><br>B Subsurface dreinage with open drains |

- pumped drainage, in which deep tube wells are used to draw down the groundwater, and saline water from tube wells is discharged into open surface drains.

# 4 MANAGEMENT OF IRRIGATION AND DRAINAGE SYSTEMS (I&DS)

Management is an essential component in any enterprise, but is not always given the consideration it deserves in the irrigation and drainage sector.
Manuals are often written for operation and maintenance but tend to cover the technical aspects of operating and maintaining the irrigation and drainage system (I&D system), and do not address other management issues such as accounting and finance, administration procedures, financing, staff recruitment, human resource development and training.

Management can be described as (Jurriens,1991) *Management is the organised use of resources in a given environment for the planning, operation and monitoring of certain tasks to convert inputs to outputs according to set objectives.*




In the irrigation and drainage sector the key management functions include:

- identifying, setting and monitoring of objectives;
- operating and maintaining the I&D system;
- accounting and finance;
- employing, managing and motivating staff;
- administration;
- managing human resources, including training;
- legal issues;
- public relations

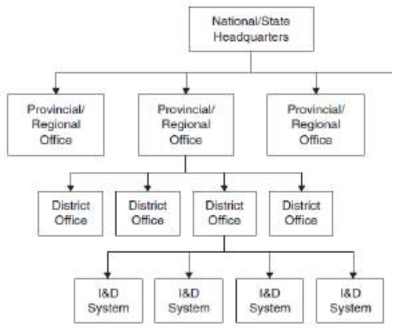
## 4.1 MANAGEMENT FRAMEWORK

At the scheme level <u>three</u> levels of management can be identified:

I. the main system level, (managed by a government agency)
II. the tertiary unit level (managed by a water user's association-WUA-) and
III. the field level. (managed by the farmer).

Also, there are traditional situations in which the entire scheme is managed by one management entity.
The management framework, both at the scheme and higher levels, has a significant impact on the way in which individual I&D systems are managed.

**Extensive I&DS:**

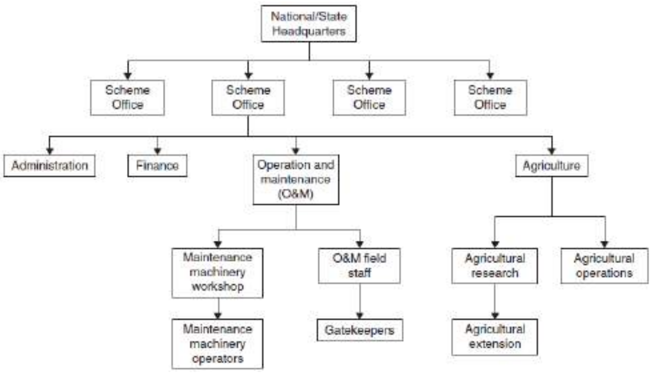



- area-based (rather than scheme based) organizational structure
- a national-level headquarters responsible for overall management and administration
- regional and district offices responsible for management at their respective levels
- District Office is the main operation and maintenance (O&M) unit, which may manage several systems within the District's administrative boundaries

- boundaries follow local administration, rather than hydraulic boundaries;

**Dispersed I&DS:** (In countries where irrigation is not extensive and I&D systems are spread out)

- scheme based (an office on each scheme)
- Management team dedicated solely to that scheme.
- Responsible for O&M of the I&DS and also of provision of agricultural inputs and machinery, crop storage and marketing.

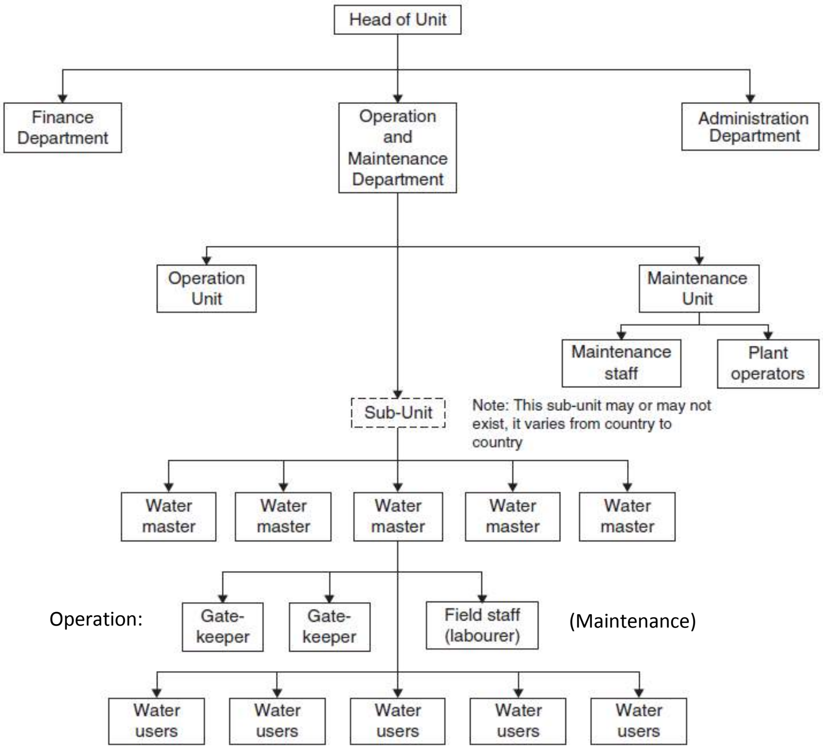



**State or national level**: management roles include policy formulation, budget allocation, planning and sourcing finance for further development and re habilitation, specification of work functions and staffing, and general overall management control and performance monitoring and evaluation. A key role is to liaise and work with other Ministries to coordinate programmes to support irrigated agriculture, and obtain an adequate budget for the MOM of I&DS, (convincing the Ministry of Finance and Government in general.

**Regional level** oversight and coordination of the lower-order units.

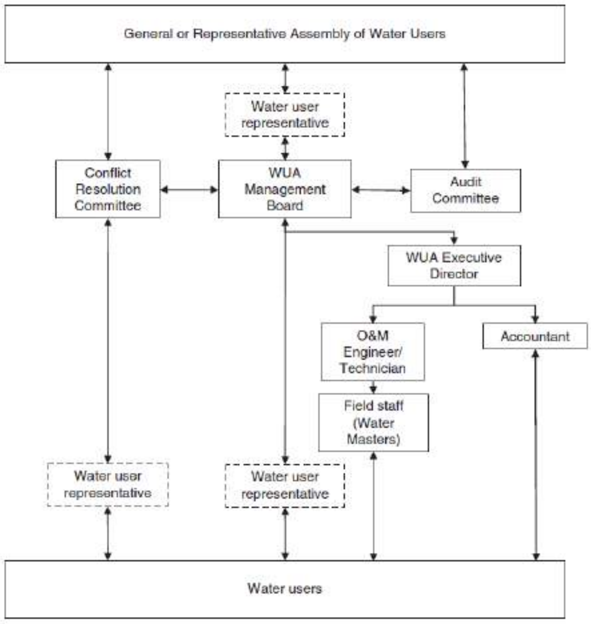
**Local Level**: the O&M is under responsibility of the District office, Scheme office or WUA. The main management role are

- ensuring adequate O&M of the I&DS.
- Matching irrigation demand by the anticipated supply (reducing demand reducing area of high water demanding crops such as rice)
- financial management (salaries, expenses, O&M costs, fee collection, etc.), general administration, staff Matching supply to irrigation demand for each time period (this can be daily, weekly, monthly)



- management and motivation, liaison with other organizations and public relations.
- The water master gives instructions (schedules) to gate keepers which should adjust gates and monitor the farm intakes, collects meteorological, discharge and flood data daily and also direct the laborers of maintenance activities.
- Increasingly, management at the tertiary unit/on-farm level is being carried out by water users associations.

**Water Users' Association**
In a Water Users' Association, the core body is General or Representative Council to which the Management Board and committees report. The Management Board oversees the WUA Executive, which generally comprises an Executive Director, an Accountant, an O&M Engineer/Technician and field staff (Water Masters).




the WUA

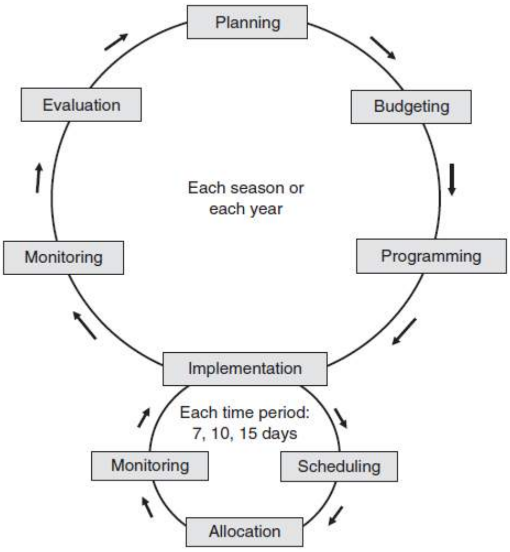
**Field-level:** the farmer, his or her immediate family, extended family, and employed labor. Assistance may be sought from neighbors and other villagers at certain times, such as for land preparation and harvesting

## 4.2 KEY MANAGEMENT FUNCTIONS

**Service delivery:** At the center of the management philosophy should be the principle of service delivery, because good service delivery is more likely to result in good levels of fee recovery. The rights and responsibilities of each party should be contained in the Service Agreement:

Specification of the services to be provided: rate, duration and frequency of water supply, the method of verification of delivery, and the certainty or security of supply.
The Conditions under which these services are provided: the fee to be paid, the location of supply, procedures for ordering and notification of need for water, procedures in case of low or restricted flows, allocation priorities, and times and procedures for closure of canals for maintenance or in case of emergencies.

**Planning and management of water delivery:**




Planning: Pre-season planning is required in order to match irrigation water demand with the anticipated supplies

Budgeting: Budgeting is required at the start of the year for financial and other resources, including staff time and labor.

Programming: the execution of operation and maintenance activities during the year or season. The timing of pre-season and in-season maintenance is particularly important, especially if canals have to be closed to carry out the work. Details of the programme will need to be discussed and agreed with water users.

Implementation: Once the irrigation season commences the system should be ready for farmers to plant their crops and receive their irrigation supplies. There is a *further sub-cycle for water supply involving scheduling, allocation and monitoring of water supplies*.

The irrigation plan made at the **pre-season** stage will give the **broad irrigation demands** and locations of demand**; the scheduling carried out within season** gives **specific discharges and volumes to be supplied** to specific locations in the system for specific dates and times.

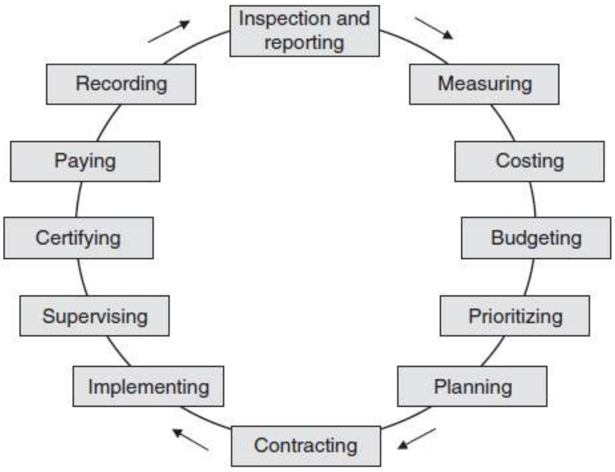
**Monitoring** of water deliveries is especially important at the main system/farms interface where **the irrigation service fee is charged** based on actual water delivered.

Monitoring: during the season the implementation of the pre-season irrigation plan and work programme should be monitored. If there is a reservoir, abstractions and remaining supplies made should be carefully checked.

Evaluation: at the end of the season several assessments should be done.

- To compare the actual implementation against the plan. Did implementation comply with the plan? What needs improvement, planning or implementation in the future?
- To assess the viability of the plan. The plan was right, or changes could be made to improve it?
- To assess how implementation was carried out. Identify areas that can be improved.
- To assess if the implementation met the needs of the water users. This assessment is part of customer service and seeks to check if the service matched water users' expectations.

**Planning and management of maintenance**




Inspection and reporting: is done either on a regular basis from field staff, or as a result of seasonal or annual maintenance inspections.

Costing, Budgeting, Prioritizing costs are calculated, compared with the budget available, and priority work is decided. It is important to consider *preventative maintenance work* that will avoid costly maintenance work in the future. Final Budget is prepared.

Planning schedule works to fit with the irrigation season(s).

Contracting and Implementing: determine which works should be contracted out for implementation, prepare tenders and contracts. Works can be also done with the own laborers or in collaboration with farmers.

Supervision: responsibility for supervision of the work should be clearly defined, and adequate time and resources committed to ensure adequate levels of supervision.

Certifying and Paying: if contractors are involved, a inspection before certification is carried out prior to payment.

Recording: a final task is to record the work done. Good records of completed maintenance work can be invaluable in asset management planning and costing of future maintenance work. Databases represent a powerful tool for maintenance management,

**Management Records and Information Systems**

Management information systems and records are an essential feature of the management of I&DS.

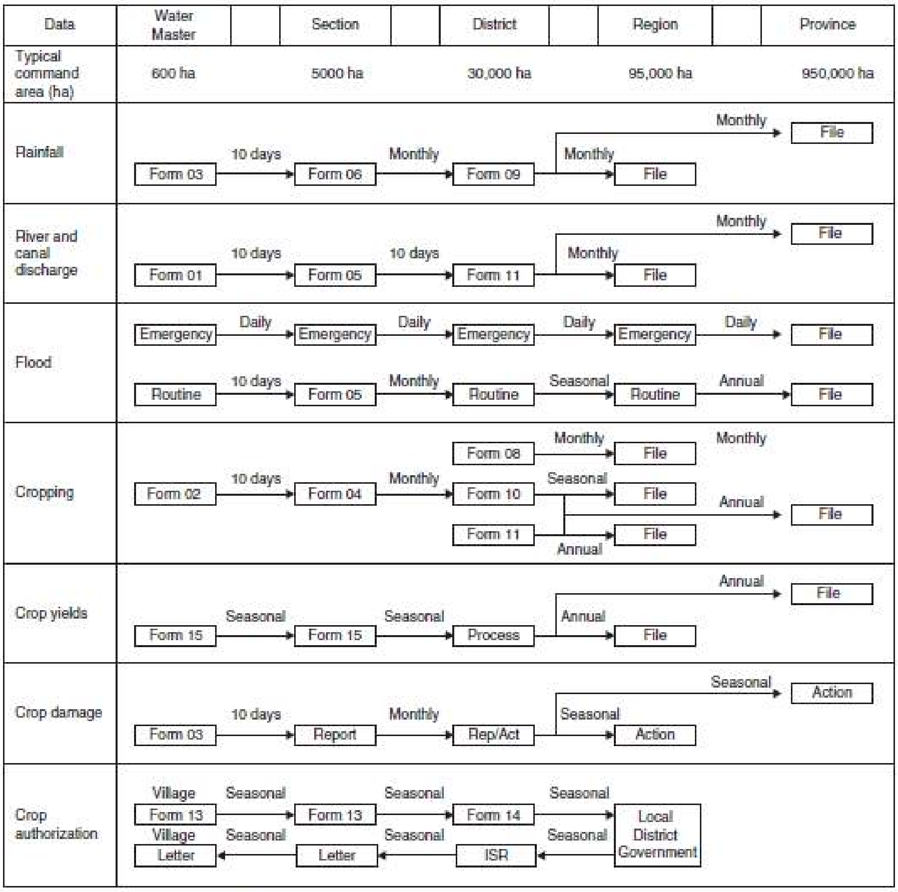
- Maps of the I&DS showing key features (canals, control structures, command areas, cadastral map showing all landholdings and their sizes, etc.)
- schematic operational diagrams showing planned and supplied discharges, crop areas, etc.
- forms for recording crop areas, discharges, climatic data, etc.;
- a maintenance register and forms for recording maintenance work required and implemented
- an asset register for all infrastructure; with engineering drawings of all the assets;
- administrative records; staff records (personal details, salary, annual reports, etc.);
- financial accounts and records.

For a water user's association, the management records should include:

- WUA registration documents;
- a register of members, with the names, landholding areas and locations for each member and non-members if they require irrigation water supplies;
- minutes of meetings;
- accounts records collect and process data on crop areas, crop types and even crop water
- demands and crop yields: cash book, register of irrigation fees paid and an accounts book showing the income and expenditure;

The design of an efficient management information system should decide:

- data to be collected and processed
- which information remains in each section and which it to be passed up the management hierarchy.




| | | | |
|---|---|---|---|
| Form 01 | Discharge measurement | Form 09 | Rainfall data summary |
| Form 02 | Crop data | Form 10 | Crop data summary |
| Form 03 | Crop damage/rainfall | Form 11 | Crop data summary |
| Form 04 | Crop data | Form 12 | Annual rainfall |
| Form 05 | Discharge data | Form 13 | Dry-season rice request |
| Form 06 | Rainfall | Form 14 | Dry-season rice request |
| Form 07 | River discharge data | Form 15 | Yield data |
| Form 08 | Crop data summary | | |

- frequency of the reporting
- Technology to be implemented:
  - spreadsheets provide a simple and effective means of storing, summarizing and presenting data.
  - general purpose databases
  - specialist database software for specific applications (processing, analysing and presenting data on rainfall, river and canal discharges, cropping, etc
  - Geographic Information Systems (GIS)
  - remote sensing applications to collect and process data on crop areas, crop types and even crop water demands and crop yields

**Figure 4-1 Data processing flowchart**

**Accounting and Finance:** management accounting and finance should be analyzed in two level:

a) For the main system service provider: For a government agency the budget will be requested from government by the Head Office and will be part of the annual budget. The allocation of the budget is often established based on previous years' allocations and finances available, rather than on the actual needs, resulting in many cases in under-financing of the maintenance component. Delays in release of funds can sometimes be a problem, especially where funds are required at the start of the irrigation season for maintenance work.

A coding system (termed a chart of accounts) lies at the heart of any accounting and finance system. Examples of Coding system and a breakdown of accounts is given:

| Category | Code | Category | Code |
|---|---|---|---|
| Salary | 1.1.0.0 | Gas | 1.3.3.7 |
| Pension contributions | 1.2.1.1 | Communications | 1.3.3.8 |
| Travel expenses – head office | 1.3.1.1 | Other utilities and rent of buildings | 1.3.3.9 |
| Travel expenses – regional | 1.3.1.2 | Procurement and services | 1.3.4.1 |
| Procurement of technical equipment/materials | 1.3.2.1 | Subsidies | 3.1.1.1 |
| Procurement of office supplies and equipment | 1.3.2.2 | Capital repair | 4.0.0.4 |
| Meal allowances | 1.3.2.3 | Procurement of major equipment and goods | 4.0.0.1 |
| Clothing/uniforms | 1.3.2.4 | Building and structures maintenance/repair | 4.0.0.2 |
| Rent and maintenance of vehicles/transport | 1.3.3.3 | Civil construction schemes/projects | 4.0.0.3 |
| Water | 1.3.3.4 | Design services | 4.0.0.5 |
| Electricity | 1.3.3.5 | | |
| Heating | 1.3.3.6 | | |

Budget cathegories and coding system example

| Item no. | Expenditure item | Total budget allocation (US$) | Budget allocation (%) |
|---|---|---|---|
| 1 | Salaries (incl. pensions) | 580,563 | 28.6 |
| 2 | Potable water supply | 1,767 | 0.1 |
| 3 | Electricity (offices) | 2,843 | 0.1 |
| 4 | Heating | 1,202 | 0.1 |
| 5 | Communications | 14,046 | 0.7 |
| 6 | Other expenses | 4,104 | 0.2 |
| 7 | Transport costs | 162,418 | 8.0 |
| 8 | Field trip expenses | 13,086 | 0.6 |
| 9 | Other services | 211,513 | 10.4 |
| 10 | Electricity (pump stations) | 401,322 | 19.7 |
| 11 | Equipment/materials | 203,234 | 10.0 |
| 12 | Capital repair and maintenance works | 437,056 | 21.5 |
| | **Total** | **2,033,155** | **100** |

Budget allocation example

The breakdown of costs into management, operation and maintenance categories is useful as it helps identify where the costs lie:

- 30% is spent on management costs (items 1–6, staff salaries, office costs, etc.),
- 39% on operation costs (items 7–10, principally electricity costs for pump stations) and
- 31% (items 11 and 12) on maintenance.

It is also useful to provide information to water users of how the income from their service fees and other sources have been utilized

b) For water user's associations: accounting and finance procedures for WUAs has to be far simpler. The basic components will be:

- annual contracts;
- crop area record book;
- Register members' fees due and paid;
- fines register;
- irrigation invoices and register of irrigation invoices;
- cash book;
- bank documents (cheque book, paying in book, monthly bank statements, etc.);
- payroll register;
- expenses register;
- procurement register and procurement forms;
- inventory of assets;
- general ledger (record of economic transactions by account type, with debits and credits in separate columns and a beginning and ending monetary balance for each account);
- annual cash flow and balance;
- budget;
- annual financial report.

Crop and fee payment register

Year:

| Name of water user | Total landholding area (ha) | Crop type and area planted | | | | | | | | Total service fee due (MU) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Barley | Wheat | Cotton | Vegetables | Alfalfa | Backyards | | Total area cropped | |
| Farid Agayev | 2.0 | 0.5 | | 0.5 | 0.2 | 0.5 | | | 1.7 | 34 |
| | | | | | | | | | | |

| Name of water user | Service fee payments | | | | | | | | | | | | | | | Total fee paid (MU) | Remaining to pay (MU) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | | 2 | | | 3 | | | 4 | | | 5 | | | | |
| | Amount (MU) | Receipt no. | Date | Amount (MU) | Receipt no. | Date | Amount (MU) | Receipt no. | Date | Amount (MU) | Receipt no. | Date | Amount (MU) | Receipt no. | Date | | |
| Farid Agayev | 5 | 1345 | 1 May | 10 | 3453 | 5 June | 10 | 3453 | 15 July | | | | | | | 25 | 9 |
| | | | | | | | | | | | | | | | | | |

**Figure 4-2 Crop and fee payment register**

| Income | Amount ($) | Expenditure | Amount ($) |
|---|---|---|---|
| Membership fees | 3,625 | Salary for Manager | 810 |
| Irrigation service fees | 6,562 | Salary for Accountant | 1,425 |
| Grants | 721 | Salaries for Water Masters (4 no.) | 1,125 |
| Previous year's payments (2007) | 150 | Office costs | 75 |
| | | Stationery, etc. | 31 |
| | | Fuel | 250 |
| | | Electricity for office | 13 |
| | | Maintenance costs (contractor) | 2,212 |
| | | Payment of ISF to Irrigation Agency | 3,820 |
| | | Watchman for headworks | 600 |
| | | Reserve funds | 510 |
| | | Contingency | 188 |
| Total | 11,058 | Total | 11,058 |

**Figure 4-3 WUA budget example**

| Cat. no. | Item no. Description | Value ($) | Total value ($) |
|---|---|---|---|
| 1 | Opening cash balance | | |
| | 1.1 Cash in bank | 500 | |
| | 1.2 Cash held | 100 | |
| | Sub-total (1) | | 600 |
| 2 | Income | | |
| | 2.1 Membership fees | 3,450 | |
| | 2.2 Irrigation service fees | 6,342 | |
| | 2.3 Fines | 522 | |
| | 2.4 Grants | 721 | |
| | 2.5 Other income | 100 | |
| | Sub-total (2) | | 11,135 |
| 3 | Bank interst and donations | | |
| | 3.1 Bank interest | 25 | |
| | 3.2 Donations | 50 | |
| | Sub-total (3) | | 75 |
| | TOTAL INCOME (including opening balance) | | 11,810 |
| 4 | Operating expenditure | | |
| | 4.1 ISF paid to Irrigation Agency | 3,820 | |
| | 4.2 Salaries | 3,960 | |
| | 4.3 Office costs | 126 | |
| | 4.4 Transport costs | 272 | |
| | 4.5 General expenditure (meetings, etc.) | 40 | |
| | 4.6 Maintenance expenditure | 2,325 | |
| | 4.7 Other | 124 | |
| | Sub-total (4) | | 10,667 |
| 5 | Investments and loan repayments | | |
| | 5.1 Payment into Reserve Fund | 450 | |
| | 5.2 Equipment and materials | 346 | |
| | 5.3 Loan repayment | 0 | |
| | Sub-total (5) | | 796 |
| | TOTAL OUTGOINGS | | 11,463 |
| 6 | Closing balance | | |
| | 6.1 Cash in bank | 242 | |
| | 6.2 Cash held | 105 | |
| | Sub-total (6) | | 347 |

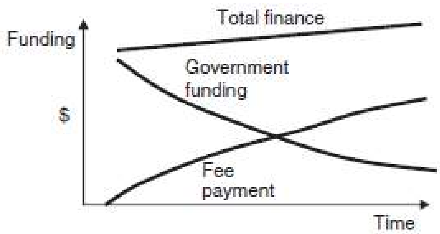
**Figure 4-4 WUA Annual Financial Report example**

**Financing irrigation management, operation and maintenance, and cost recovery**

Finding adequate funds to operate and sustain the system is the next most important management task after operation and maintenance.
Under-investment in maintenance over the last 20–30 years has resulted in I&D systems falling into disrepair and requiring rehabilitation.
The sources of financing can be:

- Government budget. It is allocated to the line ministry which assigns it to the I&D agency, which apportions the funds to the regional and district (or system) offices.
- In some countries funding and donor agencies have been providing finance to governments to support the MOM of their I&DS. It is added to the government budget allocated to the ministry.
- Fees paid by water user. It should be collected by the local office of the I&D agency and not by Ministry of Finance or other non-local agency. It is far preferable that there is a direct link between the money paid by the water users to their local office, the service that they receive, and can demand.

The hope is that over time the fee payment levels will increase to cover a greater proportion of the total MOM finance required.




- In the USA and Australia, farmers are paying levels of service fees that are adequate to cover MOM.
- In other cases farmers have not been used to paying for I&D services and a period of readjustment is required.
- In other countries, farmers find it difficult to pay high enough levels of service fees due to the small size of farmers' landholdings and the sometimes poor state of the market for agricultural goods. With landholding sizes of less than 1 ha and subsistence cropping it is sometimes difficult for farmers to find the cash to pay the service fee. In some cases, such as the Philippines, the irrigation agency has allowed farmers to pay in kind with agricultural produce. This approach has not generally been successful as the irrigation agency has to build and staff storage warehouses, and has to market and sell the produce, sometimes at rates lower than they traded the produce in from the water users.

Possible returns and ability to pay: Crop budgets

The possible returns to irrigated agriculture and the ability to pay the irrigation service fee (ISF) are determined in the following example for 1 ha maize crop budget.

Excluding the ISF the financial returns range between US$178/ha and US$432/ha for low to high yields if labour is costed, and between US$284/ha and US$586/ ha if family labour is used and not costed.
Including an adequate ISF of US$22.5/ha, the net returns fall to US$155/ha to US$409/ha with labour costed and US$262/ha to US$564/ha if labour is not costed. This is still a reasonable return for this crop; the ISF is only 9.5% of the total costs for the low-yield case and only 5% of the total costs for the high-yield case. In the low-yield case the ISF is equivalent to the expenditure on fertilizer; in the high-yield case the ISF is one-fifth of the expenditure on fertilizer.

While a full analysis should be carried out on the basis of a farm, rather than a crop, this budget example shows that charging the full ISF is not unreasonable in terms of the returns obtained from supplying irrigation water.

| Item | Unit | Quantities | | | Unit prices (US$) | | Financial costs and returns (US$/ha) | | | Economic costs and returns (US$/ha) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Low yield | Medium yield | High yield | Financial prices | Economic prices | Low yield | Medium yield | High yield | Low yield | Medium yield | High yield |
| **Gross returns** | | | | | | | | | | | | |
| Grain output | kg | 3,150 | 4,900 | 6,600 | 0.1 | 0.1 | 354.4 | 551.3 | 742.5 | 354.4 | 551.3 | 742.5 |
| Maize stover | kg | 4,725 | 7,350 | 9,900 | 0.0 | 0.0 | 59.1 | 91.9 | 123.8 | 59.1 | 91.9 | 123.8 |
| **Total** | | | | | | | **413.5** | **643.1** | **866.3** | **413.5** | **643.1** | **866.3** |
| **Costs of crop production** | | | | | | | | | | | | |
| Ploughing | times/ha | 1.0 | 1.0 | 1.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 |
| Discing/harrowing | times/ha | 1.0 | 1.0 | 1.0 | 12.5 | 12.5 | 12.5 | 12.5 | 12.5 | 12.5 | 12.5 | 12.5 |
| Furrowing | times/ha | 1.0 | 1.0 | 1.0 | 12.5 | 12.5 | 12.5 | 12.5 | 12.5 | 12.5 | 12.5 | 12.5 |
| Inter-row cultivating | times/ha | 1.0 | 2.0 | 2.0 | 12.5 | 12.5 | 12.5 | 25.0 | 25.0 | 12.5 | 25.0 | 25.0 |
| Seed | kg | 30.0 | 30.0 | 30.0 | 0.3 | 0.3 | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 |
| Farmyard manure application | US$/ha | 200.0 | 400.0 | 600.0 | | | 5.0 | 10.0 | 15.0 | 5.0 | 10.0 | 15.0 |
| Ammonium nitrate fertilizer | kg | 100.0 | 300.0 | 500.0 | 0.2 | 0.2 | 20.0 | 60.0 | 100.0 | 20.0 | 60.0 | 100.0 |
| Fertilizer application | times/ha | 1.0 | 1.0 | 1.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| Herbicide | times/ha | 0.0 | 0.0 | 1.0 | 5.0 | 5.0 | 0.0 | 0.0 | 5.0 | 0.0 | 0.0 | 5.0 |
| Herbicide application | times/ha | 0.0 | 0.0 | 1.0 | 11.3 | 11.3 | 0.0 | 0.0 | 11.3 | 0.0 | 0.0 | 11.3 |
| Pesticide | US$/ha | – | 300.0 | 600.0 | | | | 7.5 | 15.0 | | 7.5 | 15.0 |
| Labour (family & hired) | | | | | | | | | | | | |
| Harvesting & shelling | labour-day | 31.0 | 45.0 | 58.0 | 1.5 | 0.9 | 46.5 | 67.5 | 87.0 | 27.9 | 40.5 | 52.2 |
| Other labour inputs | labour-day | 40.0 | 45.0 | 45.0 | 1.5 | 0.9 | 60.0 | 67.5 | 67.5 | 36.0 | 40.5 | 40.5 |
| Transport | US$/ha | 300.0 | 450.0 | 600.0 | 0.0 | 0.0 | 7.5 | 11.3 | 15.0 | 7.5 | 11.3 | 15.0 |
| Miscellaneous costs (5% of the costs above) | | | | | | | 11.2 | 16.1 | 20.7 | 9.1 | 13.4 | 17.6 |
| **Total** | | | | | | | **235.2** | **337.3** | **433.9** | **190.5** | **280.6** | **369.0** |
| **Financial net returns before ISFs** | | | | | With all labour costed | | **178.3** | **305.8** | **432.4** | – | – | – |
| | | | | | With labour not costed[a] | | **284.8** | **440.8** | **586.9** | – | – | – |
| **Economic net returns excluding irrigation supply and distribution costs** | | | | | | | – | – | – | **222.98** | **362.53** | **497.23** |
| **Financial net returns after ISFs** | | | | | With all labour costed | | **155.8** | **283.3** | **409.9** | | | |
| | | | | | With labour not costed[a] | | **262.3** | **418.3** | **564.4** | | | |

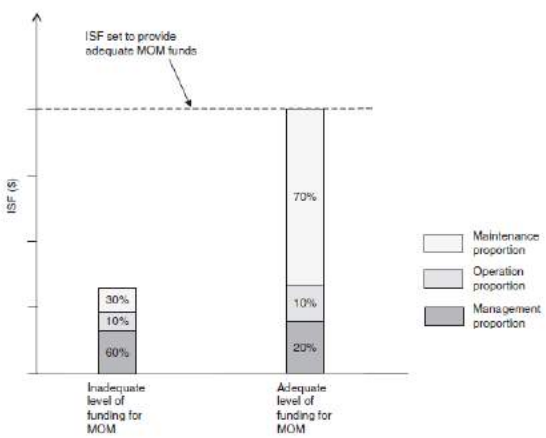
ISF, irrigation service fee.
[a]Assuming that all labour is provided by unpaid household members, and no hired labour is used.

**Figure 4-5 example for 1 ha maize crop budget**

Identifying the management and the operation cost components of the ISF is relatively easy. The main difficulty is in identifying and quantifying the maintenance costs as:

i. they are particular to individual systems;
ii. they vary from year to year depending on which infrastructure items need repair/maintenance;
iii. (iii) it is difficult to know what should be the optimum level of maintenance.

In gravity-fed I&D systems a rule-of thumb is that the maintenance expenditure should be about 70% of the total MOM expenditure.




In organizations where the expenditure on management costs (mostly salaries) is more than that on maintenance there is often a maintenance problem, leading to deterioration of the I&D system.

A problem that has been encountered in several systems is that service fees are not paid where water is not supplied, either because it is not available (due to a drought) or due to adequate rainfall. Thus in very dry or wet years the service provider may not get an adequate income from providing irrigation water, yet they will still incur costs (staffing, maintenance, etc.).
In order to cover these costs there is a reasonable

argument that all landowners within an irrigation/drainage command area should pay a fixed annual area based fee, irrespective of whether they irrigate or not. This area-based fee would be set to cover the fixed costs, and additional charges would then be made to those who do irrigate for the variable costs of service provision.

Other method of charging ISF are

- based on volume of water supplied,
- irrigable command area (irrespective of area cropped),
- cropped area,
- crop area and crop type.
- time taken to irrigate (positive effect of water users completing irrigation as quickly as possible)

The question is whether irrigation management transfer to WUAs will mean that I&D systems are adequately financed and the cycle of deterioration followed by rehabilitation halted. In some countries it may be that government will need to continue to support and subsidize the management, operation and maintenance of I&D systems, and recover the costs from other sources of taxation.

**Staffing and Human Resource Development**

An organization's human resource is an important asset.
In an I&D agency there should be norms governing the number and category of staff at different levels within the organization, together with job descriptions for each position.
It is important that these staffing levels, and associated job functions, are periodically reviewed and updated, especially in situations where

- Salaries are rising (staffing costs increasing),
- new technology is bringing about changes in the way systems are managed, operated and maintained for example:
    - automatic water level control devices, or remote gate operating systems;
    - provision of more efficient transport (motorbikes, instead of bicycles or travel by foot);
    - computers are being introduced for data collection, processing and analysis.

In general, the attitude towards human resource development (HRD) within irrigation agency is still quite poor, with a reliance on top-down management and little encouragement, motivation or training for staff. The work is often seen as repetitious and therefore not requiring any significant inputs into staff motivation and training.

The HRD lessons learned over the last 20–30 years in the business and industrial sectors do not appear to be recognized or applied in the irrigation and drainage sector.

This will need to change if irrigation agencies are to be made leaner and fitter for purpose, especially in relation to service delivery and customer satisfaction.

If water users are expected to pay more for their water delivery and removal services, they will expect far better levels of service and accountability than is the case in some situations at present.

**Administration**

Efficient administration processes and procedures are the oil in any organization's machinery.
Typical administrative responsibilities for an I&D agency include:

- procedures for recording, handling, storing and retrieving correspondence - directing it to the responsible person for action and a tracking system to ensure that it is acted upon in good time;
- procedures for organizing staff travel and payment of relevant per diems and allowances;
- procedures for provision of support services, (communication, secretarial, IT, draughtsmen, drivers, etc.)
- provision of meeting and conference organization and related facilities
- procedures for procuring office supplies, maintenance; printing and reproduction facilities;
- procedures for procuring equipment, spare parts, materials, supplies and support services; their storing and inventory control.

For water users associations the procedures are much simpler, and relate mainly to ensuring that the association's books are kept safe, the office is adequately maintained and meetings properly organized, with adequate notice being given, minutes kept and information disseminated to water users.

**Legal Issues**

There are a number of areas where legal issues occur, for an irrigation and drainage agency, for a water users association or for individual water users. These include:

- drafting of new, or redrafting of existing legislation to establish water users associations and transfer management, operation and maintenance to water users;
- drafting of new, or redrafting of existing, legislation on the water law – this may include establishment of water rights for individuals and groups of water users, establishment of river basin councils, establishment of new agencies for water resources management;
- drafting of service agreements between service providers and water users;
- enforcement of service agreements in the civil courts, either by water users in relation to lack of service delivery, or by service providers in relation to failure by water users to pay service fees;
- enforcement of penalties for unauthorized abstraction or use of irrigation water, or damage to irrigation and drainage infrastructure
- action to obtain usufruct rights or full legal title to physical irrigation and drainage infrastructure;
- advice and lobbying to protect water users' associations from some elements of taxation, including property taxes for physical infrastructure and VAT on membership and service fees.

In a large I&D agency there may be a small legal team, or a legal specialist, who will be engaged to advise on legal matters. For water users' associations, legal advice is often provided as part of a WUA establishment project.

**Public Relations**

Good public relations (often shortened to 'PR') are a useful management tool for any organization.

**For the I&D agency** good public relations with WUAs and water users makes life easier and irrigated agriculture more productive.

Irrigation and drainage service delivery differs from domestic water supply and provision of electricity in several important ways:

I. irrigation is an open-access resource, which is very difficult to police and protect fulltime (especially at night).
II. irrigation and drainage is often fundamental to people's livelihoods, it is not an option as may be the case with electricity.
III. Irrigation is rarely provided on demand.

IV. close cooperation and communication is required between the user and the supplier if supplies are to be reliable, adequate and timely. Good irrigation and drainage service delivery is about working in partnership with water users, not in conflict with them.

Good public relations are useful for the I&D agency in liaising and working with other government agencies and organizations, such as local and regional governments, and national government. Good public relations can strengthen the position and standing of the I&D agency; similarly, poor public relations can weaken its standing in the community, and within government.

**For water users' associations**, good public relations are particularly useful

- promotion of the WUA concept on television and radio, and through newspapers, improves the understanding of WUAs and helps in gaining support for these new management entities.
- Promotion to gain acceptance and support of the WUA concept by politicians
- communicate and work closely with water users if they want the support of the water users.

WUAs need good public relations in order to ensure their access and rights to water, and to ensure that they are taken seriously as a voice for the irrigation community.

# 5 Operation of the Main System

Operation of irrigation systems can usefully be divided into three levels:

(i) the main system, comprising primary and secondary canals;
(ii) the tertiary unit or on farm system, comprising the tertiary and quaternary canals; and
(iii) the field or farm level, comprising the field or farm channels and ditches.

The drainage system mirrors these divisions, though there is generally not much operation involved unless there is pumped drainage.

The reason for dividing the operation into these three levels is that the management is different, both in terms of the organizations and people involved and in terms of the processes and procedures.

Generally, the main system is managed by a government agency, though this is changing as systems are being transferred to management by water users associations (WUAs) or federations of WUAs.

The next management unit is the tertiary unit or on-farm level, which is generally managed by water users, either directly if they own or farm all the land at this level, or by groups of water users through WUAs or similar farmer groups.

The lowest management level is the field, where the farmer manages the application to the land of the water provided by the other two management levels.

There are a number of approaches used worldwide for operation at the main system level. The operational processes and procedures used depend on decisions made at the design stage and will include consideration of:

- the number, capability and cost of staffing available;
- the finances available for construction of the irrigation and drainage system;
- the anticipated finances available for management, operation and maintenance;
- the nature availability of the water resource;
- the level of technology employed at field and level and the capability of farmers;
- the benefits and returns to irrigated agriculture.

A further factor is also the 'school' of irrigation engineering with which the designer is familiar, be it based on experience in the USA, Europe, India, Russia, China, Egypt or elsewhere.

## 5.2 Main System Operation Processes

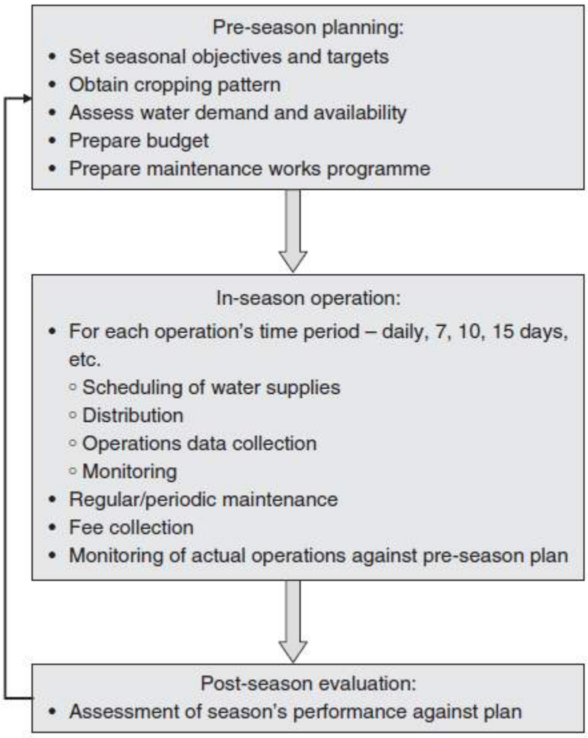
The aim of the main system operation is to match the supply of water to the demand at the hand-over point to the water user at a given time and date.

The water demands made by the water users may be determined by using sophisticated techniques including soil moisture probes, or they may be based simply on demands by farmers without any detailed calculations of the actual crop water needs.

The three variables governing the supply of irrigation water are the flow rate, the duration of flow and the frequency of supply (interval between deliveries).
At the main system level the ease of varying the flow rate, duration and frequency of supply is governed by the type, number and location of control and measurement structures and the skill of the staff responsible for operation of the system.

In order to specify the values of these key variables set processes and procedures are required.

The main system operation processes comprise




**Planning** takes place at two levels:

- before the irrigation season, to obtain information from water users on their planned cropping patterns and irrigation water requirements. Pre-season planning often takes place in systems where the main system service provider needs to ascertain if the required discharges can be met from the predicted available water supplies. Farmers or WUAs submit an application to the WUA or main system service provider detailing their planned cropping pattern. This application is checked and a contract is signed for provision of this water supply
- during the irrigation season, in any irrigation system in-season planning will be required to plan the water allocation and discharges at control points for each irrigation time period. The in-season planning will take place at the start of each irrigation time period (often each 7, 10 or 15 days) and will use information collected from the previous time period, including requests from water users and information on actual discharges supplied (Fig. 4.2).

In a system with arranged-demand scheduling, this in-season planning is essential as the requests made by the water users have to be collated and the required discharges planned and allocated.

In a system with a fixed rotational pattern the in-season planning is much simpler, as the supply is fixed and the water users have to adjust their irrigation to suit the supply available.

In a system with demand irrigation the planning and in-season operation procedures are simpler still as the system will automatically respond to the irrigation demands by the water users.

During **Operation**, the irrigation season irrigation supplies will need to change in order to match the changing crop water demands. In non-automated systems this requires that the main system service provider collects data on the irrigation demands on a regular basis and then prepares a schedule to match supply and demand.

In some schemes the irrigation demands are determined by the main system service provider based on the farmers' cropping patterns; in other schemes the irrigation demands are prepared by the water users and given to the main system service provider at intervals during the crop season. The frequency of the changes to the schedule varies from scheme to scheme; in some cases, schedules are prepared daily, in others they are prepared each 7, 10 or 15 days. There is a significant difference in the amount of management effort that goes into these different processes.

**Monitoring and recording** the water allocation during the irrigation season in order to:

- know what water has been allocated where, and if the planned allocations have been made;
- monitoring and recording of discharges to know what fee to charge the water user or group of water users or WUAs for irrigation water delivered;
- feed back into the planning process for the next time period;
- monitor and evaluate operational performance.

It is important that proper systems are established for recording discharges. These will include standardized forms, printing of stage–discharge charts or discharge tables for measuring structures, and procedures for joint recording of measurements taken between the water user(s) and the service provider's field staff to avoid disputes over the readings and quantities taken.

FORM 04 WATER REQUEST, ALLOCATION AND ACTUAL SUPPLY SUMMARY

Division: Region 3 Canal name: B3 Branch Canal

Period: From 11 July to 20 July

*Note: These last columns are completed at the end of the time period*

| Water user association | Primary/ secondary canal | Command area (ha) | Design canal capacity (l/s) | REQUEST | | | PLANNED ALLOCATION | | | ACTUAL | | MONITORING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Area irrigated (ha) | Discharge (l/s) | Duration (h) | Discharge (l/s) | Duration (h) | Handover discharge (l/s) | Discharge (l/s) | Duration (days or h) | Delivery performance ratio (actual/ planned) |
| Col. (1) | Col. (2) | Col. (3) | Col. (4) | Col. (5) | Col. (6) | Col. (7) | Col. (8) | Col. (9) | Col. (10) | Col. (11) | Col. (12) | Col. (11) / Col. (8) |
| | B3 | 1668 | 2852 | 236 | 1282 | 24 | 1282 | 24 | 1282 | 1273 | 24 | 0.99 |
| Cane Grove | B3-1 | 110 | 132 | 20 | 66 | 24 | 66 | 24 | | 64 | 24 | 0.97 |
| | B3-2 | 90 | 108 | 18 | 60 | 24 | 60 | 24 | | 70 | 24 | 1.17 |
| | B3-3 | 80 | 96 | 15 | 50 | 24 | 50 | 24 | | 60 | 24 | 1.21 |
| | Sub-total | 280 | - | 53 | 175 | 24 | 175 | 24 | 1031 | 194 | 24 | 1.11 |

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## 5.3 METHODS OF WATER DISTRIBUTION (IRRIGATION SCHEDULING)

Scheduling of irrigation is the core function of operation of an irrigation system, at any level. The three main variables involved in scheduling of irrigation applications are:

- **Frequency:** (or interval) is how often the water is supplied, (every day, every week, every 2 weeks)
- **Flow rate:** is the quantity of flow
- **Duration:** is the period (in seconds, minutes, hours, days) for which the water is available

Multiplying the rate and duration gives the volume of water supplied during an irrigation event.

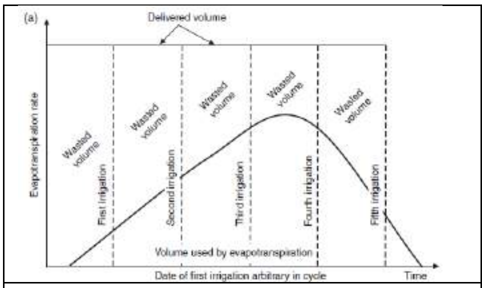
Different combinations of these variables give three commonly used forms of irrigation water supply:

- **continuous flow:** flow is continuous, 24 hours per day, 7 days per week. The main variable considered is the flow rate, the other two are already determined
- **rotational flow:** irrigation supplies are rotated between delivery points, with canals running at full or partial discharge, or closed. The frequency and duration of flow become the key variables, together with the rate.
- **on-demand flow**: the supply can be continuous or intermittent; it is entirely up to the demands made at the point of delivery

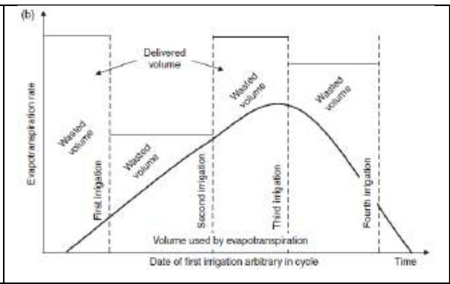
**Types of Schedules**

Using these three variables all water delivery schedules can be categorized, and can be broadly divided into two types:

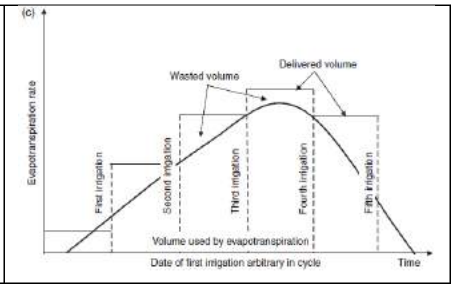
1) **Rigid schedules:** Rigid, predetermined, supplier-controlled schedules are:
    - constant-amount, constant-frequency; the more rigid schedule is less able to match the pattern of irrigation water demand with either over-supply or undersupply
    - constant-amount, variable-frequency;
    - varied-amount, constant-frequency




constant-amount, constant-frequency




constant-amount, variable-frequency




varied-amount, constant-frequency

2) **Flexible schedules.** User controlled, there is often a need for compromise between the irrigation service provider's ability to supply water and the farmer's demand. There are various flexible schedules:

- **Demand**: there are no restrictions on the frequency, rate or duration. Automation of the control systems is essential to implement this schedule, and storage often has an important role to play.
- **Limited-rate, demand:** The flow rate may be restricted by supply capacity, but there is no restriction on the frequency or the duration. Again, automation is essential to implement this schedule.

- **Arranged:** no restrictions on the frequency, rate or duration, only that these have to be agreed prior to delivery with the water service provider. This process requires an adequate communication, data collection and data processing system.
- **Limited-rate, arranged:** The flow rate is restricted, otherwise as for the arranged schedule above.
- **Restricted-arranged**: Further restrictions are made on the arranged schedule. The date, rate and duration have to be discussed and agreed beforehand, once agreed they cannot be changed by either party. This schedule requires the highest level of management by the farmer, who has to plan well ahead.
- **Fixed-duration, restricted-arranged:** The duration is fixed by policy (usually 24 hours), the rate and date are arranged. This schedule allows the water masters to plan their work and reduces the number of manual changes in flow rate. (USA)

**Table 5-1 Schedule Constraints**

| Degree | Schedule name | Frequency | Rate | Duration | Location/Comment |
|---|---|---|---|---|---|
| | Demand | Unlimited | Unlimited | Unlimited | Small Scale Macedonia (No management) |
| FLEXIBLE | Limited-rate, demand | Unlimited | Limited | Unlimited | |
| | Arranged | Arranged | Unlimited | Unlimited | |
| | Limited-rate, arranged | Arranged | Limited | Unlimited | Golbourn-Murray Australia |
| | Restricted-arranged | Arranged | Constant | Constant | Relative area method. East Java |
| | Fixed-duration, restricted-arranged | Arranged | Constant | Fixed by policy | USA |
| | Varied-amount, constant frequency (modified amount rotation) | Fixed | Varies as fixed | Fixed | Warabandi (NE India&Pakistan) |
| | Constant-amount, varied frequency (modified frequency rotation) | Varies as fixed | Fixed | Fixed | |
| RIGID | Constant-amount, constant-frequency | Fixed | Fixed | Fixed | Hills (Nepal) (No management) |

**Terminology**: *unlimited*, unlimited and controlled by the user; *limited*, maximum flow rate limited by the physical size of the system turnout capacity but causing only moderate to negligible constraints in farm operations, the applied rate is controlled by the user and may be varied as desired; *arranged*, day or days of water availability are arranged between the service provider and the user; *constant*, the condition of rate or duration remains constant as arranged during the specific irrigation turn; *fixed*, the condition is determined by the service provider.

At the design stage, the decision made on the form of the rate, frequency and duration of supply at different locations in the irrigation system will define:

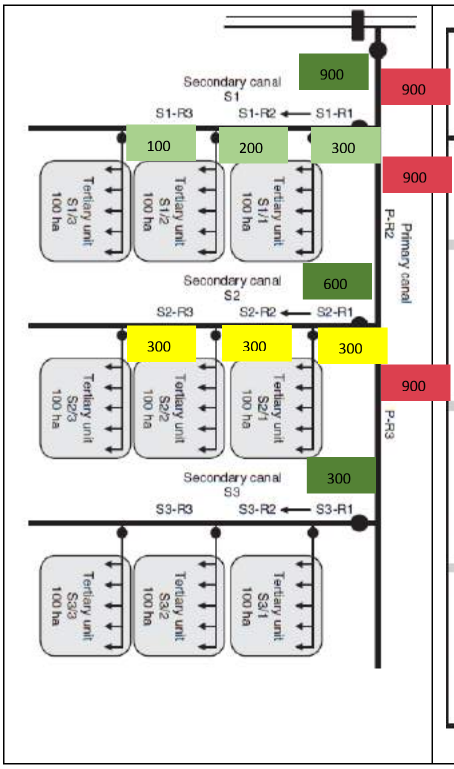
- Type of control and measurement structures,
- Capacity of canals and the operational procedures to be followed.

For example, a decision to rotate irrigation supplies at any location in the system will mean an increase in the capacity of the canals below that location and the provision of a control structure (and possibly measurement). Provision of this control structure will require someone to operate it and management procedures to determine how the structure should be operated.
Example: Continuous flow water duty 1 l/s/ha, delivered according to the following options:

- Continuous flow to all tertiary units
- 1 in 3 day rotation to 1 tertiary in each secondary
- 1 in 3 day rotation to all tertiary units on 1 secondary

The consequences of rotating flow at the main system level are illustrated in the next table

**Table 5-2 Variation of canal discharges with rotation of irrigation**

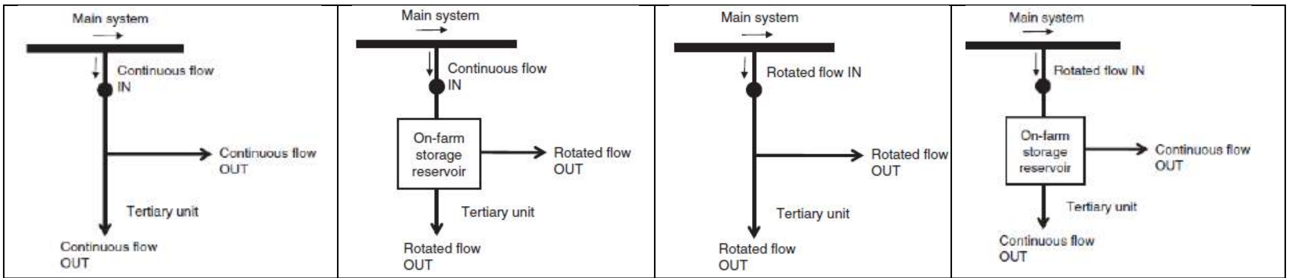



Water allocation and flow rate calculations

| Canal/Canal reach | – Continuous flow to all tertiary units | | | – 1 day in 3 rotation to 1 tertiary in each secondary | | | – 1 day in 3 rotation to all tertiary units on 1 secondary | | |
|---|---|---|---|---|---|---|---|---|---|
| | Day 1 | Day 2 | Day 3 | Day 1 | Day 2 | Day 3 | Day 1 | Day 2 | Day 3 |
| | Discharge (l/s) | | | | | | | | |
| Primary canal Reach P-R1 | | 900 | 900 | | 900 | 900 | | 900 | 900 |
| Primary canal Reach P-R2 | | 600 | 600 | | 600 | 600 | | 900 | 0 |
| Primary canal Reach P-R3 | | 300 | 300 | | 300 | 300 | | 0 | 0 |
| Secondary canal Reach S1-R1 | | 300 | 300 | | 300 | 300 | 0 | 0 | 900 |
| Tertiary S1/1 | 100 | 100 | 100 | 0 | 0 | 300 | 0 | 0 | |
| Secondary canal Reach S1-R2 | | 200 | 200 | | 300 | 0 | 0 | 0 | 600 |
| Tertiary S1/2 | 100 | 100 | 100 | 0 | 300 | 0 | 0 | 0 | |
| Secondary canal Reach S1-R3 | | 100 | 100 | | 0 | 0 | 0 | 0 | 300 |
| Tertiary S1/3 | 100 | 100 | 100 | 300 | 0 | 0 | 0 | 0 | |
| Secondary canal Reach S2-R1 | 300 | 300 | 300 | 300 | 300 | 300 | 0 | 900 | 0 |
| Tertiary S2/1 | | 100 | 100 | 0 | 0 | 300 | 0 | 300 | 0 |
| Secondary canal Reach S2-R2 | 200 | 200 | 200 | 300 | 300 | 0 | 0 | 600 | 0 |
| Tertiary S2/2 | | 100 | 100 | 0 | 300 | 0 | 0 | 300 | 0 |
| Secondary canal Reach S2-R3 | 100 | 100 | 100 | 300 | 0 | 0 | 0 | 300 | 0 |
| Tertiary S2/3 | | 100 | 100 | 300 | 0 | 0 | 0 | 300 | 0 |
| Secondary canal Reach S3-R1 | 300 | 300 | 300 | 300 | 300 | 300 | 900 | 0 | 0 |
| Tertiary S3/1 | 100 | 100 | 100 | 0 | 0 | 300 | 300 | 0 | 0 |
| Secondary canal Reach S3-R2 | 200 | 200 | 200 | 300 | 300 | 0 | 600 | 0 | 0 |
| Tertiary S3/2 | 100 | 100 | 100 | 0 | 300 | 0 | 300 | 0 | 0 |
| Secondary canal Reach S3-R3 | 100 | 100 | 100 | 300 | 0 | 0 | 300 | 0 | 0 |
| TertiaryS3/3 | 100 | 100 | 100 | 300 | 0 | 0 | 300 | 0 | 0 |

As can be seen, the continuous flow option gives lower maximum flow levels in the middle and lower reaches of the primary and secondary canals. The option of rotating flows to all tertiary units at the same time on one secondary gives the highest maximum flow rates in the primary and the secondary canals.

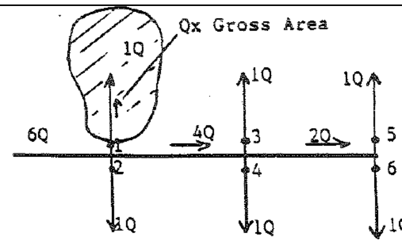
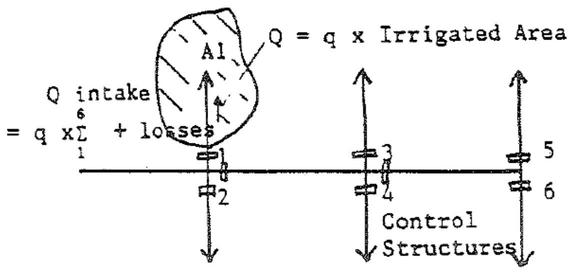
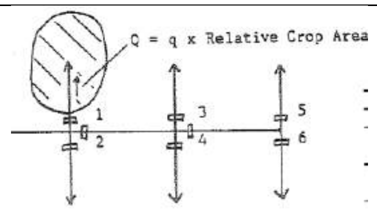
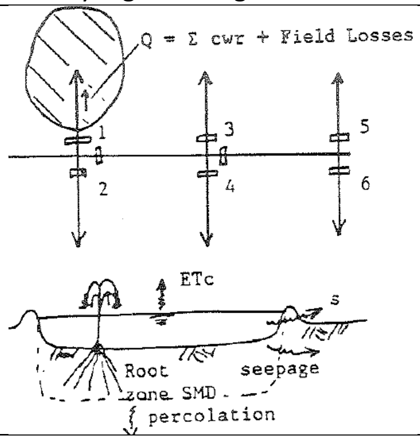
**Storage** has an important part to play in relation to the rate, frequency and duration of irrigation water supply in an irrigation system. The storage can be on the main system, within the tertiary unit, on the field or in the root zone, and may be for storage of water overnight or for several days.




| | | | |
|---|---|---|---|
| Continuous flow day & night | Cont. used only at day with a night storage | Rotated flow provides rotated flow on farm | Rotated flow provides continuous flow on farm |

**Selection of Scheduling**

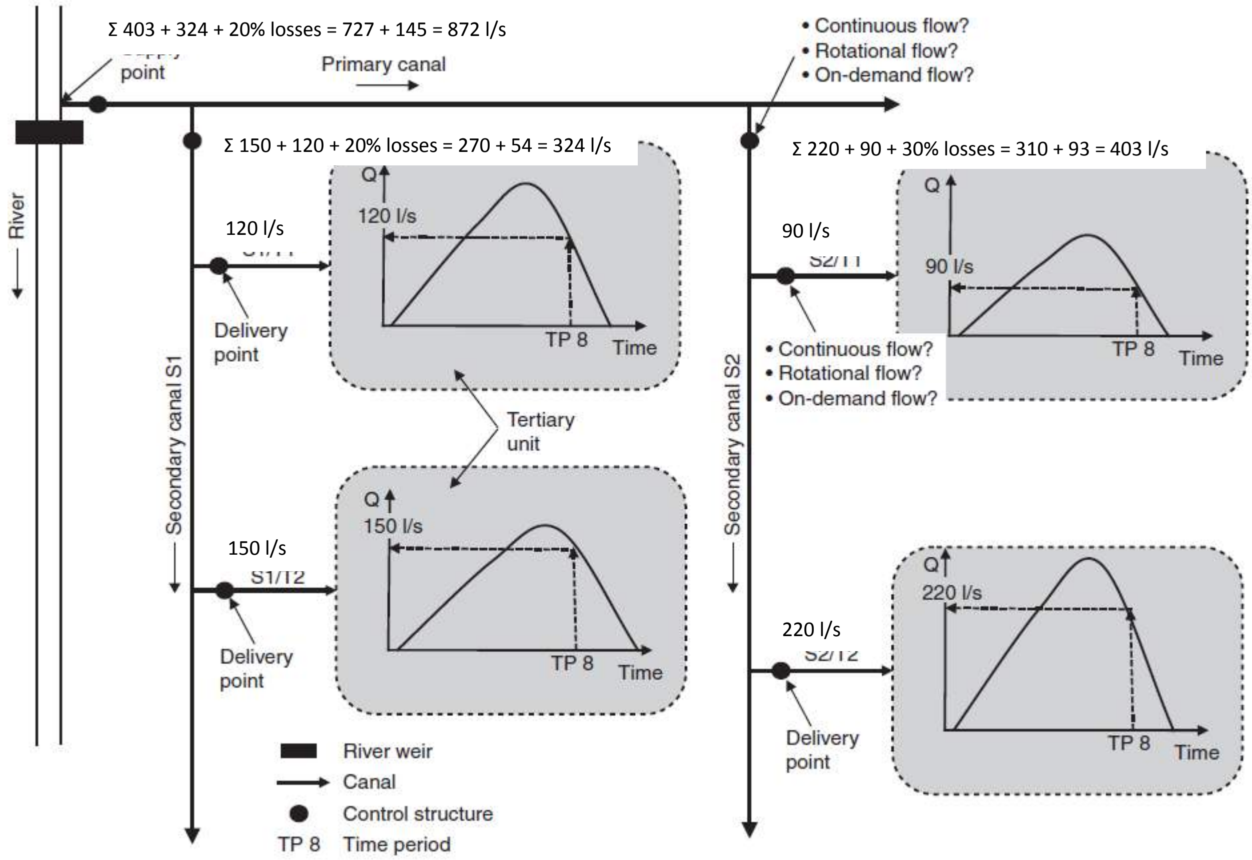
The decision on which type of scheduling system to adopt will depend on the design of the irrigation system (the types of storage, control and measuring structures), the staffing levels and capabilities, and the operation procedures (data collection, communication, processing, control structures).

| | |
|---|---|
| **Proportional Distribution**<br>• Management simplified<br>• No attempt to match supply to crop demand, farmers vary the cultivated area<br>• Can be inefficient in water use<br>• Low staffing levels. Poor farmers knowledge |  |
|  | **Irrigated area method**<br>• Need to know irrigated area (data collect.)<br>• Simple and equitable<br>• Needs control structures to vary discharge<br>• Does not match supply to crop demand<br>• Moderately high staffing level<br>• Poor farmers knowledge |
| **Factored crop area method**<br>• Need to know crop type and area (data collect.)<br>• Simple and equitable<br>• Needs control structures to vary discharge<br>• Matches supply to crop demand closely<br>• Moderately high staffing level |  |
|  | **Soil moisture deficit method**<br>• Need to know (data collection):<br>  ○ crop type and area<br>  ○ planting date<br>  ○ soil type<br>  ○ climatic data<br>• Needs control structures to vary discharge<br>• Matches supply to crop demand exactly. Theoretically correct<br>• High staffing level or high level of automation |

**Adjustment of schedule during cropping season**

The demand patterns within the irrigation system will vary depending on the type, area and planting date of the crops in the fields. This variation in demand needs to be matched with the supply available; the accuracy with which the demand is matched will depend on the system design, the staffing levels and their capabilities, and the operational procedures. An example is provided in next figure

**Figure 5-1 Adjusting patterns of irrigation demand with supply**




In time period 8 (measured from the start of the irrigation season) the irrigation demand in each of the tertiary units is different, due to the different command areas, cropping patterns, soil types, etc.

The main system service provider thus has to determine the demand at each tertiary unit intake during the time period and seek to match this with the flow at the system intake from the river.

The control gates on the primary canal need to be operated to pass the required secondary canal discharge. Likewise the tertiary unit gates need to be operated to pass the required tertiary unit discharge. These discharges need to be maintained nearly constant during the time period, requiring regular adjustment by the gate operators.

The process requires ascertaining the demands, planning the supply, regulating and measuring the flow, and reporting back. A failure to properly operate the gate, particularly on the primary canal, will result in a shortage of water at some locations, and an excess at others.

## 5.4 CONTROL SYSTEMS

Control systems and structures are required to enable the system managers to divert, distribute (enable the management of the frequency, rate and duration) and measure water supplies to water users. A further variable is the water level; control structures manage the water level in order to maintain sufficient command at key locations in the irrigation network.

Control systems are **separate** from control structures. Various types of structure may be used for the same system and different systems may use similar structures. The control system **does not necessarily define** the water distribution method (scheduling), although downstream control tends to be flexible and demand-oriented and upstream control is usually associated with more rigid supply-oriented water delivery.

Canal control systems can be classified as

- **upstream control**, supply-oriented. Requires a known flow rate delivered to specific offtakes
- **downstream control,** demand-oriented. Flow rates and delivery times are not calculated.

The different canal control systems available for the operation of main and secondary irrigation systems are briefly described in the following table

**Table 5-3 Canal control methods**

| Canal control method | Water control | Water delivery[a] | Automation | Control location | Control equipment |
|---|---|---|---|---|---|
| Fixed upstream control | Upstream water level | C | – | – | Proportional dividers (weirs) |
| Manual upstream control | Upstream water level | C, R, A | Manual | Local | Manual or motorized sluices or radial gates |
| Auto-electric upstream control | Upstream water level | C, R, A | Auto-electrical | Local | Undershot or overshot gates with electrical controllers |
| Auto-hydraulic upstream control | Upstream water level | C, R, A | Auto-hydraulic | Local | Automatic gates for constant upstream water level |
| Auto-hydraulic level-top canals | Downstream water level | D | Auto-hydraulic | Local | Level-top canals with automatic gates for constant downstream water level |
| Auto-electrical level-top canals | Downstream water level | D | Auto-electrical | Local | Level-top canals with electrical controllers |
| Combined upstream and downstream control | Upstream and downstream water level | A | Automatic | Local | Any combination of the above arrangements for automatic control (usually hydraulic) |
| Centralized arranged control | Upstream and downstream water level | A | Auto-electrical | Central | Electrically operated gates operated by central computer program |
| Centralized responsive independent control | Flow or volume in downstream pool | D | Auto-electrical | Central | Sloping canals with locally independent electrical controls and sensors at each gate with microprocessors |
| Centralized dynamic regulation | Hydraulic simulation | D | Auto-electrical | Central | Almost all systems are electrically controlled by a central computer |
| Pressurized systems | Flow | A, D | Automatic | Central | Pipelines |

[a]C=continuous; R=rotation; A=arranged; D=demand.

**Fixed upstream control:** water distribution is controlled by dividing incoming flow into predetermined and generally fixed proportions (usually based on the area served) by means of proportional dividers at each bifurcation point. Control structures are designed to divide flow proportionally whatever the flow rate arriving at the structure.

|  |  |
|---|---|
| Proportional flow controler Kilimanjaro Tanzania | Proportional flow controler Nepal |

Examples:

1. Warabandi system (NW India and Pakistan), flow is proportional down to tertiary level (proportionally fixed by size of outlet, based on command area) and is then rotated between farmers within a block (proportionally fixed by time share based on landholding size).
2. In Nepal, Bali and northern Tanzania the flow is divided in proportion to the area supplied, using simple proportional division structures.

Characteristics: All structures are non-adjustable and therefore operational requirements are minimized. The service provider needs only control the flow into the system and fulfil the maintenance requirements of the system. Is a very inexpensive system to run. The system is theoretically entirely equitable, although in practice equity is hard to achieve because structures rarely divide flow in the correct proportions over a wide range of flow conditions (flow levels, siltation, velocities, head loss across the structure, critical depth at blade, influence by downstream conditions). Properly designed flow splitters can be very effective; poorly designed ones can be relatively ineffective. (though this observation can be applied to all control structures). Because there is no control in the canal system it is difficult to respond to sudden events (such as a canal breach) along the distribution system. Water cannot be used efficiently in terms of crop production per unit water as the fixed control is inflexible and unable to respond to the varying demands of farmers with differing water needs.

**Gated upstream control:**

- **with flow rate control;**
- **with water level control;**
- **with structures for manual operation;**
- **with structures for automatic operation.**

Water distribution is controlled by adjusting gates within the system to provide the required flow at each offtake. At the inlet to the canal system gates are adjusted to allow the required flow into the system. All cross regulators downstream of the inlet should then be adjusted to maintain a specified flow/water level in the main canal immediately upstream of the structure with offtake gates then adjusted to pass the required discharges. Depending on how the flows are regulated there may be problems with fluctuations at these division points, which can cause variations in the flows entering the offtaking canals. Some systems are designed to minimize the adjustment required at each control point. These include using Neyrpic gates on the offtakes and long weirs in the parent canal, which are designed to minimize the impact on offtake flow of the variation of upstream head over the gate.

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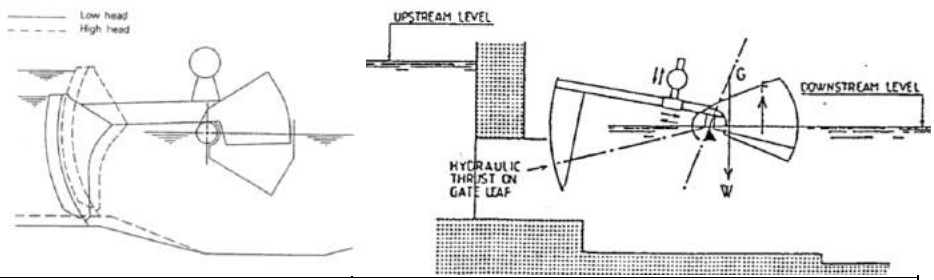
<td>
</td>
</tr>
<tr>
<td>Diagonal weir in parental canal with a Neyrpic offtake gate on the right-hand side</td>
<td>When the downstream water level drops below the desired level, it lowers the floater and rises the gate so that water flows into the downstream section and the water level rises again.</td>
</tr>
</table>

<u>Characteristics:</u> this system may be used for a range of delivery schedules except demand schedules. It is best suited to arranged delivery, as adjustments can be made according to farmers' predetermined requirements and gate settings coordinated throughout the system. However, this requires good communication between the farmers and the irrigation agency. If manually operated, gated control also requires a large number of dedicated staff to operate gates throughout the system. Although this type of control is relatively cheap to install, the high staffing levels required make it expensive to operate. When extra flow is added to the system it takes hours or days to arrive at the desired location. The supply and demand cannot be exactly matched. At the tail end of the canal any errors in gate adjustment will be magnified, leaving either a deficiency of water or wasting water into the drainage system. Corrections are difficult to make accurately and a large number of small adjustments are necessary. This makes automation a desired method of control. Automated gated control requires a higher degree of maintenance than manual gate control. Staff need to be well-trained in the operation of automatic gates and in preventative maintenance of control structures.

**Downstream control with level-top canals.** Downstream control is entirely demand-oriented. When a farmer opens an outlet the change in flow rate within the system causes upstream gates to make corresponding adjustments automatically until, eventually, gates at the source respond. Structures on the main canals must have some way of sensing the change, either hydraulically or electronically, in level or flow rate. Each structure has a set target level, which it automatically maintains. As demand can vary at any time all structures must be automatic. In order to be able to regulate for a flow rate of zero the canal banks must be level although the bottom banks must be level although the bottom of the canal may have a standard slope.

<u>Characteristics:</u> although control is by demand downstream of each control structure, this <u>does not necessarily mean that demand schedules are being used</u>. Canal capacities may not facilitate even a limited-rate demand schedule; however, water supplies may be turned off by the farmer at will, without risking damage to the canal system. As canals must have level tops, the canal bed slope between structures should be kept to a minimum. On steeper gradients a level top become prohibitively expensive. As flow rates and delivery times are not calculated, the need for data collection, processing, and communication systems, is lower, leading to lower staffing costs. Level-top control does not require electronic communication systems (all structures are connected hydraulically through the canal system).

**Upstream and downstream combined control.** Combined control uses upstream control for the headworks and along the major canals. A storage reservoir is then required where upstream control converts to downstream control. Below these reservoirs downstream control is exercised by water users taking water either on demand or by arrangement. Control structures are as described for upstream and downstream control in the sections above. The reservoirs are generally located off the main line of the canal to avoid excessive siltation, though in the case of the Gezira Irrigation Scheme in the Sudan the secondary canals are over-sized to allow storage of water during the night. Off-stream reservoirs need only be able to store 1–2 days' supply of water provided communication is sufficient to alert the main system managers of fluctuations in water level in the reservoir.

Characteristics: This system of combined control allows the flexibility of downstream control without the cost of providing for maximum capacities in the larger canals. Although there is an additional cost for building storage reservoirs, overall construction costs are lower than for a completely downstream-controlled system. The demand must be roughly predicted and upstream gates adjusted to maintain necessary flow, with the storage reservoir either supplying or absorbing the difference between expected and actual demand.

**Centralized control:**

- **with non-responsive scheduling;**
- **with responsive, arranged delivery.**

All centralized control methods exercise control from a single centre where all data are collated and processed and all gate adjustments are made. This system may be automated but is usually manual. Normally centralized control is used with monitoring to provide an arranged system based on water users' needs. Gates are electrically operated and adjustments made from the control centre using water level or volume data from monitoring points along the canal and water orders from users. Computer models of the irrigation system may also be used for setting gates.

Characteristics: enables the irrigation agency to coordinate the operation of an irrigation system much more rapidly because gates are not independent and therefore gate settings can be predictive, reducing response times through the canal system. Because changes can e made simultaneously throughout the system water users at the tail end of the system do not have to wait for 2 or 3 days for a change in delivery to reach them (unless the changes in flow required are significantly greater than the storage available within the system, in which case the routing of the flow will take longer).
For systems which are not fully automated, data are generally processed using a simulation programme and then instructions for gate settings are given to operators who manually adjust the gates. This requires well trained, dedicated and motivated staff to ensure accurate operation of the system.
Centralized control may use a computerized automated system. This requires robust electronic equipment, reliable power supplies to each gate, and skilled operators and maintenance personnel. Maintenance also needs to be preventative rather than curative as manual override of malfunctioning gates is not always possible.

**Responsive systems for sloping canals:**

- **general;**
- **with local independent controllers;**
- **with dynamic regulation.**

Responsive systems require centralized monitoring although gates may be either independently controlled or moved together. Measurements are taken every few seconds or minutes and water-use predictions updated. A computer programme examines water levels in pools and actual flow rates are compared with a statistical prediction of demand, then gate movements are dictated from the central facility.

Characteristics: The centralized systems described above require arranged delivery schedules whereas responsive systems allow much greater flexibility and are demand-oriented. The risk of failure is high if personnel, maintenance, power supply, initial equipment quality and communications do not perform very well, and so a skilled and efficient operational environment is needed to ensure rapid response to problems.

There is minimal human intervention in the operation of the canal system, which can operate fast and effectively in response to users' needs. It combines the advantages of downstream control with a coordinated centralized system. Canals do not have to be as large or as level as for level-top canals and therefore this control system may be used on steeper topography. The equipment necessary is complex, sophisticated and expensive, although savings are made in canal design and reservoirs are not needed in the system.

**Pressurized system.** This are systems where the conveyance structure are closed pipe systems, Main an secondary are generally high pressure. They work as a drinking water supply system.

Characteristics: High conveyance efficiency, minimal maintenance if properly designed, low silt level in water, simple operation unless complex pumping is needed. The disadvantages are that they may require expensive pumping, initial investments are higher than canals, pressure regulators are needed at turnouts because pressure might fluctuate hourly due to flow changes in turnouts.

**Issues affecting the choice of control system.**

The choice of canal control system depends on a wide variety of technical and non-technical issues. If farmers do not get the water supply desired then they may take action to give them the water supply they want which may disrupt the planned operation of the irrigation system.
Although a control system may be technically appropriate for a particular scheme there are many non-technical issues that will affect whether or not that control system will work effectively and whether it is feasible to alter the control system to improve scheme performance. The nontechnical issues related to control may be divided into the following categories:

- Institutional
- Organizational
- Economic and financial
- Environmental
- Social
- Agricultural/farmer

**Institutional:**

- the irrigation agency is private or public. Is it a strong or weak institution? A weak, publicly run agency will not be able to have effective control over a system that requires frequent close control.
- degree of commitment the staff and management have to the scheme and the farmers on the scheme. An irrigation agency will usually benefit if it is already established and has found its place within the wider society
- Computerized systems require a power supply that depends on the electricity supplier who must be reliable. Also require specialized maintenance where in house staff do not have the necessary skills to carry out maintenance tasks.

**Organizational**

The agency or other institution that runs the irrigation scheme has organizational structures for the operation of the system, are they complex or simple, well stablished or new, rapid or slow. Different control systems require different degrees of operation through these organizational structures and usually rely on them for the effective operation of the system.

Scheduling is an important part of many irrigation systems but would be impractical for schemes with limited communication between the agency and farmers. If scheduling does exist then it is important

whether or not these schedules accurately reflect both the actual supply and the farmer's requirements. Demand orientated control systems do not require the same level of scheduling as centrally operated systems which must inform farmers of their expected supply even if they do not consult them to discover their desired supply.
For most control systems monitoring is necessary and for some it is essential. There must be the capability for rapid and accurate monitoring of systems performance according to the needs of the control system being used.

Some schemes and control systems require a large and dedicated staff in order to operate effectively. Non-automatic systems rely entirely on the staff in the field to adjust gates etc. at the correct time and to the correct settings. Some control systems are particularly difficult to operate demanding many small changes in gate settings to achieve a desired water level. These systems will only work where the staff are committed to performing the task well.

Training must also be part of the organizational structure if different control systems are (to be introduced or the operation of existing systems improved. The skill level of the staff must be appropriate to the technology employed by the irrigation scheme.

Organization at village level such as water users' associations are an essential part of some control systems especially those which involve scheduling of any sort. Where WUAs are established and effective care must be taken if changes are made to water control systems that lessen the influence of the WUA. Such village level organizations provide an important means of communication which may be used by the irrigation agency to improve the operation of the system.

**Economic and Financial**
The operational costs of control systems tend to decrease as the capital cost of the system increases. This is true also when considering changing control systems.
The canal control system will affect the way in which charges are made for water within a system. Where the agency decides how much water is delivered to a particular part of the project, it is relatively simple for the agency to calculate water charges. However, many control systems rely on maintaining water levels without necessarily knowing the flow through control structures and consequently water charging is not so easy. Were irrigation water is not allocated but is supplied on demand, other methods of water charging may be required.
The farmers economic stake in the irrigation system is another consideration affecting the appropriate canal control system. If the farmers are subsistence farming, then they will desire a very reliable water supply even if it is not the most efficient. If, however they are growing cash crops and are paying for water volumetrically, then farmers will desire a more efficient and flexible system.

**Environmental**
The environmental effects of control system relate to the over or under supply of water along the distribution system. Some control systems that respond slowly to changes in demand, allow water to overflow at the tail end of the canal systems. This can lead to waterlogging and salinity problems in areas with an already high water table. It is also inefficient in areas where water may be scarce. The sustainability of an irrigation project does not depend entirely or directly on the choice of control system, however this must be considered when choosing a control system in order that the system may be adaptable to possible future situations without the need to cause unacceptable damage to the environment.

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**Social**
An inexperienced irrigation community will need much more central control than one where there is much irrigation experience. However, experienced communities may be unwilling to adapt to new and potentially more complicated control systems when current systems appear to operate satisfactorily.
The relationship between farmers, and authorities in general and the irrigation agency in particular are important when considering a change in control system that may alter the balance of power in favor of an unpopular agency
The technology level of the local community will affect how they respond to the introduction of new complex irrigation control systems. The community's familiarity with technology will also affect the hiring and training of staff for the irrigation agency.
The local community will usually provide labor for irrigation projects and so a control systems that requires a large labor force can only be implemented if the labor is available. The community must also be willing and motivated if control systems dependent on community participation are to work effectively.

**Agricultural/farmer**
All irrigation systems depend on the final water users for their effective operation. For farmers, water supply is only one of a number of factors that have to be taken into account when planning activities. A good control system will allow the farmer maximum flexibility and predictability of supply in order that decisions on other aspects of farming do not have to be fitted wound water supply. This does not necessarily mean that demand orientated control systems must be used as long as the scheduling of upstream control is such that it is convenient for the famer.
Although most farmers will desire a certain independence in their water use, where there are established systems for cooperating over water supply these systems may be used effectively for water distribution.

## 5.5 DISCHARGE MEASUREMENT

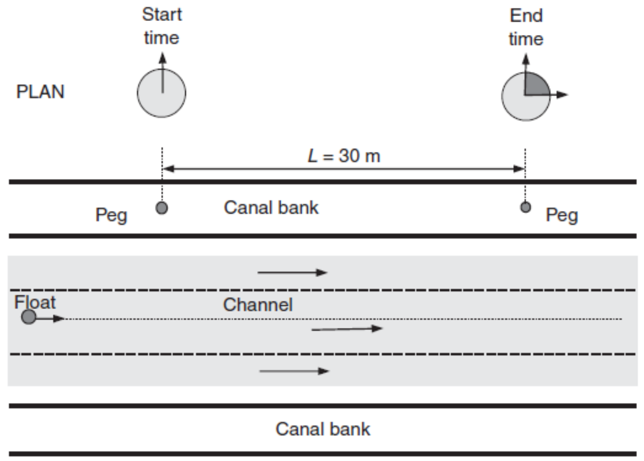
In many irrigation and drainage systems measurement of discharge is an essential component of the operation process. Discharge measurements need to be made in rivers, canals, drains and pipelines and can be made in a variety of ways using:

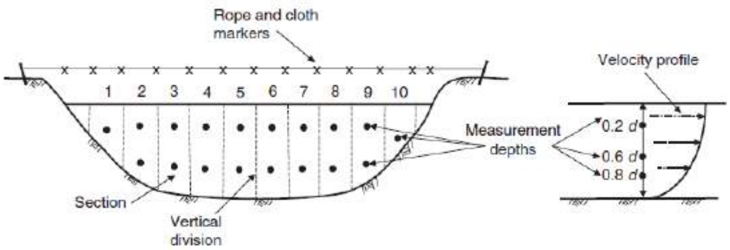
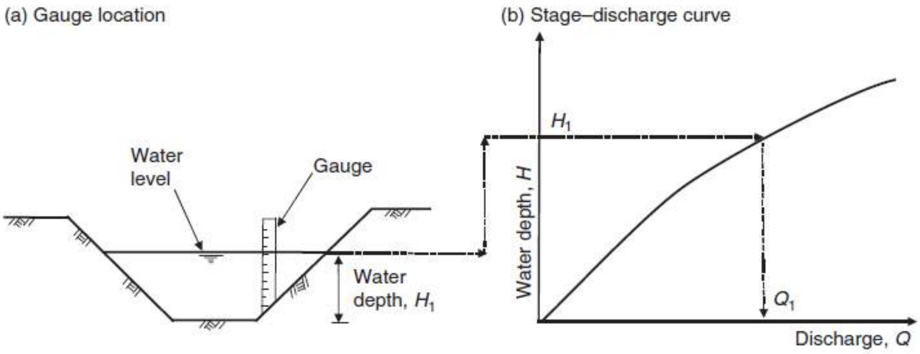
1. **velocity–area methods;**
2. **hydraulic structures;**
3. **flowmeters**
4. **slope–hydraulic radius–area method:** Measurement of water surface slope, cross-sectional area, and wetted perimeter over a length of uniform section channel are used to calculate the flow rate, by using a resistant equation such as the Manning formula
5. **dilution techniques:** the flow rate is measured by determining how much the flowing water dilutes an added tracer solution.

The most commonly used techniques are the velocity–area method, hydraulic structures and flowmeters.

1. **Velocity–area methods;** they involve the measurement of the channel cross-sectional area (using a tape and level staff or depth gauge) and the average velocity of flow, determined with a current meter or a float.

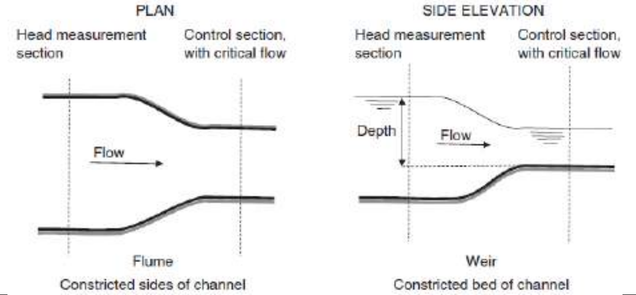
**2.**

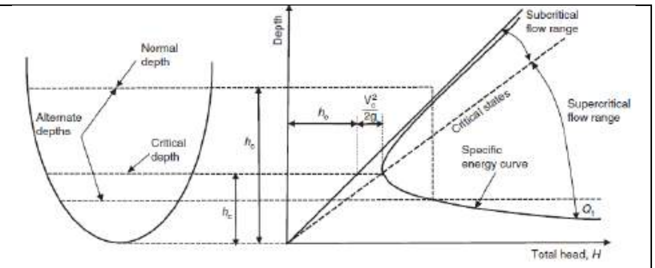
<table>
<tr><th colspan="3">Velocity–area methods</th></tr>
<tr><td>Float method</td><td>
</td><td>

The float method is a simple, yet effective way to determine the discharge of a flow stream. (accuracy ±20–30%), well suited to smaller channels<br><br>Q=0,7 * Area * Average Velocity</td></tr>
<tr><td>Current meter</td><td>
</td><td>
Current metering can be an accurate method (±5%-10% )</td></tr>
<tr><td>Stage discharge cuve at gauged station</td><td>
</td><td>When measurements have been taken at a given location for a variety of flow conditions a stage–discharge curve can be formulated to enable discharge to be determined from the depth alone</td></tr>
</table>

3. **Hydraulic structures**; If constructed to the standard designs they provide an easy-to-use and accurate method of discharge measurement relating <u>a single measurement of water depth to the discharge</u> flowing over the structure. In a measuring structure the channel cross-section is constricted (side width, bed elevation, or both) such that the specific energy level is reduced from subcritical through the minimum to supercritical. The transition from supercritical back to subcritical occurs downstream of the control section in the form of a hydraulic jump. For some measuring structures the relationship between depth and discharge can be derived mathematically; (from the relationship between the **velocity** at the critical depth, Bernoulli’s equation and the continuity equation) for others it must be determined empirically through measurements in a laboratory.

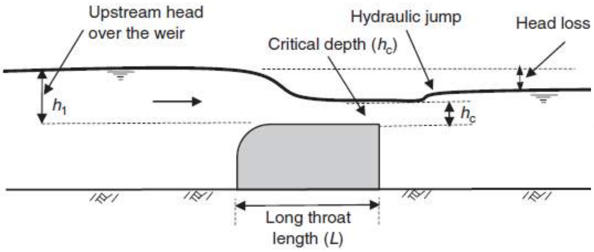
> The discharge measuring structure does not reduce the flow entering the canal; this is often a cause of concern among farmers who may sometimes damage a measuring structure as they think it is impeding the flow. The structure raises the water level upstream by 5–10 cm, and increases the velocity of flow in the control section. The discharge is the same as in the canal without the measuring structure.



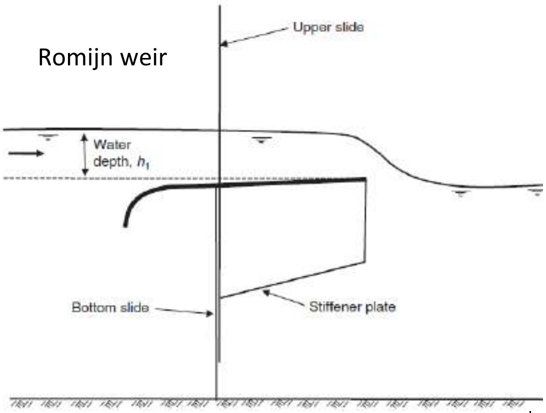

## Hydraulic structures

**Broad-crested weirs;**



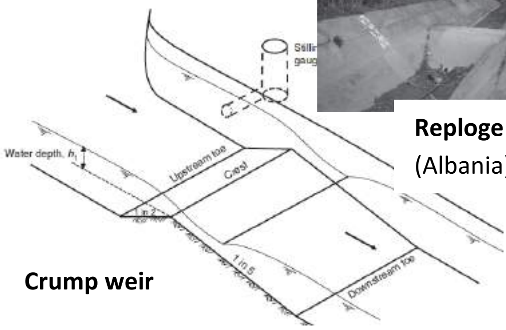

$Q = 1.71\ b\ h_1^{(3/2)}$ (b width of the weir)

Broad-crested weirs are more robust than sharp-crested weirs though they are not as accurate. They have a high modular limit and do not require such a high head loss across the structure. On the other hand they can be difficult to construct (ensuring parallel faces, a uniform and horizontal crest, and smooth, even upstream curves in the case of round-nosed weirs)




**Romijn weir** combines a flow regulation and a measurement function. It is adjusted up or down to pass the required discharge over its crest.

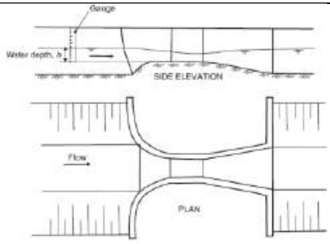
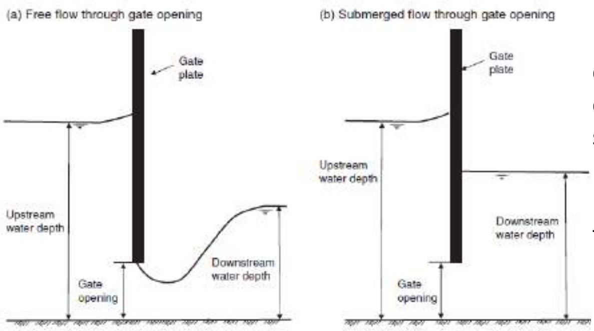
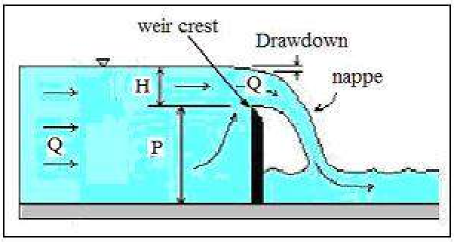
**Short-crested weirs;**



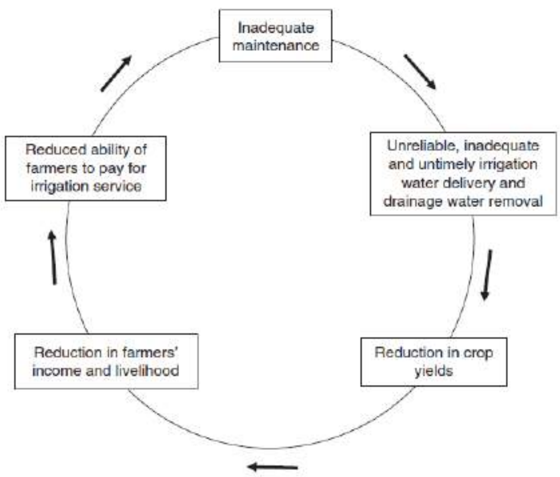

**Crump weir**

**Reploge weir** (Albania)

**Crump weir** is suitable for many sizes of canals and rivers, is accurate, relatively cheap and easy to construct, and has a high modular limit, and the structure passes sediment freely.
**Replogle weir** is similar to a Crump weir in having a sloping front face, but a short horizontal crest section with either a vertical or sloping back face. Easy to construct and suited to trapezoidal or parabolic lined channels.

| | | |
|---|---|---|
| **Flumes** |  Flumes are similar to weirs except that the constriction of flow is obtained by narrowing width rather than raising the bed level.<br>**Long-throated**: Can be treated analytically<br>**Short-throated**: flow in the throat is not parallel, cannot be treated analytically, stage–discharge relationship determined by laboratory and field calibration. **Parshall flume, H-flume** |  |
| **Orifices** |  | Flow regulation gates can be used for discharge measurement but they have to be individually calibrated due to the variation in the flow conditions (gate thickness, side wall and bed shape and condition). Calibrating the gates can be difficult. Using such procedures for discharge measurement is not generally recommended for regular operating purposes; a standard measuring structure is preferred |
| **Sharp crested weirsted** | <br>Sharp Crested Weir Parameters |  |
| | If correctly installed and maintained, are extremely accurate (±5%). Their disadvantages are that the sharp crest is prone to damage by floating debris, a relatively large head loss is required for correct operation and they are prone to sedimentation upstream, and thus inaccuracies in measurement | |
| **4. Flowmeters** |  |  Electromagnetic flow meter |
| | The propeller meter is commonly used for flow measurement in pipes. It is a <u>totalizing</u> metering that the number of revolutions is proportional to the total flow passing | Non-intrusive flow measurement devices. These operate through Doppler shift or the accurate measurement of time of travel of ultrasonic signals located on opposite sides of the pipes. |

# 6 MAINTENANCE




An I&D system which is inadequately maintained will fall into disrepair. Gates will become inoperable, measuring structures will drown out, canals and drains will silt up, vegetation will block canals and drains, canals will overtop and breach. As a result irrigation water supplies will become irregular, unreliable, untimely, inadequate and uncontrolled. Drainage water removal will be hindered, leading to a rise in the groundwater table and salinization. The ultimate consequences of a lack of maintenance are a reduction in crop yields and overall crop production, leading to a reduction in farmers' incomes and the ability to pay the service fees

**Figure 6-1 The vicious circle of inadequate maintenance**

Unless preventative action is taken an I&D system will deteriorate over time as a result of natural forces, as well as from human and animal activities.

Natural forces:

- rainfall; wind;
- erosion by surface runoff, flow of water in canals and drains;
- transportation and deposition of silt in rivers, canals and drains;
- vegetative growth in and around canals, drains and structures;
- corrosion and rusting of gates; biological degradation of organic matter (e.g. wooden gates)

Animal and Human activities:

- rodents and burrowing animals (in embankments);
- human and animal traffic across canals and drains; corrosion and rusting of gates; biological degradation of organic matter (e.g. wooden gates); thermal expansion and contraction.

Reasons for deterioration:

- **Lack of adequate funds for maintenance**
- Lack of understanding of the need and priorities for maintenance;
- Poorly defined maintenance procedures;
- Lack of staff training in the identification, reporting and processing of maintenance requirements;
- Poor allocation of available resources, incorrect or undefined maintenance priorities;
- Poor supervision and monitoring of maintenance work;
- Poor design and construction of the system, or parts thereof, in the initial instance;
- Poor operation practices:
  - Incorrect operation of the gates at the river intake, for example, can result in unnecessarily large quantities of silt entering the canal system, while filling and emptying canals too rapidly can cause embankments to slip, collapse or breach.
  - Incorrect operation of cross regulator gates can result in overtopping and breach of canals, and a failure to close down the irrigation system during periods of heavy rainfall can lead to overloading of the drainage system as unused irrigation water is added to surface water runoff.

If the lack of funding is the key issue then it is important to quantify the level of funding required, the scale of the shortfall and the consequences. The cost to individual farmers and to the local and national economy in lost agricultural production of failing or failed I&D systems will almost always be more than the costs associated with providing adequate maintenance.

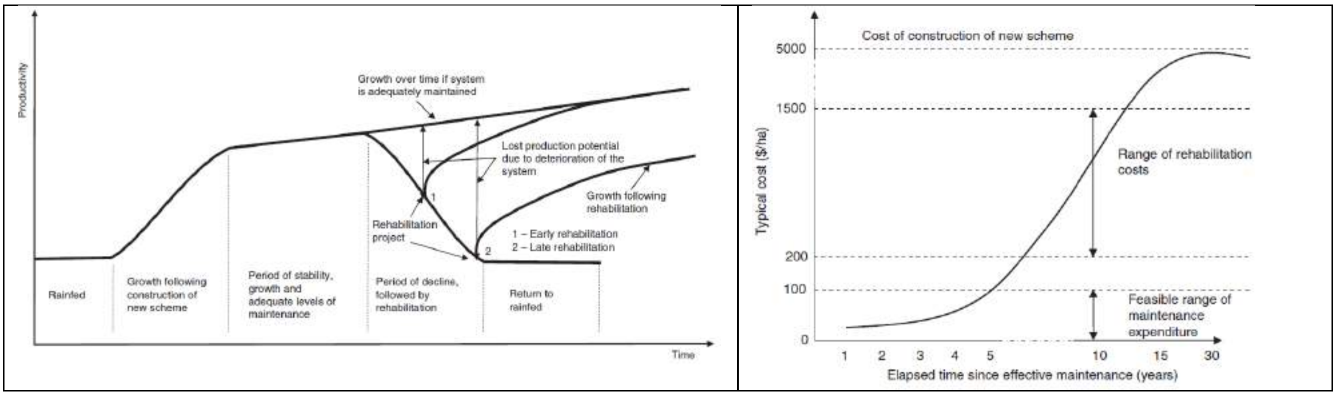



**Figure 6-2 Possible stages of growth and deterioration of I&DS with and without adequate levels of maintenance / Cost of remedial works**

**Objectives for maintenance**

The objectives for maintenance of an I&D system can be stated as:

- Keeping the system in good operational order at all times;
- Obtaining the longest life and greatest use of the system's facilities;
- Achieving the above two conditions at the least possible cost.

**Maintenance Categories**

Maintenance can be classified into six main categories:

- routine;
- periodic;
- annual;
- emergency;
- deferred;
- preventative.

Maintenance work can be carried out under these categories by one, or a combination, of the following:

- direct labor, either as individual laborers responsible for certain sections or components of the I&D system or as maintenance gangs – this labor may be employed full- or part-time;
- contractors;
- local communities.

**Routine maintenance**

Routine or day-to-day maintenance is small maintenance work that is carried out on a regular basis. It is usually carried out by manual labor. Such work includes, but is not limited to, the following:

- minor repairs to earth embankments – small gullies from rainfall runoff, animal damage, machinery damage, cracks and small seepage holes;
- clearance of silt in canals and drains near structures, especially near gates, measuring structures and siphons;
- clearance of floating rubbish from canals and structures, rubbish screens and gate wells;
- removal and cutting back of vegetation from within canals and drains, from embankments (trees and bushes) and from around structures;
- greasing and oiling of gates.

Routine maintenance work is usually done by a gatekeeper, maintenance laborer or by farmers working individually or in groups.

**Periodic maintenance**

Periodic maintenance is small-scale, often preventative, maintenance work that does not pose any immediate threat to the functioning of the system. Such work may require skilled labor or machinery and should be carried out at intervals during the irrigation season, as required. This work includes but is not limited to the following:

- repairs to concrete canal lining and structures;
- repairs and maintenance to wood and metal works, in particular gates;
- repairs to measuring structures, and installation of gauges;
- repairs to canal embankments if there is leakage or overtopping;
- painting of metal and woodwork;
- repairs to machinery such as pumps and engines;
- access road upkeep.

Some of this work could be carried out though small contracts but can also be done by an in-house maintenance team. This team might comprise a foreman, concrete/masonry artisans, carpenters, fitters/mechanics, maintenance plant operators and laborers. The maintenance team would be mobile and have a pick-up truck and possibly some maintenance plant such as an excavator.

**Annual maintenance**

Annual maintenance is work that is planned as a result of maintenance inspections, which is too large or on too wide a scale for periodic maintenance work. It could also include work related to the improvement of the system rather than maintenance. The maintenance work is carried out when the canals or drains are not in use, either at the end or the beginning of the irrigation season. Such work includes but is not limited to the following:

- major desilting work in main canals and drains;
- repair of canal lining;
- repair of headworks and canal/drain structures;
- maintenance of canal embankments, service roads and flood bunds;
- repair or replacement of equipment, gates, pumps, motors, etc.

Contractors are generally hired to carry out this work.

**Emergency maintenance**

Emergency maintenance is work that cannot be planned for and is carried out as the need arises. The uncertainty of what and where the problems are going to be makes coping with the problems difficult. Flexibility of working practices throughout the system is required as a result. Work in this category may include:

- temporary repairs to river, canal or flood bund embankments in the event of a breach or possible breach;
- preventative work to avoid structure failure, or temporary repair as a result of a structure failure;
- work to alleviate flooding, landslides or mud flows.

The nature of the work requires it to be carried out quickly. Prompt action minimizes the extent of any damage and of the repair work required. Good communication systems are extremely useful in these circumstances. for example, with a canal breach to communicate with the headworks to close down or reduce the intake discharge.

Carrying out a risk assessment for the scheme to identify areas where emergencies might occur can save time, resources and expense when these events actually occur. The risk assessment will review historical emergency events, inspect the site and talk with scheme staff and water users to identify areas of risk and measures to prevent, mitigate or deal with them if they occur. This might, for example, take the form of storing sand and sandbags in villages near areas of river prone to overtopping during extreme river flow periods, maintaining a list and contact details of village headmen, and organizing a practice emergency call-out with the villagers.

**Deferred maintenance**

Deferred maintenance is work that has been identified following inspection of the infrastructure but which is either of low priority or cannot be carried out due to lack of sufficient funds. The work is recorded in the maintenance register and periodically reviewed. Some of this work may be related to system improvements such as:

- improved footbridge crossings, road culverts;
- improvements to access along canal embankments.

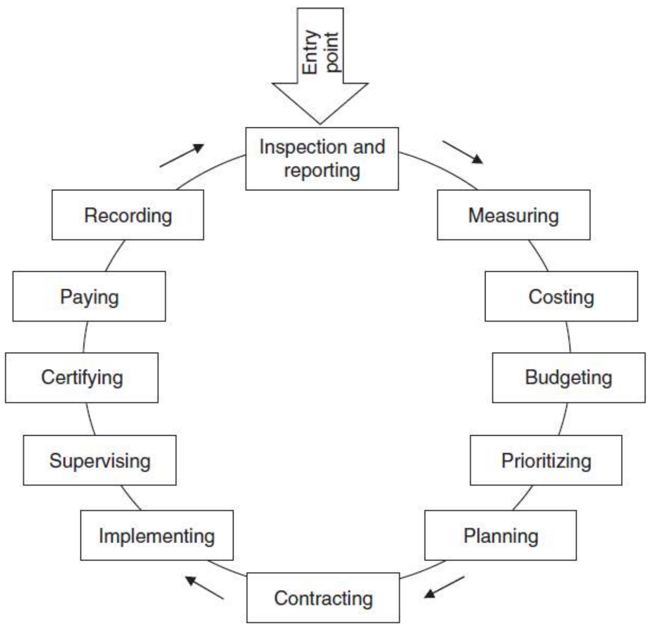
The phrase 'deferred maintenance' is also sometimes used to refer to work carried out under rehabilitation projects, where maintenance work has been 'deferred' and carried out under the rehabilitation project.

**Preventative maintenance**

Preventative maintenance is work that, if carried out, will result in preventing more expensive maintenance or repair work at a later date. A classic example of preventative maintenance is the prevention of seepage around or under hydraulic structures; if seepage is identified and remedial action taken in good time, the collapse of the structure can be prevented, saving considerable expense. Priority areas for preventative maintenance include:

- checking for seepage around or under structures, especially if there is a high pressure head across the structure;
- grading of embankments and canal/ drain inspection/access roads to avoid ponding of water and gullying;
- closing river intake gates before high flood levels in the river, both to avoid excessive discharges in the canal and intake of water with high sediment loads;
- painting of metal and wood components, particularly gates and gate frames.

## 6.2 MAINTENANCE CYCLE




**Maintenance inspections and reporting**

Inspection of irrigation and drainage works for maintenance can be carried out by engineers, operation and maintenance (O&M) staff or field staff. There are two forms of maintenance inspection:

1. Inspections as part of the day-to-day work;
2. Annual or seasonal inspections.

Standard procedures for inspection and reporting of maintenance are an obvious prerequisite for effective maintenance. Unfortunately, such procedures are not always properly developed. The following are required:

- a set of clearly defined instructions and procedures detailing when inspections should be carried out, by whom and how often;

- clearly defined reporting procedures, comprising a set of reporting forms and a maintenance register – the maintenance register should have a record of all the maintenance work required, and its current status and categorization (required, periodic, annual, deferred, etc.).

**Inspections as part of the day-to-day work**

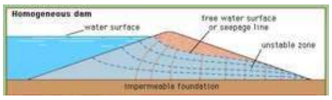
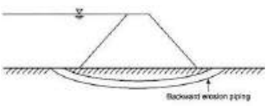
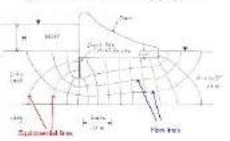
Inspection and monitoring of maintenance needs is part of the field staff's work, and should be part of their daily routine. Field staff, gatekeepers and pump operators should have field books in which identified maintenance work can be written down and then reported to the office.

Daily routine maintenance, such as greasing of gates, need not be reported and booked, though the annual and periodic inspections should check that this work is being carried out by field staff.

Any maintenance requirements observed by field staff that they cannot carry out should be reported and recorded in the maintenance register. In the case of emergency maintenance, the field staff should take action immediately, and do what they can to get help in dealing with the emergency.

Maintenance needs that should be looked for during the irrigation season is listed in next table:

**Table 6-1 Points to look for during in-season maintenance inspections.**

| Where to look | Typical problem / maintenance need | Consequence | Possible solution |
|---|---|---|---|
| Canal section  | Vegetation obstructing flow | Capacity of canal is reduced. May cause overtopping of the canal embankment resulting in a breach in the canal  | Cut or remove vegetation |
| | Rubbish obstructing flow at siphons, aqueducts, culverts, etc. | | Remove rubbish |
| | Undersized culverts or structures | | Replace culverts |
| | Siltation | | Remove siltation |
| Canal embankments  | Seepage through embankments  | Loss of water, in the longer term the embankment may collapse. Large breaches often start with small leakages | close the canal, excavate damaged section and refill with compacted material |
| | Erosion  | Eventual breach of the canal | Identify cause:<br>Human or animal traffic put protection (steps, stones, etc.), Rainfall: grade embankment top |
| Structures  Figure 10.19 Backward erosion piping failure.  | Seepage through structures' concrete or masonry | Loss of water, but in the long term may lead to piping and undermining the structure. | Replace with sound concrete or masonry, Replace and compact any eroded backfill |
| | Seepage or piping around structures | Loss of water. Erosion of the soil material around the structure and it will collapse. Common failure and the most expensive to | Close the canal and repair by excavating and replacing eroded backfill material . Extend wingwalls or cut-offs to increase the seepage path |

| | | | |
|---|---|---|---|
| | | repair | |
| Gates, valves and hydrants  | Leakage through closed gates | Loss of water | Replace rubber, gate plate or the whole gate. |
| | Unable to operate gate properly | Inability to control water, (wastage or inability to deliver water according to demands. Serious consequences for downstream users | Replace broken or damaged portion of gate (spindle, nut, plate, frame) or whole gate |
| | Corrosion | Leakage. Inability to move gate | Preventative regular painting. Very cost-effective |
| Measuring structures, flowmeters | Drowned out or damaged measuring structure. Flowmeters out of calibration or useful life. | Cannot measure flow. Inability to match supply and demand. Shortage or wastage of water. Incorrect fee collection and conflict with water users | Look for cause of drowning<br>• raise crest level (if head available)<br>• remove vegetation/ obstructions downstream,<br>Repair damaged section<br>Replace flowmeters |

**Annual or seasonal inspections**

Annual or seasonal maintenance inspections should be carried out by experienced engineers.
There should be

- <u>one pre-season inspection</u> to identify work to be carried out before the irrigation season starts,
- <u>one inspection at the end of the season</u> that identifies work that may need to be contracted out and completed before the following irrigation season commences.

Ideally the annual or seasonal inspections should take place under two conditions:

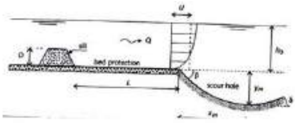
- <u>when the canals are empty:</u> enables inspection of infrastructure below the normal water line
- <u>when the canals are flowing at design capacity:</u> allows assessment of the carrying capacity of the canals, and the functioning of conveyance, control and measuring structures.

For drains similar practices apply, with inspections when the drains are relatively dry and when they are flowing full. (during or immediately after periods of heavy rainfall and runoff).

Points to look for during the annual/seasonal inspection are presented in next table:

**Table 6-2 Points to look for during the annual/seasonal inspection**

| Where to look | Typical problem / maintenance need | Consequence | Possible solution |
|---|---|---|---|
| Canal or drain section | Vegetation obstructing flow | Capacity of canal is reduced. | Cut or remove vegetation |
| | inadequate functioning of weep holes to relieve pore pressures | Pressure will build up behind the canal lining and the lining will collapse | Clean out weep holes or install new ones |
| | Sediment | Capacity of canal is reduced. | Survey and remove |
| Canal or drain embankments | Vegetation along canal or drain embankments | Roots of large vegetation can damage the embankment | Cut down, also remove roots |

| | | | |
|---|---|---|---|
|  | Vegetation obstructing access | Cannot inspect or move along the embankment. O&M will be impaired | Remove vegetation |
| | Low spots in embankments | Possibility of overtopping and breach of canal | Raise section to design level with compacted fill material |
| Structures  | Cavities beneath masonry or concrete floors or side walls (test by banging with a stout pole). | Indicates seepage or piping. If not dealt with the structure or lining may collapse, requiring costly repairs | Locate and repair the cause of the loss of backfill (e.g. piping, seepage, etc.). Break out the concrete or masonry and backfill the affected areas or excavate behind the structure and place compacted backfill |
|  | Cracks in masonry or concrete. Check depth and extent of cracking. Check if reinforcement exposed | Loss of water. Undermining of the backfill material and eventual collapse of the lining or structure. If reinforcement is exposed, steel will rust. | Cut out affected area and replace with well compacted concrete |
|   | Scour hole downstream of structures, (cross regulators or drop structures). Plumb holes with plumb line, or drain with a pump to inspect fully | The structure may be at risk of collapse  | Check if the situation is stable or not. If scour is continuing then a full engineering inspection may be required |
| | Partial blocking of culverts, siphons, etc. | Impeded flow, possible overtopping upstream | Remove sediment, rubbish and vegetation causing blockage |
| Gates,valves & hidrants | Condition of metal and woodwork | Deterioration of wood or rusting of metal can lead to failure | Protect wood and metal parts with creosote, varnish or paint |
| | Inoperable gates (test if gate can be fully opened/closed) | Inability to control water, | Replace broken or damaged portion of gate (spindle, nut, plate, frame) or whole gate |

**Maintenance reporting**

A key part of inspections is the recording of the maintenance work required and the details of when, how and by whom it was carried out when it has been dealt with. For this purpose, a Maintenance Register is useful in order to:

• help in processing the data collected on maintenance requirements;
• assist in prioritizing and allocating maintenance work;
• record the maintenance work carried out in a transparent and accountable format.

**Maintenance Work Sheet**: To assist in the measurement and quantification on the field.

MAINTENANCE WORK SHEET

CANAL/DRAIN: ____________________

LOCATION: ____________________

| Decription of work required: | Units | Quantity |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

SKETCH (If required, showing location and/or damage details)

The registered work can then be prioritized and a decision made as to who will do the work (in-house maintenance team, contracted labour, contractor, local community voluntary labour, etc.).

**Maintenance register:** keeps data collected from the field, plus unit costs of the work items to determine the total estimated cost of the work and once the work has been completed, details of the work done will be recorded, including the sum paid, the name of the contractor and the date completed.

MAINTENANCE REGISTER

| LOCATION | | WORK REQUIRED | BILL OF QUANTITIES | | | | | ACTION TAKEN | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Canal/structure type | Chainage (m) | Description and drawing of the work required | Unit | Quantity | Rate | Amount | Priority | Date completed | Cost | Name of contractor |
| | | | | | | | | | | |

**Maintenance measurement and costing:** Measurement of the maintenance work is needed to quantify the work to provide a basis for estimating **measurement and costing** the time required to do the work, and the cost.

| Item | Unit | Quantity | Unit rate ($) | Amount ($) |
|---|---|---|---|---|
| **Earthworks** | | | | |
| Compacted fill | | | | |
| Removal of sediment | | | | |
| Repair of access road | | | | |
| …… | | | | |
| **Canal lining** | | | | |
| **Structures** | | | | |
| **Control and measurement structures** | | | | |
| **Miscellaneous** | | | | |

**Maintenance prioritization**

It is often not possible to carry out all the required maintenance work, generally due to financial, resource (labor, machinery, etc.) or time constraints.

In some cases, it is not efficient to carry out the maintenance work each year, for example in the case of sedimentation of canals or drains where it is more efficient and cost-effective to remove sediment once every 3–5 years rather than on an annual basis.

Once the required maintenance work has been identified it can be prioritized and planned to fit within the available budget and resources.

It is difficult to set a generic set of rules for prioritization of work for I&D systems; for some systems with heavy sediment loads in the river the priority is sediment removal, in a system with low sediment loads the priority might be vegetation removal (as weeds grow more quickly in clear water). Factors influencing the setting of priorities are the following:

- **How sophisticated is the system?**
  - In simple systems conveyance is more important than measurement
  - In more sophisticated systems measurement has a high priority as it allows fees charging.
  - In systems with downstream control timely maintenance is essential.
- **What are the consequences of not doing the maintenance work?** What is the risk of failure, and what is the cost of such failure on crop yields, agricultural production and repair work?
- **Will water be lost or used inefficiently?**
  - If the system is water-short then conserving water will be a priority,
  - if there is sufficient water then the loss of water is less important, but waterlogging and salinization may be issues.
- **Will control be lost or impaired?** An inability to control the flow at division points mean that some users get too much water while others do not get sufficient, leading to wastage on the one hand and possible crop yield reduction on the other.
- **What command area is affected by the maintenance work?**
- **How cost-effective is the maintenance work?**
  - A classic example here is: masonry lining of canals, which has little effect on seepage losses, versus repair of damaged control gates.
  - Repairs to gates are often cost-effective relative to canal lining;.
- **Can it wait until next year?** In some cases work can be deferred, in other cases there is a high risk of failure and increased costs

For any given I&D system such a list of priorities should be drawn up by experienced personnel to act as a guide for the selection and prioritization of maintenance work

**Table 6-3 Example of priorities for maintenance work**

| Priority | Type | Comment |
|---|---|---|
| 1 | Diversion weir and intake. Pump stations | Failure of this structure would have serious consequences. Top priority for maintenance, particularly the gates and pumps. |
| 2 | Leakage, unauthorized offtakes and overtopping | Can lead to failure of the embankments with serious cost consequences |
| 3 | Gates, valves and control structures | The system cannot be operated efficiently without control structures in good condition |
| 4 | Lining repair | Repairing of cracks and maintenance of construction joints in lining is necessary before water gets in behind the lining, causes cavities and |

| | | |
|---|---|---|
| | | piping, leading to collapse |
| **5** | Embankment protection | Erosion, low spots, rodents' holes, human and animal traffic, roots. |
| **6** | Measuring structures, flowmeters | Inefficient, incorrect and therefore conflictive water management and water charging |
| **7** | Silt removal | Silt removal upstream of measuring structures has higher priority, general silt removal has a lower priority, except when reduced canal capacity or freeboard |
| **8** | Vegetation removal | • to maintain the carrying capacity.<br>• to maintain access.<br>• from cracks in lining<br>• removing strong-rooting shrubs and trees from canal banks and around structures |

### Maintenance budgeting and planning

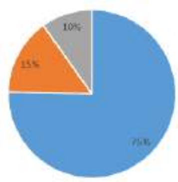
A key part of maintenance planning is to schedule maintenance work to come within the annual maintenance budget. The maintenance budget should be set at a level such that all the required maintenance work can be carried out over a period of 5–20 years.

Peaks and troughs in expenditure should be avoided, with the work required spread out over time such that the expenditure is smoothed and an annual budget can be set. Thus, for example, the main drains in a system might need desilting every 5 years; to avoid a peak each 5 years this work will be scheduled so that different reaches of the drainage network are cleaned each year, with a return to a given reach in 5 years time.

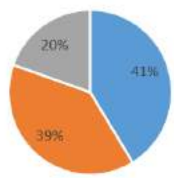
**Table 6-4 Example of estimating the maintenance costs based on annual and multi-year replacement**

| | €/ha | | 300 | ha | €/ha | | 30000 | ha |
|---|---|---|---|---|---|---|---|---|
| **Annualized maintenance costs** | 35,00 | **52%** | 10500 | | 53,20 | **81%** | 1596000 | |
| Main & 2ry canal and collector drains maintenance cost | 19,00 | 28% | 5700 | 41% | 22,90 | 35% | 687000 | 75% |
| Management costs public system | 18,00 | 27% | 5400 | 39% | 4,50 | 7% | 135000 | 15% |
| Operation costs public system | 9,00 | 13% | 2700 | 20% | 3,00 | 5% | 90000 | 10% |
| **Total public system MOM costs** | **46,00** | 69% | 13800 | 100% | **30,40** | 46% | 912000 | 100% |
| | | | | | | | | |
| Field canals and drains maintenance cost | 16,00 | 24% | 4800 | | 30,30 | 46% | 909000 | |
| On farm management costs | 2,40 | 4% | 720 | | 2,40 | 4% | 72000 | |
| On farm operation costs | 2,40 | 4% | 720 | | 2,40 | 4% | 72000 | |
| **Total on-farm MOM costs** | **20,80** | 31% | 6240 | | **35,10** | 54% | 1053000 | |
| | | | | | | | | |
| **Total MOM** | **66,80** | 100% | 20040 | | **65,50** | 100% | 1965000 | |
| Property tax | 6,00 | | 1800 | | 6,00 | | 180000 | |
| VAT on public system MOM (18%) | 8,28 | | 2484 | | 5,47 | | 164160 | |
| **Total on-farm MOM costs including taxes** | **81,08** | | 24324 | | **76,97** | | 2309160 | |

MOM cost for 30.000 ha system




MOM cost for 300 ha system




■ Main & 2ry canal and collector drains maintenance cost
■ Management costs public system
■ Operation costs public system

### Maintenance contracting

Once the maintenance work has been drawn up, costed and prioritized, contracts can be let for the work (unless it is to be carried out by direct labour or by the water users themselves).

Tender documents with bills of quantities, specifications and the contract terms are drawn up and contractors invited to bid.

It will be important to include guidance in the contract and penalty clauses to ensure that the contractor takes due account of the constraints that it will be working under. This may include ensuring that irrigation water supplies are maintained to water users during the maintenance period, and that the maintenance work is completed before the start of the irrigation season.

Delays in re-opening canals can have serious financial consequences for farmers, and must be avoided. Ideally the contract should allow for compensation payments to be made to farmers where water supplies are delayed or impaired, or allowance made in the contract for compensation payments to farmers where diversion channels are built on their land to bypass construction work.

In some cases, a long-term framework contract might be let, which will state the general type of work and invite the contractor to submit rates for stated types of work. The contractor will then be given specific work to be carried out each year, based on these rates. Such contracts are usually let for several years at a time, and enable the client to budget for the cost of the work and call on the contractor in case emergency work is required.

Contracting out maintenance work is increasingly being used in many countries as the private-sector contracting industry strengthens; formerly it was only government agencies that had the financial resources to purchase construction machinery and equipment.

Contracting out maintenance work can have financial benefits over direct labour maintenance work provided that the tendering process is open and transparent, and there is an active contracting sector where competitive bidding exists.

**Implementation and supervision of maintenance work**

It is important that the maintenance work is properly supervised, whether the work is carried out by direct labor or by a contractor.

- if the work is being carried out at the on-farm level then farmers should be informed of the nature of the work so that they can keep an eye on the work, as well as the supervising body.
- At the main system level, the field staff should be informed of the work to keep an eye on it and for smaller works, the field staff may be delegated to carry out the day-to-day supervision
- For large maintenance works a full-time supervisor may be placed on site.

A key role of authorized supervision personnel will be authorizing payments for maintenance work carried out by contractors. The procedures for measurement and authorization of these interim payments need to be clearly specified in the contract.

The timing of carrying out the maintenance work is important.

- The cropping season: If possible should be avoided caused by maintenance work.
- The climate: avoid adverse climatic seasons, such as rainy, flood, frost and freezing conditions.
- The availability of labour: If the work is to be carried out with community assistance, then the work has to be timed to avoid peak agricultural labour demands.

It is increasingly the case that water users are involved in the identification of maintenance work required on the main system, and also in the certification of the work done. This involvement increases transparency and accountability and enables the water users to see how, where and for what the service fees are being used.

**Recording maintenance work done**

It is important to record the maintenance work that has been carried out, and to document:

- the time that the work has taken,
- where it was located,
- who carried it out and
- how much it cost.

These data can then be used to build up a database of the type and cost of work carried out; this will be of considerable assistance in the planning and costing of future maintenance work.

**Maintenance Plant and Equipment**

| | |
|---|---|
| **Dragline excavators** |  Used to clean sediment and weeds from large channel sections and rivers, especially upstream of river pump stations. Not efficient for small sections |
| **Hydraulic excavators and backhoes** | Most commonly used piece of maintenance plant. Either tracked or wheeled.  Used to remove sediment and vegetation from canals and drains EXCAVATOR BACKHOES  |
| **Dredger** |  Used to remove sediment from canal and drain sections and sediment/settling basins. Suitable where sediment load is high and round-the-year removal is required |
| **Bulldozer** |  Used to flatten spoil heaps left by excavator following sediment and vegetation removal, also used in river beds following flood season to form temporary diversion structure and river training. |
| **Tipper truck** |  Used to remove sediment from the vicinity of the canal or drain and dispose of at some distance away, and Also used to bring in soil for rebuilding of embankments or for compacted backfill |
| **Scraper** |  Used to move large volumes of earth over relatively short distances (generally up to 1 km). Can be motorized or pushed by a bulldozer |

| | | |
|---|---|---|
| **Tyre or sheep's foot vibrating roller** |   | Used to compact soil following placement in embankments. Used in conjunction with a water bowser |
| **Scraper** |  | Used to move large volumes of earth over relatively short distances (generally up to 1 km). Can be motorized or pushed by a bulldozer |
| **Water bowser** |  | Used to wet soil prior to compaction and maintain optimum soil moisture content for compaction |
| **Grader** |  | Used to grade roads and embankments to maintain uniform surface and avoid formation of ruts and gullies |
| **Front-end loader/ shovel** |  | Used to lift soil into tipper trucks, or to move materials. |
| **Tractor-powered attachments** |     | There is a wide range of tractor-powered attachments, including weed and vegetation cutters, water pumps, etc. |
| **Tractors and chain** | Two tractors, one on each bank, pull a heavy chain along the canal or drain to tear out vegetation | |
| **Flat-bed loader** |  | Required to transport tracked maintenance plant such as bulldozers, draglines and excavators from one location to another |
| **Concrete mixer and vibrator** |   | Essential for mixing concrete. Portable so that it can be moved from site to site<br>Concrete vibrator: Required to compact concrete. |
| **Hand-moved soil compactor** |  | Required to compact soil around structures. An essential item of equipment to avoid piping and undermining of structures |

## 6.3 ASSET MANAGEMENT

Assets such as canals and drains serve a function from which benefits can be derived. Maintaining or enhancing this function results in sustained or enhanced benefits, either financial or social.
Asset management can be defined as:

***A structured and auditable process for planning, implementing and monitoring investment in the maintenance of built infrastructure to provide users with a sustainable and defined level of service.***

Asset management planning identifies asset stock (canals, drains, structures, roads, buildings, etc.) and quantifies its condition and performance. From the assessment of the asset condition and level of performance estimates can be made of the investment required to:

- maintain the existing asset condition and system performance;
- enhance or extend asset condition and system performance.

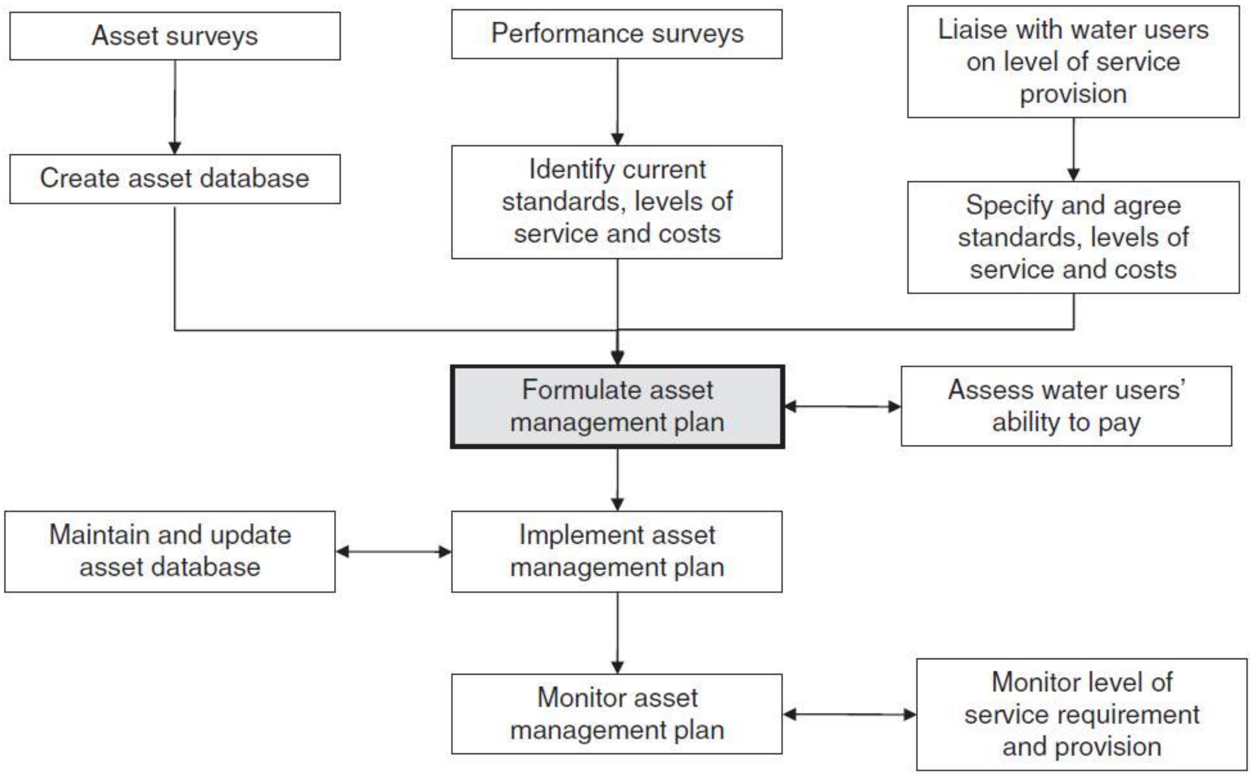
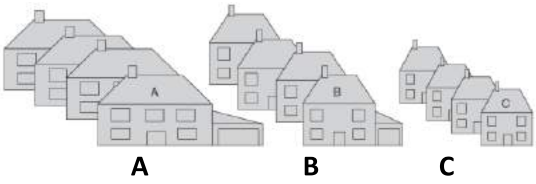



**Figure 6-3 Framework for asset management and strategic investment planning for irrigation and drainage**

Asset management planning seeks to relate investment and expenditure to specified, user-defined levels of service. The process involves:

- defining the level of service to be provided,
- quantifying the ability of the water users to pay for the specified service,
- identifying the condition and performance of the assets (canal, drains, structures, roads, etc.),
- quantifying the investment and expenditure required to maintain, improve or extend the assets in order to satisfy the specified levels of service.

An explanation in terms of the asset management of a group of houses owned by a housing association helps to explain asset management In the group of 30 houses there are, say, ten houses which are Grade A (four bedrooms), ten which are Grade B (three bedrooms) and ten which are Grade C (two bedrooms).




| Category | Current condition | Current performance | Performance indicator (actual rental) | Performance indicator (potential rental) | Investment profile to achieve potential performance |
|---|---|---|---|---|---|
| A | Good | Habitable | $500/month | $500/month | High O&M |
| B | Adequate | Habitable | $300/month | $400/month | Moderate O&M |
| C | Poor | Just habitable | $100/month | $250/month | High capital initially to repair, moderate O&M thereafter |

Each group has different current performances (habitable or not) and a performance indicator (rent) both actual and potential. The houses will require different levels of maintenance at different intervals.
It may also be that the housing association at some stage decides to modernize the houses. This modernization will enhance the level of service provided to the tenants for which an increased rental may then be charged.

**A fundamental principle in this process is that the income from rental is able to cover these costs, including an allowance for management overheads**.

A similar process can be applied to irrigation and drainage infrastructure.

- the function and value of the infrastructure can be assessed
- the infrastructure categorized according to the potential level of service that it can provide (ability to deliver water to match crop demands).
- the level of expenditure required to keep the system operational over time at a specified level can be ascertained and the fee level to be charged to water users determined.
- If further investment is made and the system is modernized, then the fee level can be changed to reflect the increased level of service provision.

For example, the conversion of a system with manually operated gates to a system with automatic level control gates will increase the level of service by facilitating water distribution on-demand, thereby better matching supply and demand and facilitating enhanced agricultural production. There will be capital expenditure to remove and replace the control structures while the day to - day operation costs may be reduced due to the saving of labour costs. The balance of the costs and savings will need to be determined by discounting over a 10–20 year timeframe to ascertain if the irrigation service fee level needs to be increased or decreased to pay for the changes made.

**Asset management processes**

<u>Asset surveys:</u> The asset survey determines the following:

- The category of components of the system (canal, head regulator, etc.).
- The extent of the assets that exist (how many and in what categories).
- The size of the asset (these can be grouped into size bands to facilitate costing).
- The ‘importance’ of the asset. This relates to the impact that malfunction of the asset might have on the system as a whole.
- The value of the assets in each size band, based on the modern equivalent asset (MEA), which is the cost of replacing the structure at today’s costs.

- The components of each asset (e.g. gates and masonry in a control structure)
- structure). Different asset components may deteriorate at different rates.
- The condition of the asset and its components. Condition grades are used.
- The serviceability of the asset; that is, how well it performs its function. An asset may be in a poor condition (masonry damaged) but performing its function satisfactorily. Serviceability of structures can be divided into:
    - hydraulic function (ability to pass design discharge) and
    - operations function (ability to control flow across a specified range, ability to provide command level, etc.).

Serviceability grades are used and standard forms are used to record the survey data

Asset database: Data collected from the asset survey need to be recorded in a systematic manner in the asset database.

Performance surveys: Performance surveys are required to assess the current and potential performance of both

- the I&D system (the network of canals, drains, structures). The performance relates basically to the delivery of, and removal of excess, water in a reliable, adequate, timely, equitable and cost-effective manner and
- the I&D scheme. (the physical system plus the land plots and crops) as a whole (additional indicators such as crop production, crop yields and crop income are evaluated)

Defining and agreeing on standards and levels of service provision: the desired level of service and the performance shortfall is determined by measuring the current levels that are being provided by the assets (assuming there are no management constraints). The ability to deliver the desired level of service will primarily depend on:

- The type of irrigation infrastructure provided;
- The condition and serviceability of the infrastructure;
- The capability of the O&M management.

Assessment of the desired level of service can be made through interviews and discussions with water users. One of the benefits of the asset management process is that it requires the stipulation of the standards by which performance will be measured, and that it also requires the stipulation of the desired level of service. Making these explicit facilitates communication between the irrigation service provider and the water user.

Engineering studies and costs: Engineering studies are required to study

- the deterioration rate of different types of assets and asset components;
- the development of cost models (costs for rebuilding/upgrading/rehabilitating assets);
- the relationships between individual asset performance and system performance.

Through engineering studies, the cost database for maintaining or enhancing the condition/ performance of each type of asset (river weir, canal head regulator, aqueduct, culvert, etc.) can be ascertained and applied to the asset condition/performance of each asset. In this way the cost of maintaining or enhancing the condition/performance of the I&D system is determined.

Preparing the asset management plan Utilizing information developed from the asset surveys, the performance surveys and the engineering studies, the investment requirement in the assets over time is determined. This calculation leads to the formulation of the long-term investment profile as presented earlier in Fig. 6.4. This long-term plan needs to be broken down into a schedule of planned activities, and a short-term budget prepared for a 2–5 year period. Financial modelling is an integral part of the preparation of the asset management plan, as adjustment may be needed to the initial plan to match the investment required with the finances available. This plan may incorporate contributions from different sources, including the irrigation service fees and government subsidies.

Assessing water users' willingness and ability to pay The investment plan may need to be revised tomatch the ability of the water users to pay for the service. If this occurs, the potential level of service provision arising from the condition and performance of the infrastructure may be reduced. A reduced level of service may result in a reduction in crop yield and a diminished ability to pay for water.
It is important to note that there is a difference between the water users' ability to pay and their willingness to pay.

Implementing the asset management plan: Though asset management plans generally look at a longer-term timeframe (15–20 years), they are implemented in short-term time segments (2–5 year period).

Maintaining the asset database The asset database will undergo continuous revision. Maintenance work will be recorded, and periodic updates made to asset condition and performance gradings through further asset surveys.

Monitoring service provision and the implementation of the asset management plan: Monitoring and evaluation (M&E) are important parts of the asset management process, allowing for the monitoring of the levels of investment, and its impact on the service delivery. M&E systems need to be set in place which are transparent and accountable, so that those paying for the investment (water users, and/or government) can be satisfied that their money is being efficiently and effectively used. Feedback mechanisms are an important part of the M&E process. Asset surveys will monitor the condition and performance of the infrastructure, while monitoring of key indicators (such as water delivery versus water demand) coupled with user surveys will assess the level of service provision.

# 7 TRAINING

Training is an integral part of the effective functioning of any organization. Training is the process by which staff are taught the skills necessary to perform their job functions, such that they can carry out those functions effectively and efficiently.

Training in the irrigation and drainage sector is required for a wide range of personnel, from system managers to water users; and in a wide range of disciplines, from general management to specific and detailed technical procedures.

Training is a difficult task, which requires specialist expertise to carry out effectively. It requires a thorough understanding of the subject matter and of the training needs of the participants

Institutional development is increasingly being allied to physical rehabilitation projects, a key component of which is the formation and support of water users associations. Reform is now also focusing on the main irrigation and drainage service provider, with restructuring and reform of government-run irrigation and drainage agencies to provide a more effective and efficient service provided to water users.

**What is training?**

In training, generally speaking, we are interested in effecting change in a person's behavior. We may want gauge readers to be more accurate with their gauge reading, we may want farmers to use less water and be more efficient with application of irrigation water to the fields. In order for that person to change their behavior they must go through certain processes:

1. They must be aware that their performance, or their situation, could be better;
2. They must want to learn how to improve the situation;
3. They must do some learning;
4. They must implement what they have learnt.

The outcome of the training must be a change in performance of the activity for which the person has been trained (i.e. the gauges must be read more accurately, or irrigation water used more productively). Training is not education; in education the objective is improving a person's general level of knowledge, it is not always specific to a defined task or activity. Even if a person does not use their education we still feel that they, and society, have benefited. If a person has been trained and does not apply it, we consider that to be a loss, we could have spent the time and money on training someone who would apply it. Training could thus be defined as:

*The process of bringing about change in behavior of an individual or group which results in improved performance in their work or situation.*

**Training needs assessment.**

Training needs assessment can be summarized as:

**Required knowledge and skills** minus **Existing knowledge and skills** equals **Training need**

Before the training course the trainee's level of knowledge and ability should be ascertained and compared with the required level of knowledge and ability. The difference is the training need.
For example, for senior management a series of lectures is effective in getting information across in a short time, with reinforcement through discussion sessions; for gatekeepers very short lectures (on basic principles) followed by demonstrations and field practical experiences are appropriate.

Training in this area often relates to helping people understand other people's views and situations. An example is training aimed at sensitizing operation and maintenance (O&M) staff to the importance to farmers of delivering irrigation water at the right time, in the right place and in the right quantity to suit their needs. Changing people's attitudes is perhaps the most complex task in training; it requires an understanding of psychology to be able to set up a learning environment that effectively alters people's attitudes or levels of motivation. The Irrigation Management Game (Box) is an example of a training exercise designed to change understanding, attitudes and behavior in relation to irrigation water delivery in the main system.

***Box 7.1 The Irrigation Management Game: A Simulation and Role-playing Exercise for Training in Irrigation Management (Burton, 2010)***

*The Irrigation Management Game places participants in the position of either irrigation agency staff responsible for managing the main canal system or farmers responsible for managing irrigated landholdings within the main canal command area. Usually one or two people take on the role of the main system service provider and eight to 16 people take on the role of farmers managing landholdings within the eight tertiary units (with one or two participants per tertiary unit). The exercise is run by two trainers, one as the Game Controller, the other as the Trader. The game usually takes a full day to play, including a debriefing and discussion session at the end.*

*In the game the tables and chairs in the training room are set out following the layout of the main canal and eight tertiary units. The available water (represented by blue counters) at the river intake is distributed by the main system management staff to the eight tertiary units within the system, working down the system from top to bottom. The farmers take their allocation of water from the main system managers and distribute it among their four fields.*

*The farmers have to decide on the crops to be grown on each of their four fields (based on data provided on crop costs, yield response to water and prices), and then use yield response to water graphs to decide how to allocate the available water among the four fields. Water is generally in short supply, so the final crop yield is dependent on water allocation decisions made in each of the three crop growth stages.*

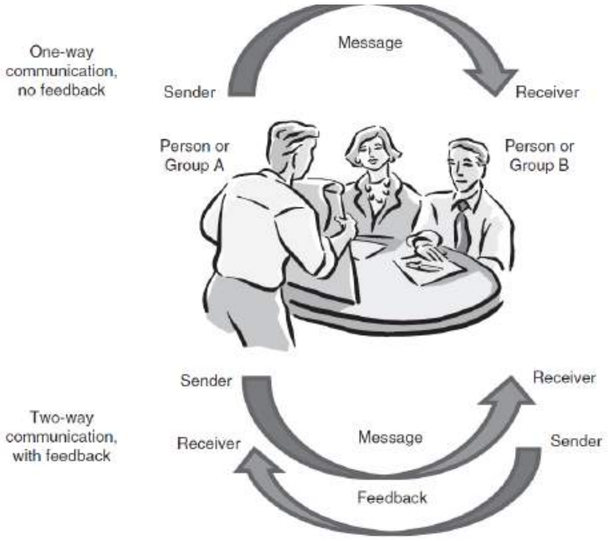
*The main system management staff have to make decisions on the water allocations to each tertiary unit based on different water allocation procedures for each allocation round. In the first round allocation is in proportion to tertiary unit command area, in the second round in proportion to irrigation water demand, and in the third round based on demands and actions at the tertiary unit gate by the farmers. In the third round farmers can override the allocation by the main system managers by 'breaking' padlocks on the gates and adjusting the gate settings to suit their needs. These actions tend to benefit the upstream farmers, and lead to (simulated) conflict between head and tail-end farmers.*

*The exercise serves to demonstrate the interactions between the main system management staff and the farmers, and the impact that their decisions and actions have on farmers and agricultural output from individual tertiary units within the system. It also raises issues of system maintenance, corruption, water trading, value of irrigation water, yield response to water, performance assessment and inter-personal relations, both between the main system managers and farmers and between the farmers themselves.*

**How people learn**

People learn by observation, listening to others and doing. In training we use a variety of methods for communicating with our trainees, the least effective method of which is acknowledged to be through lecturing, the most commonly used medium! Lectures are the most widely used medium for conveying information; they can be significantly enhanced with the use of visual images and can be reinforced through practical exercises that put into practice the taught word.

**Communication and learning**




Communication is a means of exchanging information; it should be a two-way process. One-way messages represent poor communication, and can appear to the receiver as being commands rather than messages.
Communication means sending messages and listening to, and in many cases acting upon the response.
In wanting to communicate with water users we need to consider the following:
• it is important to get water users to express their needs and wishes and to understand the context;
• water users have a considerable amount of experience, which should be respected;
• water users will take on board new concepts and ideas that are useful to them;
• training and extension messages should be tailored to meet the needs of the water users, and the context within which they live and work;
• care should be taken not to confuse government information needs with those of the water users;
• there is a variety of ways of imparting ideas and information, some of which are more useful than others in certain contexts;
• people accept most easily ideas that they think are their own, or which are based on their own understanding of reality;
• water users are not a homogeneous group, they are made up of many different groups with different needs for information and different motivations.

Similar considerations apply when communicating with system O&M staff, more particularly:
• communication between senior and junior levels of staff can significantly improve job satisfaction and levels of motivation at the junior level;
• field staff have a wealth of knowledge about actual field conditions and the issues affecting farmers, and they can pass this information on to senior management.

**Steps in Establishing Training Programmes**

The following steps and associated activities can be identified in setting up a training programme for staff on an irrigation and drainage scheme:

1. Establish training needs;
2. Identify suitable trainers;
3. Plan training programme and course structures in detail;
4. Prepare and test training material;
5. Implement training programme;
6. Monitor and evaluate the training given.

**Step 1: Establish training needs**

The first step of preparing a training programme is to identify who needs to be trained, and what they need to be trained in. A detailed Training Needs Assessment (TNA) should be carried on.
The TNA involves carrying out a survey of all staff within each organization under review (be it the irrigation service provider, water users association (WUA), extension service or related organization). This survey will ascertain the structure of the organization, the numbers of staff at each level, age, educational background, current and required capabilities, etc. The process will require collecting secondary data (such the names, age, educational background, etc.), which will be held by the human resource department, and primary data through interviews with individuals or groups at different levels within the organization.

The output of the TNA will be a Training Plan, which will detail who will be trained, and how that training will be accomplished. A useful structure of a Training Plan is provided by answering the following questions.

- Why?
  - Why is the training required?
- Who?
  - Who will be trained?
  - Who will carry out the training?
- What?
  - What are the objectives of the training programmeme/course(s)?
  - What are the desired outcomes?
  - What are the training needs?
  - What are the key features of the training programmeme/course(s)?
  - What are the training topics?
  - What will it cost?
- How?
  - How will the training be imparted?
  - How will the course be structured?
- Where?
  - Where will the training be carried out?
- When?
  - When will the training be carried out?

The Training Plan will outline the scale of the training to be carried out and the resources required. The variables which influence the scale and extent of the training proposed include:

- the total time available for the training programme;
- the time required for training each trainee;
- the number of trainees;
- the availability of suitable trainers;
- the costs of training;
- the budget available.

**Step 2: Identify suitable trainers**

Great care should be taken in the selection of trainers, as the success of the training programme will rest mainly on their shoulders. Criteria that may help in identifying suitable trainers include:

- experienced at the level at which the training is being carried out;
- having an interest in training and education of others;
- an ability to communicate and empathize with people;
- having an interest and willingness to share information and knowledge with others;
- organized;

- energetic, but also patient!

**Step 3: Plan training programme and course structures in detail**
The Training Plan should provide an outline of the training required by answering the questions set out in the section above. It will provide sufficient detail for management to decide on the training priorities and to allocate a training budget.
The trainees will have been identified in the Training Plan, together with an outline of the training course(s) required. In the detailed planning of each training course decisions will need to be made on the training methods to be used. These can include:

- lectures/presentations;
- case studies;
- practical exercises;
- site visits or field trips;
- discussion groups;
- individual guided reading;
- remote study.

**Step 4: Prepare and test training material**

Preparation of training material can be a difficult and time-consuming process. Once the training material has been prepared it is as well to test it on a small scale prior to the start of the training programme. The trainers must be careful to remain objective and to welcome constructive criticism. Changes are both easier and cheaper to make at this stage. Another reason for having trial runs is that a new training course can be stressful for the trainers, but as they gain experience so their confidence grows.

**Step 5: Implement training programme**

If the course is residential, details of accommodation, per diems, etc. should be discussed at this stage. Records should be kept of who has attended each training course; this is especially important for training programme where there are a number of courses. Also is important to obtain feedback from the participants at the end of the course, through a questionnaire and/or discussions on the training given. Feedback forms can be designed to cover a number of aspects, including training content, training methods, facilities, refreshments, accommodation, etc., together with requests for suggestions for improvement.

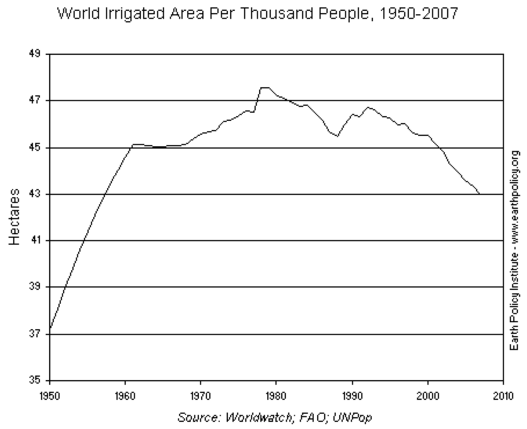
**Step 6: Monitor and evaluate training given**

The training programme will require monitoring to check that it is being implemented as planned. The effect of the training given can be monitored and, if necessary, changes made to the training material or course structure if the desired levels of ability are not being achieved.
The monitoring exercise should be carried out by members of the training team in order that they see for themselves the effect that their work is having.
Evaluation of the training programme is a separate exercise from monitoring as its positive objective is to assess the success of the training programme in bringing about a change in the trainees' behavior, measuring the success of the training against the objectives and outcomes set. It is advisable to prepare the evaluation procedures at the start of the training programme, and to test the situation before and after training using the same parameters. Evaluation should not be carried out by the same person or team that planned, prepared or ran the training programme or course. It should be carried out by an independent evaluator

# 8 IRRIGATION MANAGEMENT TRANSFER AND ORGANIZATIONAL RESTRUCTURING

**BACKGROUND**

The rapid increase of irrigated area in the 1970s and 1980s temporarily addressed the food crisis.




- The world irrigated area has increased from 94 Million (M.) hectares (ha) in 1950 to over 287 M. ha in 2007 (Earthscan/IWMI, 2007)
- The world irrigated area per thousand people has varied relatively little, from 37.3 in 1950 to 43.0 ha/thousand people in 2007
- The world irrigated area per thousand people has declined from a high of over 47 (in the late 1970s) to only 43 ha/ thousand people in 2007. Macedonia in 2007 had 79.638 ha/ 2,065 M = 38 ha/ thousand people.
- Growing populations and pressures on agricultural production have meant increasing food insecurity around the globe. The number of hungry people in the world declined from 878 million in 1970 to 825 million in the mid- 1990s, but it has been rising ever since.

The rapid increase of irrigated area left governments with a heavy financial burden for the management, operation and maintenance (MOM) of irrigation schemes. Though money was available for capital works from international development funding agencies (such as the World Bank), many governments have had serious difficulties in providing adequate recurrent funds to sustain I&D systems.

In addition, operation of the system by government agencies has, in many cases, been poor, with operation and maintenance (O&M) staff poorly paid and poorly motivated. As a consequence of the failure to adequately operate and maintain them, the irrigation systems have fallen into disrepair, leaving many farmers with unreliable, inadequate and untimely supplies of irrigation water. Agricultural production and rural livelihoods have suffered, and the contribution to the national economy has declined.

Rehabilitation of existing schemes has been a feature of irrigation development since the late 1970s, with funding for capital works obtained from the international development agencies. Despite protocols between lending agencies and government requiring that government provide adequate funds for operation and maintenance, systems have continued to decline due to lack of recurrent funding. The lack of funds for O&M is such that in many countries rehabilitation is occurring of previously rehabilitated schemes.

To address this situation, and to improve the performance of the irrigation sector, a process of irrigation management transfer has been initiated. The top-down government-led technically driven developments of the 1970s and 1980s are giving way to bottom-up institutionally driven initiatives, which seek to fully involve the water users in the acquisition, management and use of water for irrigated agriculture.
The transfer of irrigation management from well-established government agencies to groups of water users marks a significant change in the way in which irrigation and drainage is organized in many countries. The main objective is to shift ownership and operational responsibility of I&D systems from state to irrigators;

the process is dynamic, progressing over time from lower to higher order infrastructure as mutual benefits are recognized. Institutional and legal reforms are essential for successful irrigation management transfer programmes.

The term 'irrigation management transfer' (IMT) is defined by FAO (1999) as:

*… the relocation of responsibility and authority for irrigation management from government agencies to non-governmental organizations, such as water user's associations. It may include all or partial transfer of management functions. It may include full or only partial authority. It may be implemented at sub-system levels, such as distributary canal commands, or for entire systems or tubewell commands.*

Irrigation management transfer involves changes in:

• public policy and legislation at national and local level;
• social attitudes, rights, roles and responsibilities;
• social and organizational arrangements at community level;
• financial arrangements for government irrigation agencies;
• financing of irrigation service provision;
• restructuring and reorientation of government agencies and redefinition of roles and responsibilities;
• nature of support services provided to farmers on irrigation and drainage schemes (I&D schemes);
• management, operation and maintenance procedures;
• relationships between government and water users.

A large number of countries are engaged in the IMT process. Some countries such as the USA, Spain, France and Argentina have adopted irrigation management transfer

**Table 8-1 Countries or states that have adopted irrigation management transfer in the past 30 years.**

| Latin America | South, South-east and East Asia | Africa and Near East | Europe and Central Asia |
|---|---|---|---|
| Brazil | Australia | Ethiopia | Albania |
| Chile | Bangladesh | Ghana | Armenia |
| Colombia | China | Jordan | Azerbaijan |
| Dominican Republic | India | Madagascar | Bulgaria |
| Ecuador | • Andhra Pradesh | Mali | Croatia |
| El Salvador | • Bengal | Mauritania | Cyprus |
| Guatemala | • Gujarat | Morocco | Georgia |
| Mexico | • Haryana | Niger | Kazakhstan |
| Peru | • Maharashtra | Nigeria | Kyrgyz Republic |
| | • Tamil Nadu | Senegal | Macedonia |
| | Indonesia | Somalia | Moldova |
| | Laos | South Africa | Romania |
| | Nepal | Sudan | Uzbekistan |
| | Pakistan | Turkey | |
| | Philippines | Zimbabwe | |
| | Sri Lanka | | |
| | Viet Nam | | |

In the 1980s there was increased research interest in traditional farmer-managed irrigation systems, with their comparative success often being used as justification for the transfer of government-run systems. At this time Chambers (1988) identified three points of entry for action to improve performance:

- operational plans;
- rights, communications and farmers' participation;
- performance monitoring and computer analysis.

In practice, with the advent of irrigation management transfer, the rights, communications and farmers' participation has to some degree overtaken the other two points of entry.

The experience gained during the 1980s and 1990s with irrigation management transfer resulted in the publication of Guidelines for the Transfer of Irrigation Management Services (FAO, 1999). This comprehensive piece of work provides detailed guidelines for the IMT process, broken down into four phases:


**Phase 1** is about mobilizing support for adoption of a transfer policy. This includes sensitizing the public and policymakers, discussing, preparing and adopting a transfer policy statement. The process might stop here if there is not enough support for it, or if it is the wrong time or place.

**Phase 2** is strategic planning to organize the basic arrangements for the reform process. This may include formation of a coordinating committee, working group and issue groups and preparation of a concise strategic plan.

**Phase 3** is about resolution of key policy issues before planning for implementation can begin. (i) how the irrigation sub-sector is going to be financed after irrigation management transfer; (ii) what legislative and sector-level restructuring is needed; (iii) what management functions should be transferred; and (iv) what type of organization should take over management from the government.

**Phase 4** is about planning and implementation. These are combined for efficiency and because, in practice, planning is elaborated in the process of implementation. The key tasks in this phase are creating and strengthening water users' associations and water service providers, making improvements in irrigation infrastructure, carrying out monitoring and evaluation and adjusting plans in accordance with lessons learned.

## 8.1 PHASE 1 MOBILIZATION OF SUPPORT

### PREPARATION AND ADOPTION OF A TRANSFER POLICY

Before a transfer policy can be adopted, planners will need to assess whether there is enough justification and support for such a policy. Support may come from:

- perceptions of inadequate performance in the irrigation sub-sector ( O&M, financing irrigation at scheme or sector levels, agricultural productivity or environmental sustainability.
- broader changes undertaken to liberalize economic policy, as in the cases of Mexico, eastern Europe and central Asia.

Before a transfer policy can be adopted, planners must assess whether there is enough justification and support. Planners may need to answer the following questions:

1) What are the main kinds of performance gaps in irrigated agriculture?
2) How important are gaps?
3) Is IMT necessary in order to overcome current management performance gaps?
4) Will IMT be feasible to implement?
5) Is there strong enough political commitment to IMT?

If planners decide it is important to overcome perceived gaps in performance, the next question becomes: "What actions are needed to overcome them?" There are two basic options:

- management enhancement or
- basic reform.

Most of the governments that adopt irrigation management transfer reforms have already tried a series of improvement efforts but have found that the gaps in performance continue to widen.
The result of this analysis, and the main output for Phase 1, is the IMT policy statement which contains the objectives of the government with regard to IMT and some of its salient features. The main steps in its preparation and the elements to be covered are described.

**What performance gaps exist in irrigation management?**

There are four potential kinds of performance gaps that can occur with irrigation systems:

1. Technological performance gap: the infrastructure of an irrigation system lacks the capacity to deliver a given hydraulic performance standard. The normal solution to technology performance gaps is to change the type, design or condition of physical infrastructure.
2. Implementation performance: how system's irrigation management is supposed to be implemented and how they are actually implemented: gates adjustment, canals maintenance, information reporting, etc. These requires changes in procedures, supervision or training.
3. Achievement performance: the gap is a difference between management targets (size of area served by irrigation, cropping intensity, irrigation efficiency, water delivery schedules and water fee collection rates) and actual achievements. Such problems are generally addressed either by changing the objectives (especially simplifying them) or increasing the capacity of management to achieve them - through increasing the resources available or reforming organizations. "Are we doing things right?"
4. Impact performance: what people think should be the ultimate effects of irrigation and what actually results. (agricultural and economic profitability of irrigated agriculture, productivity per unit of water, poverty alleviation and environmental problems such as waterlogging and salinity). Ultimate impacts do not arise from the managing organization performing badly, since these effects are generally beyond its direct control. The problem is that the objectives of the organization do not produce the desired impacts. This is more a problem of policy than management. "Are we doing the right things?"

At the beginning of the reform process, planners may need to answer the following three questions:

- What are the main kinds of performance gaps?
- How big are the performance gaps?
- How important is it that these gaps be overcome?

Generally, an analysis of performance will suggest how modest or radical are the measures that will be needed to overcome deficiencies. If data are not available to permit quantitative analysis of performance gaps, rural appraisals and meetings with farmers and irrigation department staff should be used to assess performance gaps qualitatively to determine whether or not minor or major changes will be needed.
The analysis of irrigation performance should be done within the context of integrated water resources management at the water basin level, given that competition for water and environmental problems at the river basin or aquifer level are growing rapidly and in the future will be likely to constrain performance significantly

**Is enhancement or reform required?**

If planners decide it is important to overcome perceived gaps in performance, the next question becomes: "What actions are needed to overcome them?" There are two basic options:

1. Enhancement: If the impact performance gap is minor and the procedural or outcome gaps are significant, then an enhancement strategy (training, upgrading O&M procedures and repair of infrastructure) to improve procedures or capacity to implement might be enough, without changing the existing organizational or technical framework. intra-organizational changes, such as decentralization or needs-based budgeting, may suffice.
2. Reform. if impact, achievement and procedural gaps are all significant, a basic reform is probably needed. A reform strategy changes basic organizational roles and structures. The surest sign that basic reform is needed is when a series of improvement efforts has already been tried but achievement and impact gaps continue to widen significantly.

Reform implies to restructure roles and relationships among water sector organizations:

| | |
|---|---|
| Public irrigation agencies are widely under-financed, known to have relatively poor management performance and have little accountability to farmers. | Agriculture in developing countries has become increasingly commercialized and market-driven |
| ➔These factors have caused planners to look to management transfer as a means to overcome performance gaps in financing and O&M | |

**Is irrigation management transfer feasible?**

IMT is potentially sensitive and there may be opposition to it by influential groups such as line agencies and politicians (who often campaign with promises to drop water charges to farmers).

Therefore, it may be necessary for the decision to be made at the highest levels of government. If this level of support is not possible, the country may not be ready to adopt an IMT policy - even if it is found to be necessary and technically feasible. In this case perhaps pilot exercises with IMT can be made to test feasibility and eventually generate more widespread support

Sometimes what is politically feasible (e.g. enhancement) overrides what is really needed (e.g. reform), perhaps due to political resistance from vested interests. Due to pressures from donors, technical assistance agencies and internal interest groups, management transfer programmes may be adopted in environments where it may not yet be feasible, such as in places of severe poverty or social conflict.

After planners have determined that management transfer is needed and is politically feasible, they must assess whether or not IMT is a practical option. Most of the following factors will probably need to be in place in order for IMT to be feasible:

- · capacity to create or alter local organizations to take over management;
- · liberalization and openness of the political economy;
- · supporting legislation and support services for local water service providers;
- · clear water rights (especially for competitive and water scarce environments);
- · absence of strong opposition to IMT by bureaucracies and local elites;
- · irrigated agriculture which has modest costs and high profitability; and
- · irrigation infrastructure which is suitable for management by farmer organizations or other non-governmental service providers

Irrigation Management Transfer pre-planning decision-making process

The Irrigation Management Transfer pre-planning decision-making process is a complex decision-making process which logically has the following steps:

1) assessment of performance gaps
2) analysis of whether modest enhancements versus basic reform is needed
3) whether basic reform (such as management transfer) will be feasible.

Next Figure summarizes (somewhat simplistically) the essence of an Irrigation Management Transfer pre-planning decision-making process

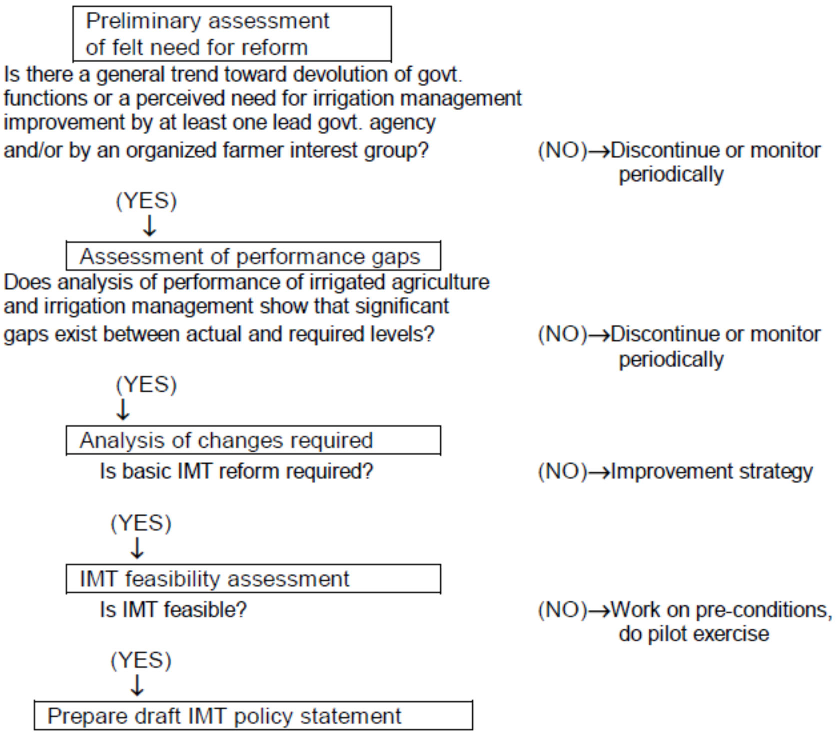



Figure 8-1 Irrigation Management Transfer pre-planning decision-making process

**The transfer policy statement**

The chief output for Phase 1 is the IMT policy statement. The following steps may be involved in preparing an IMT policy statement:

- · analysis of performance gaps, changes required and feasibility of IMT;
- · identification of new objectives and their justification;
- · analysis of stakeholder participation options and capacity;
- · identification of units and functions to be transferred;
- · identification of changes to be made in public agencies, policy and legislation;
- · consolidation of above components into an IMT policy statement.

A transfer policy statement would normally include the following elements:

- · objectives and justification for the IMT policy;
- · existing policy and legal basis for the proposed IMT policy;
- · brief description of what kinds of irrigation systems or sub-systems will be transferred;
- · brief description of what management functions will be transferred;
- · brief description of what new entities will take over management;
- · brief description of what changes will be made in public agencies relative to IMT;
- · identification of the organization to direct implementation;
- · outline of suggested time-frame and mode of financing.

Each of the above points should only provide a short sketch of what the government intends to do in the future. The details will come in the programme planning and implementation stages which will follow.

## 8.2 PHASE 2 STRATEGIC PLANNING

**ORGANIZING A STRATEGIC CHANGE PROCESS**

To be effective, reform should be both participatory and strategic.

Participatory: when it includes all stakeholders in the process

Strategic: when it deals with fundamental issues.

A successful outcome will normally depend on forging consensus among a diverse set of stakeholders. Participation can be in many forms but always validates and mobilizes support for the process.

Basic planning structure:

- **a senior steering committee** will commission, oversee and guide the process.
- **a working group** which will coordinate all planning activities.
- **special issue groups** may be created to focus on key issues which demand more in-depth analysis, negotiation and mobilization of support.

**Strategic plan**: a relatively brief document which

- identifies the basic structure for the overall process of policy and programme development.
- highlights key objectives, principles, parameters and modalities.

The strategic plan should be written not as a blueprint but as a proposal to invite key officials and stakeholders to participate actively in the process. The strategic plan should forecast the order in which basic functions will be performed.

**What is a participatory and strategic change process?**

To be effective, reform should be both **participatory** and **strategic**.

**A reform is participatory** when it includes all stakeholders in the process of assessment, policy making, programme formulation and implementation.

A stakeholder is any person or group which has an important interest in the prospective reforms.

**A reform is strategic** when it deals with fundamental issues and is forward-looking, politically feasible and integrated with the external environment.

Strategic change is difficult. It requires a methodology and coordination with stakeholders, in order to mobilize diverse inputs and build consensus. Participatory and strategic reform generally involves the following elements:

- representational involvement of stakeholders;
- setting objectives;
- assessing management gaps and options for change;
- developing a shared vision of the future;
- developing policies and programmes;
- facilitating teams to work on the process;
- analysis, negotiation and possibly experimentation;
- organizational restructuring; and
- performance assessment and review.

Two things are essential for reform:

(i) strong political commitment and

(ii) stakeholders are willing to cooperate constructively: they should include owners and cultivators of irrigated land, irrigation department staff, tax payers, policy-makers and planners in the water and agriculture sectors, technical assistance experts, agriculture crop processors, merchants and consumers. Also people who desire access to water from the irrigation system for non-irrigation purposes and other water users at the basin level, agricultural cooperatives, labour unions, NGOs and environmental interest groups.

To avoid opposition and suspicion planners should not restrict the planning process to a small group of likeminded people, such us:

- Head-enders or Tail-enders farmers, or rich or poor
- farmers but not irrigation department staff
- irrigation department staff but not finance and planning departments

The opposite extreme of attempting to maximize participation of all stakeholders may also not be advisable:

- farmers or others are busy and content to have representational participation
- maximum participation of all stakeholders from beginning to end causes confusion and frustration. People tend to become impatient attending numerous meetings which do not produce immediate results and in which the direct participation of all stakeholders is not essential.

Several members of a special commission or working group may be nearly fully occupied with the strategic planning process. Others may feel that their interests can be met through participation of representatives of their interest group in important events. Representatives of stakeholders can be invited to state the extent to which they wish to participate.

With these inputs, the commission can plan the appropriate type of stakeholder participation. The following are ways whereby stakeholders might participate in IMT programme development:

- · seminars, workshops and other meetings;
- · interest groups which lobby politicians and government officials;
- · participatory rural appraisals or other field visits where stakeholders can convey their views and local knowledge;
- · analyses by resource persons in issue groups;
- · private consultations for sensitive matters;
- · preparation or review of IMT documents; and
- · action research or pilot exercises.

Table 2 is a 'stakeholder participation matrix'. It shows a hypothetical list of stakeholders in the reform process. Row headings are the major activities in the process. Symbols are placed in the cells to indicate the primary type of participation each stakeholder is expected to have for each activity.

**Table 8-2 Stakeholder participation matrix**

| Activity | Senior Politi-cians | Senior Admin. Officers | Farmer Reps. | Senior Govt. Techl. Experts | Techl. Consul-tants | Irrig. Mgmt. Staff | Researchers/ NGOs |
|---|---|---|---|---|---|---|---|
| Policy Coordinating Committee | L | D | D | A | | | |
| Working Group | L | D | V | A & V | A & V | V | A |
| Policy statement | L & D | V & D | V, D | A & V | A | | |
| Issue analyses | | L & D | V | A & V | A & V | V | A & V |
| Pilot experiments | | L & D | V, A, L, I, D | V & D | A & V | V, D, I | A & I |
| Planning and implementation | L | L, V & D | V, L, I, D | V, A, D, I | A, V & I | V, D, I | A & I |
| Organizing WUAs | | L | V, A, L, I, D | V | A & V | V & D | A & I |
| Infrastructure improvement | | L | V, A, L, I, D | A, V, D | A & I | A, V & I | V |
| Monitoring and evaluation | | L | V, A | A & V | A & V | V | I, A & V |
| Course correction and adaptation | L | V & D | V, A, D | A & V | A & V | V | A & V |

Primary forms of participation:
1. Provide viewpoints = **V**
2. Analysis = **A**
3. Legitimization = **L**
4. Implementing = **I**
5. Decision making = **D**

The process is more likely to be valid and result in true reform if key stakeholders are involved to some extent in the above five forms of participation.

**How should the process be structured?**

The structure of the process is defined in two ways:
(i) the roles of participants in the process and
(ii) the basic steps in the process.

**A senior steering committee** formed by senior representatives from involved government departments and perhaps the legislature will be needed to commission, oversee and guide the process.

**A working group** formed by representatives from farmers' associations, non-governmental organizations (NGOs), consulting firms and research institutes can be essential participants in planning meetings which will coordinate all planning activities.

**Special issue groups** may be created to focus on key issues which demand more in-depth analysis, negotiation and mobilization of support.

## THE STRATEGIC PLAN

The strategic plan is a 'plan to plan'. It outlines the basic structure of the process, and should give answers to the following questions:

- What are the objectives and justifications for management transfer?
- What are the major issues likely to require special attention?
- What are the options and implications for financing the transfer process?
- How can planners avoid strategic overload?

### Objectives and justifications for management transfer

**Objectives**

- are the expected key outcomes or direct results of reforms which are.
- specify the primary reasons why IMT is being adopted
- provide the basis for identifying the basic principles which should guide policy development.
- are the first element in the strategic vision of the future.
- help identify who are the key stakeholders
- help stakeholders assess the implications of IMT.

Typical objectives for IMT programmes:

- · eliminate recurring government expenditures for operation and maintenance
- · establish financially self-reliant water service providers to replace the public agency in the management of irrigation systems;
- · reduce the rate of deterioration of irrigation infrastructure;
- · provide transparency and accountability of the service provider to water users.

<u>Characteristics or the objectives</u>:

- can be modified during the change process.
- Should be clearly stated at the beginning which objectives and changes are negotiable and which are not (otherwise, stakeholders may feel betrayed to find out later that not all issues are open for negotiation).
- should be measurable, quantitative (expenditure) or qualitative (transparency and accountability)
- should be clearly stated. Vague language may help minimize controversy at first, but it will not provide sufficient guidance to the process.
- Planners should provide justification for the objectives by referring to broader water, agriculture, environmental or financial sector policies and to important interests of stakeholders.

When adequate consensus and support for the objectives is obtained, the senior steering committee should formalize the statement of objectives by incorporating it into an official decree or policy statement.

### Major issues likely to require special attention

**Policy issues** are generally about WHAT the future will look like. These issues do not have to be worked out in detail in a policy statement. The statement need only outline the basic direction to be taken. Details can be worked out later, in the issuance of executive instructions for the policy. The four most common and important IMT policy issues are:

- · What functions should be transferred to what organizations?
- · How will irrigation O&M and rehabilitation and modernization be financed after IMT?
- · What policy and legal changes need to be made to support transfer?
- · What changes should be made in public agency mandates as a result of transfer?

**Programme issues** are generally about HOW to get from the present to that future. The following are the four most common and important IMT programme issues:

- · How should the local organization be created and prepared to take over management?
- · What improvements in infrastructure and management need to be made?
- · How should agency reforms be designed and carried out?
- · How can an effective system of monitoring and evaluation be set up?

Implementation plans should be relatively brief and clear on the main points. It may only be possible to work out solutions to the more detailed issues in the process of implementation itself, because some issues may require

- research or experimentation (where there is uncertainty about outcomes).
- brainstorming (where there is a shortage of ideas),
- consulting inputs (where there is a shortage of expertise)
- negotiation (where there are differences in costs, benefits or values among stakeholders).

**Options and implications for financing the transfer process**

Both the source and amount of funds provided to finance an IMT process can have profound effects on the nature of the programme and its impacts.
The government, (depending on the resources and the political commitment with the IMT programme) may be able to allocate funds to finance an IMT programme or not. In the second case, they may have to choose between financing the process through external loans or making the changes ‘on the cheap’ - without any infrastructure improvement and little organizing or training.
Financial assistance from donors or loans may come with strings attached such us:

- additional objectives and requirements,
- rigid implementation schedules
- heavy administrative requirements.
- Too much external financing can transform the process into a construction project and divert attention away from the primary objective of institutional reform.
- Too little money can reduce the process to simple abandonment of public irrigation systems.
- governments may be more inclined to ‘own the process’ and be concerned with outcomes if they are required to invest some of their own funds.

**How to avoid strategic overload**
Even if they are careful, planners can get overwhelmed by the complexity and controversies in the change process. The following are five suggestions about how planners can avoid strategic overload:

- remain focused on a clear and realistic set of objectives: do not become side-tracked with non-essential matters;

- · remember that the aim is to produce broad directions for policy and programme, not exhaustive specification of detail;
- · be discerning and selective about stakeholder participation: facilitate what is needed and no more;
- · divide up the array of issues into manageable parts and delegate work on each to interest groups and resource persons;
- · remember that the process and its outcomes belong to the stakeholders and are not just the responsibility of the planner.

**PHASE 2 OUTPUTS: ORGANIZING THE STRATEGIC CHANGE PROCESS**

The main output of the strategic planning is a short strategic plan that identifies the basic structure for the overall process of policy and programme development.

The strategic plan should be

- a brief document which highlights key objectives, principles, parameters and modalities.
- It should not be a blueprint. Too much detail may create the impression that it was conceived without participation of stakeholders.
- It should be a proposal to invite key officials and stakeholders to buy into the process.

It will probably include the following components:

- objectives and justification for IMT;
- proposed organizational structure for the change process;
- expected stakeholder participation;
- expected key issues for policy and programme formulation;
- time-frame and financing plan.

## 8.3 PHASE 3 RESOLUTION OF KEY POLICY ISSUES

It is important to answer key policy questions:

- through analysis and negotiation before to proceed to the planning and implementation phases.
- proceed in a systematic order so as not to unintentionally exclude options from consideration

The four most important policy issues related to irrigation management transfer are as follows.

**1. What changes are required in how the irrigation sector is financed?**

- The government will be required to reduce or eliminate subsidies for recurring costs of irrigation.
- These costs will have to be financed largely or entirely from water charges to the users.
- Subsidies for periodic rehabilitation or modernization need to be re-designed so as to stimulate, not discourage, investment in maintenance by the water users.

**2. What services should be transferred, retained or created?**

- It should be decided whether to transfer all or only part of the functions of operations, maintenance, financing, conflict resolution and so on.
- New services may be needed, such as for agricultural services or water allocation at the basin level.

**3. What type of organization(s) should take over management?**

There is a range of organizational forms which could be used for the new water service provider.

- water users' associations may be suitable for small-scale irrigation,
- other forms, such as irrigation districts or mutual companies, may be more suited to larger scales of management.

**4. What legislative and sector-level changes are needed to support IMT?**

Legislation may be needed to:
- grant clear water rights to water users' associations (WUAs) at the point of extraction
- provide legal status to WUAs,
- create new support service entities
- restructure the irrigation agency.

### 8.3.1 ENSURING CONSISTENCY BETWEEN HOW THE IRRIGATION SECTOR IS FINANCED AND THE GOALS OF IMT

**The near consensus about how operations and maintenance should be financed**

Most stakeholders in the irrigation sector will agree that the primary (the **major**)source of funds to pay for the costs of irrigation operations and maintenance ought to be the payment of water charges by water users. If given the choice between
(a) farmers receive full government subsidy for O&M but get poor service, and
(b) farmers pay for the cost of O&M but get full control over service provision, it is likely that most farmers would opt for the latter.

Evidence for this is found where farmers pay water charges for pumping water (for reliable service) which costs much more than the cost of water for surface irrigation (for unreliable service).

But there is no consensus that irrigation costs should be solely financed by water charges. Some argue that the government should continue subsidizing the cost of irrigation O&M,
- where irrigation costs are high and profitability of agriculture is low.
- Some argue that water users' associations ought to have the right to raise secondary sources of revenue (other WUA earnings) in order to cross-subsidize the cost of irrigation themselves.

**What needs to be changed to make financing in the sector consistent with the objectives of IMT?**
- restrict detrimental political interference
- Provide more accountability of the service provider to the users if its primary source of revenue depends on delivering an acceptable service
- Stop the "rehabilitation followed by deterioration trap" and replace by a incremental infrastructure improvement approach (works in a gradual form over relatively long periods)
- WUAs should raise a capital reserve fund
- The government should provide a matching fund of a similar amount (grant or a loan on very favourable financial conditions). to WUAs that comply with accepted performance standards, which can be monitored effectively and independently.
- New mechanisms should be introduced to protect the sector from financial irregularities after IMT.
- Financial audits of WUA or WSP accounts, transparency of records and water service fees
- financial management training for WUA directors and financial staff.

**Are government subsidies inconsistent with the objectives of irrigation Management transfer?**

The main issue is how to structure subsidies so as to stimulate local investment in infrastructure and bring about improvements in irrigation management.

- Subsidies should be considered primarily as an investment (to stimulate local productivity and save government costs in the long term). This kind of subsidy normally includes requirements for local investment and for compliance with agreed standards. It builds local capacity for sustainability
- Subsidies should not be considered an aid (to artificially suppress costs for political or equity reasons). This kind of subsidy comes without strings attached and destroys local capacity for sustainability
- Misuse of subsidies should be avoid. They depend who implement the use:
  - accountable competent professionals and farmer representatives investing capital to ensure the sustainability of irrigation systems,
  - politicians promoting full financing for public works, at the expense of the local sustainability of irrigation.

Proponents of privatization sometimes argue that subsidies are inherently dysfunctional and should be dropped when management is devolved to local entities.
FAO in its guidelines takes a more moderate view: subsidies to the irrigation sub-sector may be justified

- when capital-intensive irrigation development is required to meet national policy objectives.
- After the development phase, in impoverished areas where agriculture fails to produce sufficient resources to finance irrigation and where irrigation is essential to meet food requirements.

However, subsidies are often structured in such a way that they make water users become dependent upon the government and discourage local investment in irrigation systems. This happens when:

- the amount of subsidy and true cost of irrigation are unknown to water users;
- subsidies are unrelated to corresponding investments by water users; and
- irrigators expect subsidies to continue, especially for repair of deteriorated infrastructure.

**What is the "rehabilitation— dependency— deterioration" trap?**

An example of the pernicious effects of subsidies-as-aid on maintenance and rehabilitation:
In one irrigation scheme (A) farmers do not bother to maintain their system, so the government frequently returns to do repairs and rehabilitation.
In another scheme nearby (B) the farmers are more organized and routinely maintain their scheme so they never need government assistance for repair or rehabilitation.
Farmers in scheme B eventually get upset and complain to the government. They ask: "Why is the government repeatedly repairing scheme A where the farmers don't maintain their scheme properly? Why don't they help us?" There is no good answer for them.
This suggests that government assistance should be linked to requirements for local investment

Relation between maintenance and rehabilitation

In public irrigation, typically

- the financing and decision-making for maintenance is located in a separate division from rehabilitation.
- Investment decisions about rehabilitation are generally not directly related to decisions about maintenance, nor vice versa.
- Instead of making trade-offs between the two and optimizing short- and long-term investments together, either governmental unit tends to promote maximizing its own budget.

The rapid expansion of irrigated area which occurred throughout the developing world from the 1950s to the 1980s, caused maintenance budgets could not keep up with the growing demand, and deterioration became widespread. Meanwhile farmers had become accustomed to perceiving maintenance as mostly the government's responsibility.

The conventional approach to rehabilitation has been to wait until deterioration has become severe over a wide enough area that a large rehabilitation project is needed. The government finances the cost, provides engineers and makes repairs with little, if any, farmer participation.
Proponents of this approach sometimes argue that it may be more cost-effective, especially for farmers, to under-invest in routine maintenance and then use occasional government-sponsored rehabilitation as an opportunity to restore the system to functionality and modernize it to k ep up with social and environmental change. This approach may be justified on the grounds that:

- farmers cannot mobilize sufficient resources for preventive maintenance;
- the government should subsidize the cost of irrigation; and
- it is easier for governments to obtain funding for special projects like rehabilitation than for routine maintenance.

While under-investment in maintenance may be necessary in some circumstances, in general is an undesirable practice because:

- while waiting for rehabilitation, small problems become big, costly problems;
- prior to rehabilitation, O&M performance suffers due to deterioration;
- farmer resources are not mobilized and the cost to the government is large;
- non-participatory rehabilitation often results in works that are inappropriate, overly elaborate, unnecessary and difficult for farmers to operate and maintain;
- considerable corruption and waste are often associated with rehabilitation projects;
- WUAs lose the incentive and capacity to invest in the physical sustainability of the irrigation scheme which they depend upon, but which they feel is not theirs.

There are economic arguments against the rehabilitation-deterioration trap but the strongest argument is:

*Unless the rehabilitation-dependency-deterioration trap is overcome, IMT will not be able to meet its foremost objective of ensuring the local sustainability of irrigation systems. Neither will it relieve the financial burden of irrigation on the government, because any savings in routine O&M costs will likely be cancelled by larger costs for rehabilitation in the long run.*

**Toward more sustainable irrigation with "Incremental Infrastructure Improvement"**

Incremental Infrastructure Improvement is an alternative approach to the conventional deterioration – rehabilitation followed by deterioration. FAO does not provide it as a universal recommendation, but mainly to stimulate the kind of radical thinking which will be necessary to come to terms with this difficult and widespread problem.

Characteristics of the incremental infrastructure improvement strategy:

- maintenance, rehabilitation and modernization would be integrated into the same overall financial planning forum;
- need for improvements would be identified, prioritized and scheduled primarily by the water service provider (WSP), subject to review by the WUA board and with possible technical advice from the government;

- a capital reserve fund raised and owned by the WUA, probably mainly through a surcharge on the water fee; by raising sideline sources of revenue or by collecting interest in the account
- the WUA would have access to the fund at any time for making infrastructure improvements, no matter how small the amount or scale of improvements;
- the government may provide a subsidy based on cost sharing formulae and designed to stimulate preventive maintenance;
- eligibility for the subsidy would be based on farmer compliance with agreed maintenance standards and rate of contribution to the reserve fund;
- an independent auditor could conduct technical and financial audits of WSPs once every two or three years to determine eligibility for the subsidy programme and as a support service to strengthen technical and financial management of the WSP.
- farmers will invest in infrastructure improvement incrementally, before deterioration becomes advanced, so as to minimize expenses from their own capital reserve fund.
- Government subsidies would be available for minor repairs
- farmers would have no incentive to wait until large-scale rehabilitation is required.
- The government also may have to provide security or insurance on deposits into WUA capital reserve funds.

Emergency repairs, modernization and extension of irrigation networks may need to be handled slightly differently than rehabilitation. It might make sense to alter conditions for eligibility and amount of subsidy provided for these uses. Even so, it is believed that these problems should also be addressed in the context of a capital reserve fund and with a possible link to an investment-oriented subsidy.

**How to prevent financial irregularities**

IMT will place substantial new responsibility for financial management into the hands of the WUA and WSP. Experience suggests that financial irregularities and corruption are serious threats to successful transfer of irrigation management to WUAs. Aside from minimal training in bookkeeping, most IMT programmes do not introduce measures to ensure that strict financial practices are followed by WUAs after IMT.
This aspect demands serious attention and establishment of arrangements for periodic financial audits and advisory support from government after IMT. The following are examples of measures which could be taken (among others) to help prevent financial irregularities from occurring in WUAs after IMT:

- Training in agreed financial practices for the treasurer of the WUA and the chief financial officer of the WSP should be provided
- Training in bookkeeping practices could be given to all WUA directors and WSP administrative staff.
- Financial transactions should only be made with a minimum of two authorized witnesses and a record of the transaction.
- Financial records of the WSP should be available for inspection by farmers.
- There should be a clear basis for how the level of water fees is determined.
- · Amount of water fees to be collected should be based on a known and measurable level of service, such as volume of water delivered, area served or number of irrigations.
- · An independent financial auditor could periodically examine WSP accounts.
- · Social ties between the WUA treasurer and WSP financial officer should be avoided.
- · The WUA treasurer should be replaced periodically.

### 8.3.2 RESOLVING WHAT SERVICES SHOULD BE TRANSFERRED

**At what hydraulic level should management be transferred?**

The following are the primary questions for determining at what hydraulic level management should be transferred:

- At what hydraulic level is the service area so large, and the environmental, technical and political issues so complex, that only the government could manage at that level?
- · Down to what level is the government capable of providing an acceptable service?
- · Which levels are so closely inter-connected that it would be detrimental to separate them into different management entities?
- · Up to what level can the system be managed by a non-governmental service provider that would be accountable to both water users and government?

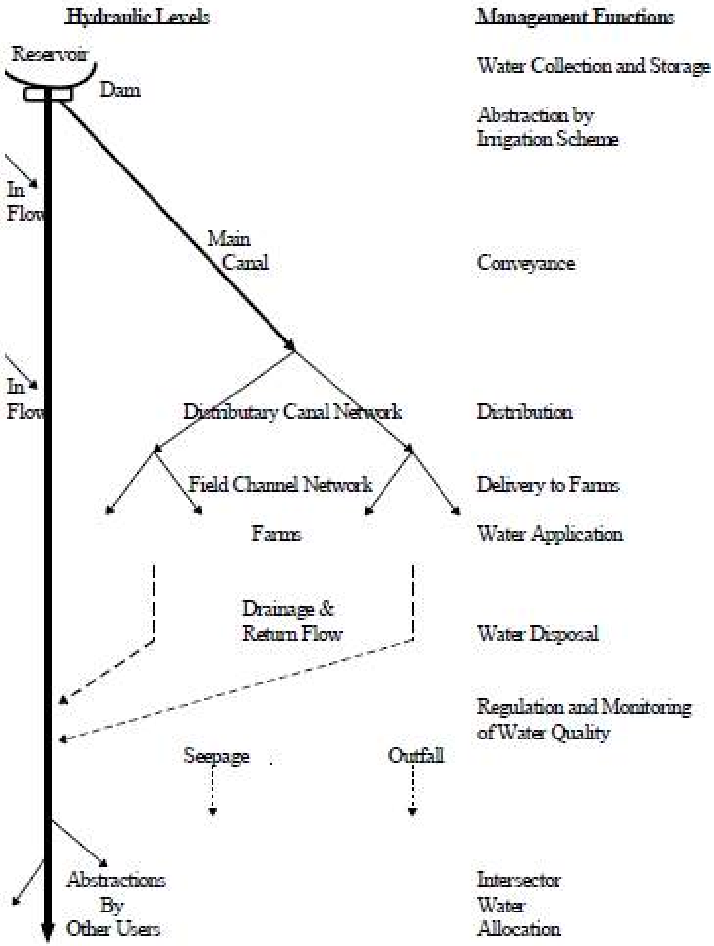



**Figure 8-2 Water service functions at basin and scheme levels**

Water can be managed at the level of the river basin, the main, branch and distributary canal network of an irrigation system, along field channels and in the drainage system. The figure identifies management service functions performed at different hydraulic levels, from the river basin to drains. There should be a clear definition of the services that should be provided at each interface between hydraulic levels. The interface between one level and the next is the point where an upstream organization provides a service to the next downstream level, which in turn may provide a service to other levels below.

**Table 8-3 Service functions and hydraulic interfaces**

| Hydraulic interface | Types of structures | Water service function |
|---|---|---|
| From river basin to irrigation scheme | Weir, pump, intake | Water acquisition |
| From main to branch canals | Weirs, flumes, gates and cross-regulators | Conveyance |
| From distributary canal to field channel | Fixed outlets, sluice gates | Delivery |
| From fields to drainage system | Open or tile drains | Disposal |

The table provides examples of structures and functions that may be located at such interfaces.

- One organization can be responsible for providing a water service from one level to another or even across levels.
- The interface between two levels is the logical place for a boundary between two organizations.
- Planners should keep in mind how each of these levels is interconnected.

- Poor performance at one level must not be primarily the result of mismanagement at this level, it may be a logical response to mismanagement at higher levels.
- Planners should identify the levels at which management problems occur and the levels at which their effects are manifested. Then, they can determine at what level transfer should occur and what should be the between the public agency and the local water service provider (WSP).
- Management may be transferred for an entire irrigation system or only for certain levels. A single system may be managed by multiple organizations. In Jointly Managed irrigation systems, a government agency manages the main and branch canals and farmer associations manage distributary and field channels.

**What core and support services should be transferred?**
Experience in long-enduring locally-managed irrigation systems suggests that there are four basic and inseparable functions which should be handled by the entity that provides the water service:

1. OPERATION, which includes the following tasks:
    - measurement of water requirements and supply;
    - conveyance and distribution of water;
    - distribution of scarce water during water stress periods;
    - application and drainage of excess water from fields and eventual reuse or removal.
2. MAINTENANCE, which should be based on operational requirements and constraints. Hence, the entity which manages operation should also manage maintenance.
3. SELF FINANCING in order for an organization to have the motivation to achieve efficiency and accountability to clients, it should be primarily responsible for its own financing, most or all of which should come from water charges to clients.
4. DISPUTE RESOLUTION, Effective and sustainable local irrigation organizations need to have the power, conflict adjudication mechanisms and sanctions to quickly resolve disputes over water or related matters. Only for exceptional cases should a higher authority be required.

These four functions constitute the core of a water service. Other supporting functions, such as providing agricultural inputs, regulating crop choices, mobilizing additional sources of revenue and carrying out agricultural processing, can also be added to the responsibilities of the entity providing the services. Advantages and disadvantages of adding these secondary functions are discussed in the next section.

The services to be transferred should be clearly defined so that they are measurable (whenever possible) and understood by the service provider and water user. This may sound obvious, but in practice it is rarely done, either by public agencies (which are often oriented toward administrative procedures rather than output objectives) or by farmer organizations (which also tend to be unaccustomed to formulating explicit objectives). A clear definition of the core service should include the following basic elements:

- from where and to where;
- how much (in volume or proportion); and
- for what duration;
- will the water be provided and/or removed.

The boundaries of the irrigation service area and the set of water users served should also be defined.

- encroachers who were not originally included in the design area,
- indirect users of the water supply (such as tubewell, drinking water or non-consumptive users).
- objectives for water quality, domestic water use etc.

After defining the core service, the primary service functions which are inseparable from the core service and should be managed by the same entity must be determined. The entity that will provide the services can be the users' organization (through its own members), or can be a contracted WSP. In practice, the WSP is often made up of a few professionals and technicians contracted to undertake the core services.

**Are there any new services that the wua should provide?**

There are a number of secondary support functions which may or may not be managed directly by the WSP, under the supervision of its WUA. Some examples are:

- provision of agricultural inputs, including credit;
- regulating crop choices and scheduling planting dates;
- mobilizing additional sources of revenue;
- carrying out agricultural processing and marketing; and
- exercising land and soil management.

| Reasons why the WSP may choose to get involved in secondary functions | Reasons why the WSP may NOT choose to get involved in secondary functions |
|---|---|
| The WSP cannot improve the productivity or profitability of irrigated agriculture enough unless it also helps to make improvements in agriculture; | Regulations prevent the WSP from doing so |
| The WSP cannot obtain enough funds to cover the cost of irrigation unless it raises revenue from secondary sources; | The WSP can obtain sufficient financing without secondary sources of income |
| The WSP cannot obtain enough support, loyalty and interest among its members unless it involves them in additional activities which increases the benefits to them from the organization | The WSP cannot maintain sufficient focus and control over its primary functions and deal with the secondary functions as well. |
| No other organizations exist which can effectively handle the secondary functions. | Other organizations exist which can handle the secondary functions adequately |

Experience in several Asian and Latin American countries suggests that WUAs often become multi-functional when they are small-scale, but this is rarely the case when they have larger service areas.
In larger schemes the more challenging management environment may require that a single entity focuses on the water service while other entities focus on other agricultural services. Larger schemes will tend to have more capacity to permit specialization for different service functions.

Multiple purpose water users systems:

Population increases, economic diversification and increasing shortages of water have meant that people are often using irrigation systems to supply multiple uses of water, including for washing clothes, bathing, livestock, recreation, industry, energy generation and even drinking water.

In this case, the WSPs may need to redefine the functions of the water service to incorporate such multiple use services into their formal management system. Such demands cannot be ignored and the WUA will have to organize itself to represent the needs of its widening base of stakeholders. This may mean that women who use water for domestic and other purposes, those who tend livestock, industrial users and so on may need to be represented in the organization.

### *8.3.3 Resolving the problem of accountability through organizational reform*

Lack of managerial accountability is a key reason that policy-makers decide to transfer irrigation management from public to local organizations. Water users are not willing to pay for services not delivered, or for services delivered poorly.

Centrally-financed public agencies with underpaid staff and inadequate O&M budgets lack the means, incentives and accountability to perform satisfactorily.

One of the basic tenets of management science most often forgotten in development strategies is:

*Unless the basic welfare of an organization depends on its achievement of agreed performance standards, it will not have the will to impose effective internal mechanisms of accountability.*

By accountable, we mean the capacity of an organization, to ensure that irrigation scheme policies and management practices are consistent with the aspirations of the general governing body of water users.

**Difference between governance and management:**

**Governance:** The organization that elects representatives and establishes articles of association, by-laws and policies is usually considered the governing body. This will normally be an association of water users with elected boards of directors.

**Management:** the organization that actually provides the water service (operations, maintenance, financing) can be called the water service provider (WSP). The WSP may not necessarily be the same entity as the governing body

Medium- and large-scale irrigation systems managed by water users' associations in more developed countries tend to make this separation between governance and management.
Officials sometimes oppose IMT on the grounds that farmers lack the skills to manage large canal systems. IMT need not mean that farmers themselves must implement the service. While farmers may gain authority over water management at some level, they may also hire technically competent staff (even engineers) or contract with an organization that has the skills to provide the service.

The key challenge is accountability: to incorporate incentives, sanctions and transparency into water service entities in such a way that they will perform according to standards established by a governing body elected by water users.

**What are the organizational options for service providers?**

There are six basic non-governmental organizational models which are used for managing irrigation systems around the world. These are:

1. · INTEGRATED WATER USERS' ASSOCIATION;

Integrated WUAs are water user groups that combine both governance and management functions. They are most suitable for small-scale irrigation systems or sub-systems, where management requirements are relatively simple and non-intensive. They are politically weak bodies which lack the power to apply strong sanctions and enforce rules. Accounting and management tasks are often handled by elected farmer representatives who tend to receive little official compensation for their contributions. WUAs often function weakly in the face of strong public bureaucracies, powerful village governments and no formal water rights. Contexts where it is probably not appropriate: large service areas with complex conditions. Corruption, capture of control by local elites, and disputes between contending factions. These are problems that often overwhelm the modest WUA.

2. · PUBLIC UTILITY;

Public utilities are normally financially autonomous and have mandates from government to provide a monopoly water service within a given jurisdiction, such as a region or river basin. Generally, they are established by the government and are not as accountable to water users as are locally-constituted districts or mutual companies.

3. · LOCAL GOVERNMENT;

Local governments such as municipalities sometimes manage irrigation systems. This is often the case with small-scale irrigation systems or sub-systems of larger schemes, where viable local organizational alternatives to villages and towns do not exist. Weaknesses of this model are that irrigation networks often cross administrative boundaries and local governments are often distracted from water management by other concerns.

4. · IRRIGATION DISTRICT;

The irrigation district is normally a kind of function-specific local public organization, or "semi-municipality". It often has certain privileges and immunities not available to other private sector organizations. Typically, a board of directors recruits a general manager and professional full-time staff to manage the system, as employees of the district.

5. · MUTUAL COMPANY;

A mutual irrigation company is normally a limited liability corporation established through stock shares in the irrigation system which are owned by water using landowners. Generally, share prices are based on a valuation of the assets of the irrigation system which are owned by members. Professional staff may be hired to manage the scheme. Mutual companies tend to exist in irrigation systems which have been developed largely through farmer or private sector financing. This model tends to work best in commercialized economies where management depends more on investment than government subsidies.

6. · PRIVATE COMPANY.

In the case of plantation agriculture or large farms managed by private companies, irrigation systems are sometimes operated by the private company that manages agricultural production in an irrigated area.

Another case is when irrigation management by contracting organizations is done when the governing organization enters into a contract with a third party firm for a limited period of time to manage an irrigation system.

The table summarizes characteristics of these different types of organizations

| Type of organization | Governance | Source of financing | Management capacity |
|---|---|---|---|
| Public utility | • Board of directors from line agencies and regional govts.<br>• Heavily regulated | • Primarily water charges, possibly with some subsidy | • Specialized & professional<br>• Can handle large-scale, complex tasks |
| Local government | • Responsible to local or state govt. | • Land taxes & other local govt. revenues | • Limited due to multiple roles, may rely on contracting |
| Irrigation district | • WUA elects board of directors<br>• Some govt. oversight | • Water charges, secondary revenue,<br>• Possible subsidies | • Moderate to sophisticated<br>• Can handle medium- to large-scales, with technical guidance |
| Mutual company | • Land & water right shareholders elect board of directors<br>• Little govt. regulation | • Water charges,<br>• Secondary revenue, may be profit-making entity | • Generally suitable for small to moderate scales |
| Private company | • Owners or shareholders<br>• Little govt. regulation | • Water charges or other profits of business | • Scale limited by size of capitalization of company |
| Contractor | • Agreement with sponsor organization | • Paid by sponsoring organization | • Can be specialized & professional<br>• Scale limited by size of company |
| Water users' association | • Representatives elected by members | • Water charges or land tax | • Small-scale where direct management by users is possible |

**How can irrigation organizations be structured to ensure accountability?**

Accountability of staff within irrigation organizations can be achieved through personnel policies, incentives, contractual agreements, terms of compensation and sanctions.

| Centrally-financed government agencies | Organizations in the private sector |
|---|---|
| • Staff positions secured by civil service codes which can make it impossible to apply bonuses or penalties based on job performance.<br>• weakest degree of staff accountability | • free to hire and fire staff, employ staff on renewable contracts, and incorporate bonuses and penalties into contracts based on job performance |

The following are five basic methods for achieving organizational accountability:

1. INTERNAL HIERARCHICAL CONTROL;

This is the supervision of lower-level subordinates by higher-level directors within an organization. This form of control is best suited for multi-level organizations where the flow of information between levels is relatively complete, but where management tasks are fairly standardized. This is generally not the situation at local or operational levels, where information is often incomplete and inaccurate, and such inaccuracies can have a major impact on performance. Low-level staff are often compelled to take actions at the field level and such actions are often out of sight of superiors.

2. CENTRAL REGULATION;

Central regulation Organizations are made accountable by regulations imposed by a central governmental authority. Regulation is most relevant for sensitive legal, political or security matters or where natural monopolies exist, such as power utilities. Technical and financial audits of irrigation management organizations are a form of regulation.

3. COMPETITION;

Where monopolies do not exist, where there is a reasonably equitable playing field for competition and where temporary inefficiencies would not have disastrous effects, competition among service providers can be an effective way to improve services and promote efficiency. Competition can be introduced into irrigation systems through contracting services to organizations. Contractors must provide an acceptable service in order to win contract extensions or new contracts.

4. INTER-DEPENDENCE AMONG ORGANIZATIONS;

Inter-dependence between organizations can create reciprocal accountability. Generally, a water service is provided downstream and financial resources flow upstream. Inter-dependence implies a rough balance of power - that one organization cannot dominate the other. One organization obtains its revenue through provision of an acceptable service to another organization. A common example of this is volumetric sale of water to water users' organizations. The need for revenue by the water supply provider makes the provider accountable to the users' organizations who purchase the water.

5. COMMON PROPERTY ARRANGEMENTS.

Local resource users may organize as a group to create property rights and regulate the use of a resource. People have done this for centuries to manage irrigation systems, forests, communal farmland, pastures and fishing waters. These are generally local, relatively small-scale organizations which develop their own systems of rights, rules and sanctions and use social pressures and local institutions to resolve conflicts. Traditional farmer managed irrigation systems provide valuable lessons for how contemporary management reforms could take advantage of organizing principles at the distributary and water course levels of irrigation systems. These include such institutions as how membership is determined, water allocation principles, water distribution practices, how resources are mobilized, sanctions, conflict resolution and so on. But it should be remembered that clear property rights for access to water have been an essential ingredient of their success. Re-imposition of traditional management institutions may fail if clearly defined water rights are absent in modern schemes undergoing IMT.

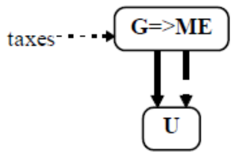
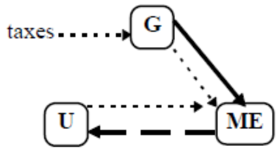
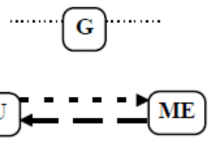
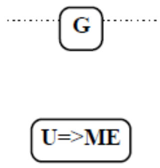
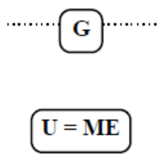
Water management is organized according to four basic service relationships. How these service relationships are structured will determine who is accountable to whom and for what services.

How these service relationships are structured will determine who is accountable to whom and for what services.

1. WHO DEFINES AND GOVERNS THE SERVICE?
2. WHO REGULATES THE SERVICE?
3. WHO PROVIDES THE SERVICE?
4. WHO PAYS FOR THE SERVICE?
5. WHO DEFINES AND GOVERNS THE SERVICE

The figure describes five basic models of service relationships

**Figure 8-3 Service relationships for irrigation management**

| | | |
|---|---|---|
| Classification is based on who<br>defines ⟶<br>provides – – ▸<br>and pays - - - ▸<br>for the service. | **G** = Government<br>**ME** = Managing Entity<br>**U** = Users | |
| 1. Government Administered Service<br><br>Government defines service and allocates budgets to line agency which provides service. Public pays taxes. Users may pay fees. |  | The government defines and provides the service with little, if any, dependence on the users to pay for it, there is little accountability for the quality of the 'service' and its results. |
| 2. Semi-public Irrigation Service<br><br>Government defines and subsidizes service. Semi-public managing entity provides service to users who pay part of the cost of the service. |  | The ME depends for most of its revenue on payment by users. This encourages accountability of the ME because farmer satisfaction is a pre-requisite for their willingness to pay. |
| 3. Independent Service<br><br>Government provides legal and regulatory framework for agreement between users, who pay for a service to a managing entity which provides the service. |  | Model 3 differs from model 2 only in the completeness of its financial autonomy. In this case all three parties are involved in defining the service. |
| 4. User Directed Service<br><br>Government provides legal and regulatory framework within which users define and pay for their service, which is provided by their own managing entity. |  | Model 4 illustrates management by an entity that is sponsored by the group of water users. High level of managerial accountability, depending how accountable user representatives are to the body of users. |
| 5. Self Service<br><br>Government provides legal and regulatory framework within which the users define, pay for and directly provide the service themselves. |  | Model 5 is a simpler version of model 4, where the users themselves directly define, implement and finance the service. (both governance and management functions directly. |

## 8.3.4 *MAKING THE NECESSARY LEGAL CHANGES*

**Why is it important that IMT be comprehensive?**

Probably the most common weakness of IMT programmes worldwide is that they are only partial in nature. They do not include all the changes that are really needed in order to permit WUAs to become viable organizations capable of discharging their essential functions and protecting their interests against competing water users and political interests.

Comprehensive transfer is the devolution of all essential and inseparable irrigation management functions. As stated before, the four essential functions of irrigation management are: operations, maintenance, financing and conflict resolution.

If full authority and capacity to implement any of these functions are not transferred to WUAs, it is likely that the WUA will be unable to discharge the other functions, because both sets of functions are inter-related.

Governments sometimes attempt to transfer responsibility to WUAs without giving them full decision-making authority over O&M plans and budgets. IMT often occurs in countries lacking water rights or where WUAs have no formal legal status. Sometimes governments adopt IMT programmes but avoid making needed changes in the scope of work of the irrigation agency, the deployment of its staff or financing mechanisms for the sector. Pressures from donors for rapid (if partial) programme implementation, financial pressures and political sensitivities can cause governments to short-circuit reform. Reform is limited to policy decrees, rehabilitation and organizing WUAs, in the absence of legislation to empower WUAs, define water rights and revise agency mandates. These missing elements can cause IMT programmes to fail to produce effective WUAs or to improve financial efficiency and productivity in the irrigation sub-sector.

**What kinds of legal changes may be required?**

It is not possible to recommend generically what legislative changes will be required in all IMT programmes, because it depends on the status of legal development in the water sector and on current political biases and environmental issues in each country. IMT Reform may require drafting new legislation, amending existing legal texts or possibly making no change at all.

The most common areas where supporting legislation for IMT is needed are the following:

- **formal adoption of the transfer policy;**

The actual transfer of authority from the government will necessarily require legal action to give it effect. It will normally take one of the following forms:

- ministerial decree: easy and rapid to accomplish, but it has less power than the other options and may not be sufficiently comprehensive in scope.
- decree by the head of state: (such as a presidential decree), allows rapid action, gives weight and legitimacy to the transfer and cuts across all sectors. On the other hand, it cannot introduce fundamental legal change and may be easily overturned by a subsequent leader
- legislative act: is the slowest and most complicated approach, but it has the greatest potential to effect comprehensive and long-term change, and generates widespread knowledge about and support for comprehensive restructuring. In decentralized system the country's subdivisions, such as regions, states or districts, may also have power to take legislative action.

*The important issue in introducing these legal changes is that they must be comprehensive*.

- **status of the WUA;**

The WUAs may need to be established legally, either with a new law or under an existing law, such as one on cooperatives. Its immunities (such as for certain taxes and liabilities) and powers must be defined. Global experience suggests that when a WUA is established, it should have at least the following powers: · to extract water from a specified source;

  - to use and maintain (and perhaps own) the irrigation and drainage infrastructure;
  - to establish rights of way for existing and future infrastructure;

  - to raise funds or muster labour inputs from its members;
  - to apply sanctions against its members for non-compliance with rules;
  - to delegate powers, such as to a water service provider;
  - to enter into contracts;
  - to purchase, own and sell property.

- **water rights;**

Water rights specify expectations about the amount, share and/or duration of flow of water to which particular kinds of water users, groups of water users or an entire irrigation system are entitled.

Increasingly, water laws also involve rights and obligations and water quality.

Water rights may need to be created or existing ones need to be updated for modern conditions.

There may be lack of clarity about how the right is measured, criteria for allocation and the means of distinguishing among different types of users. In many countries customary water rights are backed up by modern statutory laws.

There are a number of developing countries, particularly in Asia and Africa, where there are no water rights recognized by the state, and where instead all water resources in the country are considered to be owned and controlled by the state. In these circumstances, the state is responsible for allocating water according to administrative regulations and tends to see water allocation as a social welfare benefit rather than as a legal entitlement. The water user is a supplicant, not a holder of a right.
The social welfare conception of water tends to work against a primary objective of irrigation management transfer, which is to eliminate farmer dependence on the government and to create locally self-reliant organizations which can extract, distribute and dispose of water according to local needs.

Where water is scarce relative to demand, considerable uncertainty and competition for water may exist. Without water rights, farmers cannot predict or define how much water they will receive. And when conflicts or competition over water arise, there is no clear legal basis for settling disputes. This weakens their motivation to invest intensively in agriculture or water management.

Any government that has adopted a policy to transfer management should first put in place a basic system of water rights which defines the principles according to which water will be allocated among different users.

Water rights may be granted to collective entities such as water users' associations or may be granted to individuals and private corporations.

The Mexican water law of 1992 established a basis for WUAs to obtain formal water rights, whereas Chile granted absolute, tradable water rights to individual users. In the latter case, individual users may lack control over infrastructure which diverts water from the resource base (the river or aquifer), and since the WUA does not hold a right, difficulties may arise in managing water transfers between individuals.

In most countries, water rights are allocated and distributed to water users' associations, which in turn allocate rights to their individual members.

- **rights relative to irrigation infrastructure;**

Legal changes may be necessary in connection with the transfer of ownership or use rights over irrigation scheme assets.

Where farmers are in a weak position politically, ownership may be a symbol of acquisition of rights and power and may be desirable.

It may also be required where otherwise it would be illegal for farmer organizations to modify irrigation infrastructure.

Where farmers are repaying the cost of infrastructure construction and/or rehabilitation, there is a strong argument that they should have the right to own the infrastructure.

In some cases, such as Chile or New Zealand, ownership of irrigation scheme assets has been transferred to water users' associations through outright purchase, concessionary sale or administrative act.
Ownership of public tubewells has been transferred in Pakistan, Bangladesh and Senegal.

In most cases, however, ownership of infrastructure remains with the state and only the right to use infrastructure is transferred to the users.

In such cases, for example in schemes developed in the United States and in Colombia, farmers resisted transfer of ownership for fear that it would also entail unwanted liabilities, such as responsibility to fully finance the costs of rehabilitation and modernization in the future and property taxes related to the infrastructure and property damages attributed to irrigation scheme management.

It is recommended that policy-makers and planners compare the existing policy and legal framework with the rights and powers identified above and determine what changes can and should be made in the legislative framework to support the emergence and strengthening of viable water users' associations. How effectively a country will be able to effect these changes will depend on the level of development of the country's civil institutions, on the government policy (i.e., how liberal or command-oriented it is), on the political sensitivity surrounding water issues and on the water users themselves, such as: "Are they motivated and organizationally-inclined?"

- **changes in the status or mandate of irrigation agencies.**

changes in irrigation agencies are discussed separately in another chapter

**PHASE 3 OUTPUTS: RESOLUTION OF KEY POLICY ISSUES**

Outputs for Phase 3 may be in the form of short policy briefs or issue papers on the key policy issues.
Issue papers normally include a brief summary of the problem, analysis of options and a recommendation.
More detailed reports can be prepared by working groups or issue groups and be incorporated into planning documents and background papers for legislative action. The expected topics to be addressed are:
· What services should be transferred?
· What kind of organization should take over management?
· How should the irrigation sub-sector be financed after transfer?
· What legislation and other sector changes need to be made in conjunction with management transfer?

## 8.4 PHASE 4 PLANNING AND IMPLEMENTATION

### *8.4.1 DEVELOPING A PLAN FOR IMPLEMENTATION*

**What is involved in developing an integrated plan at the sector level?**

A working group will coordinate development of the IMT plan. It is important that the plan be comprehensive. This does not mean it must be detailed or a top-down exercise. It means that it should identify all essential aspects of IMT. If the plan is not comprehensive, components that are left out will probably not be effectively linked to the reform.

A comprehensive plan for IMT will normally involve the following elements

- policy changes required (i.e., organizational mandates, subsidies, etc.);
- legal changes required (i.e., water and land rights, status and powers of WUAs, means for conflict resolution, etc.);
- agency restructuring (i.e., reorganization, disposition of staff, training, etc.);
- arrangement for provision of new support services (i.e., technical advice, credit, dispute resolution, enhanced river basin management, etc.);
- creation and development of WUAs; and
- improvement of irrigation infrastructure.

Each of these aspects should be related to the plan in the following ways:

- ✓ · show how it supports the objectives of IMT;
- ✓ · show how and by whom it will be implemented;
- ✓ · produce a schedule of implementation;
- ✓ · identify the resources required.

The main challenge for the working group will be to ensure that all essential components of reform are incorporated into the plan. This will require frequent communication and trouble-shooting between the working group and each of the parties involved. This is a means to build consensus and engender commitment to the reform

**What roles should the lead agency play in the transfer process?**

The lead public irrigation agency in general

- had originally been developed primarily to design and construct irrigation systems and that is where its primary interest continues to be.
- It may not be very effective at managing and financing O&M, as if it had, management transfer would probably not be occurring.
- it should re-direct its future efforts
  - away from management
  - toward water management of the resource base - river basins and aquifers –
  - toward providing support and technical advisory services to organizations which take over management of irrigation systems.

In this context it is necessary to answer these three questions:

1. Should the irrigation agency be given the lead role to implement IMT?
2. Is the irrigation agency capable of, and willing to, reform or restructure itself?
3. Does it have the skills and proper motivation to develop strong water users' associations?

Very often the answer to these questions is "no". Nevertheless, very often the irrigation agency is assigned the task of implementing IMT. This can have the following deleterious effects, as has been observed in a number of cases:

- creating WUAs becomes a rapid, top-down and superficial exercise;
- there is an over-emphasis on infrastructure development;
- matching farmer investments or fostering other meaningful community participation in infrastructure development are not sufficiently encouraged or required;
- the perception among farmers that the government owns the system and will return to rehabilitate it in the future is reinforced;
- farmers partially defer investment in maintenance;
- WUAs are weak and are seen more as appendages of the state than as self-reliant service providers;
- the agency continues to exercise partial control over irrigation systems and continues to have field operations staff assigned to irrigation systems even after transfer has occurred.

For political and administrative reasons, special task forces accountable to the planning or finance department or to the cabinet may be required to take the lead in restructuring the agency. NGOs and progressive farmers may be more effective than the irrigation agency at organizing water users' associations.

If the irrigation agency cannot be expected to restructure itself alone and if it is not qualified to create and develop water users' associations, then what should be its role in the IMT process? Support it:

1. the agency should do its part of the job of restructuring as soon as possible. This includes making changes in personnel, reassignment of staff and training for new functions. This will help clarify to farmers that IMT is bringing about real changes and that the agency will in fact no longer handle the tasks which are being turned over to the WUAs.
2. the agency should help communicate to farmer organizations what the new division of responsibilities is and what is the new policy about subsidies and future rehabilitation.
3. Third, the agency should move into implementing its new roles as soon as possible. These may include technical assistance and training for new water service providers and enhancing water management along river basins.

**Who should take the lead in facilitating development of water users' associations?**

It should be borne in mind that with IMT there may be two kinds of organizations that need to be created and developed at the local level:

- the water users' association (the governing body) and
- the water service provider (the managing entity).

Normally, the WUA has a basic charter of authority and by-laws. It should have rules, methods and sanctions for selecting leaders, raising finances, settling disputes and supervising provision of the water service. Skills and experience in such matters may be found in cooperative associations (including farmer organizations), development NGOs, local development consulting firms, agricultural extension agencies and other government organizations. More than one organization may need to be involved but **one entity** should have the primary responsibility to coordinate inputs.

It should be avoid using organizations

- that are unaccustomed to playing the role of facilitator.
- that have reputations for corruption
- that have interests which are contrary to those of WUAs or the objectives of IMT.

In the end, it is the farmers and their representatives who really must take the lead in developing their own organizations

Sometimes there is a tendency to use an intensive amount of resources in the pilot phase of an IMT programme: expensive consultants and college-trained community development workers may be placed in the field to organize farmers. This may be justified in the early learning phase of turnover, but the general strategy for developing farmer organizations should be affordable and practical. An outline for this strategy and which organizations will take the lead in facilitating development of viable WUAs should be included in the IMT plan.

It may not be that the same organization that takes the lead in facilitating development of WUAs should also play the lead role in creating and training the WSP. The emphasis and skills required will be different.

The task of the training organization will be to prepare the WSP to provide an acceptable service managing the acquisition, delivery and disposal of water which is consistent with the service defined by the WUA. At a minimum, this should include

- development of an operation and maintenance plan
- methods for collecting water charges and other revenues,
- operating irrigation technology,
- carrying out maintenance and
- assessing management performance.

Normally, the public irrigation agency would play an important role in such training, since it was the prior service provider. But sometimes training can also be provided by others, such as experienced farmer managers from other schemes or engineers from NGOs or consulting firms.

In Colombia, the WUAs throughout the country formed a national federation of water users' associations, the Federriegos. The purpose of the federation was to prepare the WUAs to take over management of the districts from the government. Each WUA pays fees to support the Federation, which hires lawyers to assist with transfer negotiations, engineers for technical problems, accountants for financial training, etc.

**How detailed and rigid should iMT targets be?**

There is a tendency for planners and consultants to develop plans that are overly elaborate and rigid. Normally, IMT will be a learning process where specific actions, targets and deadlines can only be worked out in the process of implementation. It is not possible to predict

- the different kinds of reactions farmers might have to assuming management,
- what kinds of issues will need to be negotiated in the field,
- what technical or financial problems might arise during implementation, etc.

As a rule, plans should only be as detailed as anticipated during implementation. More complex environments will probably require less detailed plans of action but more elaborate mechanisms for testing, negotiation and adjustment.

There is also a tendency, often promoted by funding agencies and development banks, to insist on rigid targets and deadlines. Policy-makers and planners should state clearly desired targets and the expected time-frame. But the plan should not force so rapid and rigid a schedule as to sacrifice development of new and sustainable organizations. Another way to avoid this is to make support of viable local management organizations an important on-going function of sector organizations after IMT.

**Why is monitoring and evaluation important and how should it be designed?**

The characteristics of IMT are:

- As with any reform, IMT breaks new ground.
- IMT plans are like working hypotheses which need to be tested and modified in practice.
- Different stakeholders are involved and negotiation is an inherent part of the process.
- Irrigation schemes vary dramatically in their costs and degree of management intensity required to meet objectives.
- Feedback, learning and flexibility in programme implementation are essential, although they must be contained within the objective of achieving locally-sustainable irrigation management.
- It is easy to get bogged down in too much negotiating and deviation from the fundamental goal.
- Negotiation and flexibility must be constrained by the larger need: to implement a controversial reform within a reasonable timeframe despite political opposition. This requires
    - keeping the momentum of change ahead of the resistance.
    - keeping the basic structure of reform simple and clear to stakeholders.

Probably the two most common problems associated with monitoring and evaluation are:
(i) they produce an excess of unusable information and
(ii) they are not sufficiently linked to a decision-response arrangement.

The following are some suggestions for how these problems can be overcome.

1. Follow a minimalist approach. Only use indicators which satisfy the following criteria:
    - they are key aspects of implementation (i.e., performing tasks and meeting targets) for which verification at higher levels is absolutely essential;
    - they inform about essential outcomes and impacts of the programme which really must be documented and relayed to higher levels; and
    - they do not exceed the optimal amount of information that can practically be relayed to and absorbed by planners.
2. Select indicators which are “information efficient”, meaning they describe a set of associated phenomena. A good indicator provides insights about multiple aspects, so there is no need to collect direct information about all related aspects.
3. Distinguish between top- and bottom-directed needs for monitoring.
    a. conventional top-down monitoring top directed monitoring is used to compare actual with expected results. This approach uses conventional methods of data collection and processing
    b. bottom-directed monitoring conveys important information about unexpected and subjective issues that arise. Bottom-directed monitoring may rely on other methods, such as participatory rural appraisal, process documentation, direct involvement of stakeholders in working group meetings and so on.
4. Distinguish between those few indicators for which data must be collected from all sites versus those for which sampling may be sufficient.
5. Meetings of the working group, policy coordination committee and other planning groups should include review of monitoring and evaluation information as a regular part of their meetings. Such reviews should sometimes result in identification of action items for follow up or discussions about how the programme may need to be modified. These meetings are also opportunities to identify requirements for information about specific issues.

Evaluation is about outcomes, which tend to occur immediately or within a year or two, and impacts, which may occur several months or years after implementation.

Commonly-used **outcome** indicators are:

- reduction or reassignment of irrigation scheme staff;
- reduction in government expenditures for irrigation O&M;
- cost of irrigation to farmers;
- changes in irrigation scheme budgets, fees and fee collection rates;
- changes in O&M plans and procedures;
- functional condition of irrigation infrastructure.

Commonly-used **impact** indicators:

- irrigation service area;
- water delivery performance;
- irrigation efficiency;
- cropping intensity;
- agronomic productivity per unit of land and water;
- economic productivity per unit of land and water;
- farm income and employment;
- extent of waterlogging and salinity.

### *8.4.2 RESTRUCTURING THE IRRIGATION AGENCY AND BUILDING NEW CAPACITY*

**What is agency restructuring?**

Organizational restructuring means a fundamental change in the purpose, mode of operation and possibly the financing of an organization.

IMT may require such changes in the irrigation department to make it consistent with new policy.

Normally, an irrigation department or area development authority will not have the capacity to restructure itself and it may be resistant to change. For these reasons it may be advisable for governments to appoint a high-level special commission consisting of senior officials from several related departments, such as planning, finance, internal affairs, agriculture and irrigation. The purpose of the commission will be to conduct strategic planning and oversee implementation of agency structuring in coordination with the IMT working group. Restructuring may include changes in the following elements:

- mission and roles of the organization;
- governance and mode of financing;
- internal accountability arrangements.

If a government adopts a management transfer programme before it has a clear policy about what changes will be made in the irrigation agency after transfer, it may strengthen resistance to transfer within the agency. Staff may fear for their jobs, budgets and positions of influence. Transferring some of the agency's functions to farmer organizations may seem like the organizational equivalent of amputation, so it is far better simultaneously to develop a clear vision of the future for both the transfer units and the public agency. If new roles are identified for the agency, its staff will feel less threatened by transfer.

The following are examples of typical changes which are made in irrigation agencies as a result of IMT:

- release of excess staff from the agency;
- taking on new mandates, such as watershed management and environmental regulation and monitoring;

- merging the irrigation department with the agriculture department;
- conversion from a centrally-financed agency to a self-financing utility;
- withdrawal from management functions and focus on regulatory and/or construction and development roles.

In any given location, some, but probably not all, of these changes will be required. In deciding what changes should be made in the lead irrigation agency, planners will consider:

- shortage of government funds,
- civil service restrictions,
- political resistance to personnel reductions,
- management performance gaps at scheme and water basin levels and
- what kinds of support services are needed by WUAs after IMT.

**What support services will WUAS need after transfer?**

There are numerous support services that may be needed by water users' associations after IMT. In some cases these may be provided by WUAs themselves, but in many cases they will need to be provided by an external entity in the public, private or NGO sectors.

**Legal support**

- *Water rights* Once water rights are established and accounted for (at the user and association levels), the government needs to ensure that they are sustainable, but not over-appropriated or protected. This will be especially important where there is strong competition for water and where there may be undue political influence. WUAs may need legal services from the government or law firms to help establish precedents in the assignment of water rights or to otherwise protect existing rights.
- *Legal status of WUAs* Additional legislation or legal advice may be needed about entering into contracts, credit arrangements, rights of way, taxes and liabilities. Government legal officers and private law firms may provide such services.
- *Ownership of irrigation infrastructure* If the government has adopted a policy to transfer ownership of irrigation infrastructure to WUAs, and if this was not legalized in the initial transfer, there may be a need for further legislation toward this end.
- *Dispute resolution* WUAs may need to call upon the government or other local authorities for assistance in the resolution of difficult disputes about water distribution, damage to structures, non-collection of water charges or financial irregularities.

**Technical support and training**

- *Water measurement* WUA staff and even supervisory WUA board members often need to be trained in water measurement. Normally the irrigation agency will provide this training.
- *Water distribution and drainage* WUAs may need training in basic hydrologic principles to enable them to manage operations effectively. Normally such training is provided by the lead irrigation agency, but sometimes farmer-to-farmer training may be useful for less theoretical aspects.
- *Maintenance* WUAs may need training in preparation of maintenance plans, design of structural repairs and recommended preventive maintenance practices. This is normally given by the irrigation agency, but sometimes farmer-to-farmer training may be useful.
- *O&M audits* O&M audits involve an independent party inspecting organizational and management practices (including infrastructure, budgets and records) and providing a certification of compliance with agreed performance standards. Auditors may be from government or private sector engineering firms. Such audits are most often required when the government links subsidies to WUA compliance with certain management standards (as recommended in this guide).

- Rehabilitation and modernization WUAs may need assistance with planning, design, construction and financing of improvement projects.

**Financial and managerial support and training**

- *Accounting*. This is a common weakness in WUAs after IMT. It sometimes leads to scandals and organizational collapse. The government should facilitate adoption of common accounting principles and standards and agreed pricing, budgeting and reporting methods, especially where subsidies continue after IMT. Financial audits by independent auditors are extremely important in helping the WUA maintain credibility among its members and creditors.
- *Resource mobilization, credit and subsidies* Developing an effective water charging system and achieving financial viability are key objectives of most IMT programmes. Advisory assistance and credit may be required from the government, banks or accounting firms. Where WUAs cannot become financially viable immediately after transfer, subsidies for O&M may be continued after IMT on a gradually declining basis. Subsidies may be useful for rehabilitation and modernization, especially if they are linked to corresponding investment by the WUA.
- *Management principles and methods* The WUA board members and WSP management will probably need training and advisory support in upgrading their management capabilities. This may include such aspects as general management skills, computing, financial management, personnel management and information systems.

**Water basin and watershed management**

- *Data on hydrology, water quality, meteorology* Normally WUAs will need this information to be provided by the water resources department and meteorological service.
- *River basin management and water allocation* Water resources departments or river basin authorities may need to enhance management at the river basin level to ensure equitable water allocation consistent with water rights, in the face of increasing competition. More effective basin-level management will probably require a representative role for water users' associations in basin management bodies in coordinating water use schedules and allocating water among schemes.
- *Land and water use monitoring and regulation* Increasingly, government must regulate against environmental degradation to prevent irrigation systems from becoming overwhelmed by larger resource problems such as deforestation, soil erosion, unsustainable land use practices and water pollution. Federations of communities or WUAs can play a role in environmental policy advisory bodies.

**Agricultural productivity and profitability**

- *Provision of inputs* For reasons of productivity or profitability, WUAs after transfer may want to diversify cropping patterns and encourage commercialization of agriculture. Where agricultural extension services are ineffective, WUAs or farmer groups may have to organize their own extension services, perhaps through networks or federations.
- *Credit* WUAs may need the assistance of government or rural banking services to learn how to arrange credit services.
- *Marketing* and enterprise development Increasing commercialization of agriculture will require a greater farmer awareness of market and agricultural enterprise opportunities. Local consultants, traders, exporters, businesses and government agencies could provide advisory services.

Planners should conduct an analysis of the needs of water users and their organizations for support services and determine what new services and organizational changes are needed to best meet those needs.

**Mission and roles**

The mission of an organization is its basic purpose and roles. It is now common for organizations to adopt mission statements. A mission statement is a succinct answer to the questions: “What is my purpose?” or “What is my business?” Such statements provide direction and clarity about what the organization should be doing. They provide a standard against which organizational performance can be assessed.

Whether or not an irrigation department already has a mission statement, it would be well served to have a new mission statement when it adopts an IMT programme. The statement is a reference point for communicating the organizational purpose and culture and the relationship of the new agency to the farming community. The following are two hypothetical examples of mission statements for an irrigation department. The first one describes a common orientation of pre-IMT irrigation departments. The second is a possible future mission of an agency after IMT.

1. The mission of the department is to develop, operate and maintain irrigation and drainage systems and to regulate use of surface and groundwater for agriculture, in order to enhance rural livelihoods, support productive agriculture and protect the environment consistent with government policy.
2. The mission of this department is to regulate use of surface and groundwater for agriculture consistent with government policy and to provide technical and financial assistance to water users’ associations for the development of irrigation systems and improvement of their performance.

The following is a list of typical changes in roles which irrigation agencies tend to make after IMT:

- provide technical guidance to the post-IMT water service provider (WSP);
- provide managerial, accounting and financial advisory services to the WSP;
- assist with dispute resolution;
- monitor the performance of the WSP after transfer;
- environmental regulation;
- drop O&M and focus on scheme construction and modernization;
- restrict its managerial role to a higher hydrologic level, such as the river basin or main canals of large irrigation schemes;
- engage in more inter-sectoral planning and management of river basins or watersheds.

These roles can be broken down into three new types of roles:

- provision of advisory service;
- monitoring and regulation; and
- focus on higher-level management tasks.

Decisions about which new roles should be handled by the agency after IMT will depend on assessments of support service needs of WSPs and performance gaps at the level of river basins and watersheds.

**Governance and mode of financing**

There are two common options governments generally follow in reforming irrigation departments after IMT:

1) The first is to keep the department as a public agency and merely revise its scope or mandate. Sometimes this involves merging the irrigation agency with another department such as agriculture. This option will involve mostly analysis of changing capacity and needs for the agency. This might be assessed with such planning methods as SWOT analysis.

2) The second option is to convert the agency into a self-financing utility accountable to a regulatory board (which is most often an inter-departmental body). This option will involve more

thoroughgoing analyses of organizational structure, control mechanisms and financing options. It also requires a high degree of professionalism and managerial control, as well as strong legal institutions

In most cases irrigation agencies still retain their previous governance structure as public agencies accountable to a ministry or cabinet. Generally, this option is followed when the financial or political pressures are not great enough to bring about a more basic change in governance structure. Or the government may perceive that the agency's regulatory role requires it to retain its status as a government agency.

The basic sources for financing irrigation agencies after IMT are:

- general government treasury;
- special project funds;
- special regional funds;
- irrigation service fees;
- secondary revenue generation.

The first two sources are in decreasing supply around the world. However, if an agency restricts its scope dramatically, to policy and regulatory functions for example, it may be able to continue to be financed primarily from the government treasury. Project funds are increasingly being redirected by donors to regional or local levels and are used mostly for development or rehabilitation, rather than for financing agencies. Regional governments, such as states, districts or basin authorities, often have multiple sources of revenue, from taxes, levies, etc., which may be shared with irrigation agencies.
If the irrigation agency retains a role in water management after IMT, but at higher "upstream" levels (such as the main canal or river course), then it may be engaged in collection of irrigation service fees. If the ratio of funds from government versus funds from fees declines, this may provide a stimulus for the agency to improve its management performance so as to increase its revenues from fee collection. Sometimes irrigation agencies may engage in sideline revenue generating activities, such as sale of power, contracting for public works or sale of excess water. Depending on their new mandate and availability of funds from the government treasury, agencies may want to explore opportunities for generating revenues from multiple sources.

**Internal accountability arrangements**

Civil service codes and traditions can make it difficult to ensure effective accountability of staff to agency objectives and operating procedures. Such codes include granting of permanent status to staff, advancements based on seniority, lack of performance-based rewards, etc.

Unofficial practices of favoritism and corruption are an even more serious threat to internal accountability. These problems are part of the reason IMT came about in the first place. To ignore them will only exacerbate problems at upstream levels, if this is where the agency is going to focus its attention after IMT.

There are numerous options that can be considered to enhance internal accountability. These may be changes in civil service codes, introduction of work performance incentives, transparency, new information systems and so on.

Such changes will be easier if IMT is part of a broader reform of government which is under way. In some cases, it may be necessary to change the agency's charter of authority or organizational status, such as converting it into a semi-autonomous utility, as mentioned above.

The IMT special commission should take advantage of the strategic change opportunity provided by IMT to grapple seriously with these issues and make the necessary changes. Only through overcoming these problems directly can the new post-IMT agency discharge its functions effectively and provide the kind of regulatory and support services irrigation schemes need after IMT.

**What kinds of capacity need to be built into the "new agency"?**

The above section on mission and roles implies that in the future there are three kinds of capacities which irrigation agencies are likely to require after IMT.

1. Capacity to facilitate and advise

Irrigation departments are hierarchical administrative systems. Staff are accustomed to issuing or receiving instructions and fulfilling administrative quotas or following administrative procedures.
IMT may mandate a shift from a hierarchical to a partnership relationship between the agency and farmers. This requires a fundamental change in organizational culture, which must be supported by continual emphasis from above, training and possibly introduction of new criteria for assessing job performance. NGOs experienced in organizational development might be useful in providing on-the-job training for department staff.

2. Capacity to monitor and regulate environmental problems

This may include monitoring of environmental problems such as groundwater tables, waterlogging, salinity, stream flows, silt loads, irrigation intensities, etc. Agencies will need capacity to measure these variables, analyze the data and make recommendations for action.

3. Capacity to manage inter-sectoral water use at basin levels This involves an even broader range of technical and other skills and capacities, including

- water basin hydrology,
- water resources planning,
- legal expertise,
- political influence,
- negotiation methods, etc.

It will also involve a more intensive collaboration with domestic water supply, manufacturing and industry, power sectors and local and regional governments.

For some of the new roles, capacity building may require training of existing staff, hiring new staff or sub-contracting services from the private sector. Just because the government retains a role of providing a service does not mean that it must deliver the service by itself. Local needs and capacities in the public and private sectors will determine the appropriate mix of how services will be provided in a given country.

### 8.4.3 IMPROVING IRRIGATION INFRASTRUCTURE

**Should infrastructure improvement be included in a management transfer Programme?**

In a transfer programme, the condition of the physical infrastructure of irrigation systems is an important issue because many irrigation systems may have deteriorated considerably due to poor maintenance and other associated reasons. The rehabilitation and improvement of thousands, or even millions, of hectares involved in a transfer programme have large financial implications since such works will rarely cost less than

US $1 500 per hectare and therefore any government will look into this issue with special attention before making any commitment.
Considering that most of the transfer programmes are carried out under the pressure of economic reforms, governments are generally reluctant to embark on large rehabilitation programmes. Normally rehabilitation is restricted to certain special cases or conditions which require careful definition before the process is started.

Even if the investments in rehabilitation are modest they can be an important element to exemplify a new approach to irrigation management. The promotion of incremental infrastructure improvement and priority decisions by the WUAs will support the primary goal of transfer, which is to create self-reliant water users' organizations to replace government in the management of irrigation systems.

**What role does the government wish to play in the rehabilitation of the irrigation infrastructure?**

Basically, the government can adopt three different positions with regard to the financing of rehabilitation works:

1. Financing rehabilitation as a bargaining tool to promote transfer
The government negotiates individually with the concerned WUAs on the possible financial commitments that each party could make that will be used for rehabilitation works. As in any negotiating process, the rules that govern this are flexible (within a certain framework).
Farmers who are asked to receive systems in poor condition will argue that they will not be able to operate them and that they will not be able to raise the necessary funds for operation and maintenance, much less for rehabilitation. They may even refuse to accept transfer. Some WUAs may try to put pressure on the government to rehabilitate or improve the irrigation systems before transfer.
On the other hand, the government may argue that it does not have the necessary funds and that the system has deteriorated because farmers have not paid the fees that they were supposed to. Such conflicting situations are more likely to arise in those irrigation schemes where operating costs are particularly high and/or where the farmers have a low capacity to pay the fees. In such cases the financing of some of the most needed rehabilitation works can represent an important incentive to the WUAs to accept more voluntarily a transfer that may not look very attractive to them.
This negotiating approach has to be applied with extreme care, defining very clearly the bases for possible negotiation. The moment that farmers become aware that government officials have the capacity to agree to the financing of some rehabilitation works they will always find some topics to be addressed in negotiation. An important parameter that may help to determine where such grants may be provided is the farmers' capacity to pay the irrigation water fees. Irrigation schemes where this capacity is generally high should be excluded from such negotiations.

2. Full rehabilitation before transfer:
Due to financial limitations this is highly unlikely although it has been used in a few cases.
Under the argument that farmers cannot be expected to take over management of an irrigation system where functioning is impaired because it has deteriorated, the irrigation agency may sometimes promote a policy of rehabilitation before transfer. The additional argument is that it will reduce the future cost of maintenance to farmers. In reality these arguments are often a delaying tactic rather than a true intention since a full rehabilitation of irrigation schemes requires resources that will certainly slow down the process. An indiscriminate policy of rehabilitating the irrigation schemes before transfer, apart from being difficult to sustain from a financial point of view, may also be counterproductive from the point of view of promoting self-management. Some of the possible negative consequences are listed below.

- If the government sponsors rehabilitation prior to turnover, it will reinforce the perception of farmers that the scheme belongs to the government.
- Conventional bad practices will probably be repeated. Such practices may reinforce in farmers' minds the notion that the government will return in the future and finance rehabilitation.
- Farmers will then have the incentive to defer investing in maintenance, with the expectation that these costs can be pushed onto the government in a future rehabilitation project. So the scheme is again likely to deteriorate rapidly, just as before transfer. However, the assumption that government may be ready to finance any future rehabilitation may prove unjustified in the long run and this may place farmers in a difficult position in the future.
- Rehabilitation and improvement works undertaken without full involvement of the water users' association may even be counterproductive or not fully used by the beneficiaries.
- The cost of such a programme will be much greater than adopting an alternative approach based on some formulae of joint investment between the WUA and the government.
- Rehabilitating before transfer may delay the reform process because of limited funds and slow bureaucratic processes for undertaking the works. These delays may discourage local organizations from active participation in the process. Furthermore, a lengthy reform process is subject to changing currents of political support over time and this can be risky for the IMT programme.

<u>3. Joint and progressive financing of infrastructure improvements</u>
The third option is certainly the one that offers a greater potential for strengthening the transfer process but in any case, governments should define their position before entering into a more detailed plan of their activities in this area. It requires the definition of some rules for the application of government grants (or soft loans) that will be provided to WUAs to undertake the rehabilitation works if certain conditions are met.

A transfer programme will substantially alter the relationship between the government and water users in that the water users become partners with the government and enter into "the driver's seat" in the management of water for agriculture.
Farmer dependence upon the government should be greatly decreased. Strong signals will be needed to reorient both farmers and the government. If done properly, rehabilitation can provide an opportunity to strengthen this new relationship.
A future irrigation sub-sector may be envisioned where WUAs have taken over management of irrigation systems, where government only provides technical and financial support services periodically, as needed, and where government resources are extended in limited amounts to stimulate rather than discourage farmer investment in their irrigation systems. If this vision is accepted, it may be expected that the future relationship between WUAs and the government, with regard to infrastructure improvement, has most or all of the following elements:

- · the government will no longer finance the bulk of the cost of rehabilitation;
- · there will be a known formula for cost sharing between the WUA and the government;
- · the "wait-till-in-a-state-of-collapse", "all-at-once" approach of the past will be replaced with an ongoing, incremental, pro-active and smaller-scale approach of repair and restoration. Works will be done as the needs arise, before they become serious and require large investments with substantial external funds;
- · WUAs will draw on capital reserve funds (possibly complemented by some corresponding government funds) to finance these incremental repair and restoration works;
- · WUAs will identify and prioritize the works, seeking outside technical support as needed;
- · WUAs will have the legal authority to repair, modify and extend irrigation infrastructure.

It may only be possible to use infrastructure improvement as a tool for institutional reorientation if the WUA and WSP are first established and full management authority has been transferred. Only after this will the

WUA be in a position to manage the improvement process, prioritize and schedule improvements and mobilize local and government resources. This experience will prepare the WUA and WSP to take over primary responsibility for the physical and financial sustainability of their irrigation system.

**How to plan the infrastructure rehabilitation**

Once the government has defined its position regarding its role in the rehabilitation programme it should establish a clear plan about the extent and means whereby it will provide assistance for infrastructure rehabilitation. This may include the following:

- An inventory of all schemes planned for transfer should be made and planners should obtain data on their functional condition before transfer. The inventory does not need to be very detailed as it is only meant to give an indication of the extent of systems which are likely to need rehabilitation;
- Assemble recommendations from the WUAs about what rehabilitation works, if any, are indispensable;
- assess the cost involved for several hypotheses of rehabilitation (few works to be negotiated, most urgent needs, selected cases, all recommended works, etc.);
- identification of criteria that WUAs must fulfil in order to be eligible for government assistance;
- define the conditions whereby government equipment for operation and maintenance will be transferred to the new WUAs;
- define the financial and technical procedures to be followed if those criteria are met;
- check that WUAs are legally empowered to commission construction works;
- identify training needs of WUAs for infrastructure improvement;
- estimate the timeframe of the programme;
- estimate the total cost to the government and possible sources of financing

**How improvements can be identified and prioritized in ways that support the goals of transfer**

One of the first tasks that new managers of transferred systems will have to undertake is the prioritization of works in need of improvement or rehabilitation. WUAs and WSPs are likely to include the following kinds of criteria for such prioritization:

- · ensure the continuity and equity of water distribution;
- · optimize irrigation efficiency and water saving;
- · execute first those works that can be done with the available resources of the community
- and leave for later those that require external financing;
- · expand the service area and the number of service payers;
- · minimize safety risks;
- · minimize loss of productive land when extending channels;
- · make transparent the basis for water distribution;
- · design improvements that minimize management requirements and maintenance costs.

In any case, the members of the community should be consulted and invited to participate actively in prioritization. Sometimes it may be difficult to arrive at an obvious consensus where certain works may benefit some farmers more than others. It is the job of WUA leaders to forge a consensus or take decisions in the best interests of the association.

Once priorities have been identified by the WUA, a pre-feasibility study should be done to assess whether the intended works are technically and financially feasible. Lining of canals is one of the improvement works preferred by farmers but all too often it cannot be justified economically. Governments will likely require feasibility studies as a precondition for provision of assistance. Such studies should give attention to the phasing of works in order to be consistent with availability of budgeted funds and limited time for execution. In many systems the time period during which interruption of the water service can be tolerated may be rather short.

In conclusion, it is emphasized that the three most fundamental principles to remember pertaining to infrastructure improvement and management transfer are:

- the water users' association should be in the driver's seat (identifying, prioritizing and making the financial decisions);
- the irrigation agency should facilitate and provide technical assistance, not direct the process;
- future infrastructure improvement should exemplify a farmer-driven, incremental approach rather than the typical fully subsidized, non-participatory approach of the past.

### 8.4.4 DEVELOPING A WATER USERS' ASSOCIATION AND PREPARING IT TO GOVERN

**What factors support the emergence of viable water users' associations?**

It is not possible to state absolutely the pre-conditions for creation or development of water users' associations. Some factors might be essential in one place and not in another. In one place, some factors may be so important that they compensate for the absence of others. In general, it can be hypothesized that the more motivating factors exist in a location, the greater the likelihood that viable water users' associations can develop.
The following is a list of key enabling factors which are hypothesized to be conducive to the emergence and development of viable water users associations. These are not characteristics of WUAs but conditions concerning the context within which WUAs emerge.

- Irrigation makes a significant improvement in productivity and profitability of irrigated agriculture, compared with rainfed agriculture.
- Irrigated agriculture is an important component of farm family livelihoods.
- · Most farmers are either landowners or cultivators on multi-year leaseholds.
- · A generally-accepted system of land and water rights exists or can be expected to exist by the time IMT is implemented.
- · Social divisions are not serious enough to prevent communication and joint decision making among farmers.
- · Social traditions support group organization for irrigated agriculture, existence of producer cooperatives and other rural organizations.
- · Farmers are dissatisfied with the current irrigation management service by the government and believe that improvements in the quality of irrigation management could significantly increase the productivity and profitability of irrigated agriculture.
- · Farmers believe that these improvements can be realized through the association's control over the management of water services.
- · Farmers believe that their association can reduce or contain increases in the cost of irrigation to farmers.
- · Farmers generally believe that the benefits of IMT will outweigh its costs and that the benefit/cost ratio for transfer is roughly equal among farmers.
- · It is technically feasible to implement the water service with existing infrastructure or after pending improvements are made.

Some of the above items may seem rather obvious to some readers, but in fact, most IMT programmes do not take such factors into account in the planning process. Schemes that are lacking in many of the above factors may require more intensive efforts to develop water users' associations. Most planners will not have the time or resources to collect data on all the above factors to aid them in prioritizing and scheduling schemes for transfer. In order to convert the above list into a practical planning tool, it can be reduced to four concepts:

- economic motivation for IMT;
- dissatisfaction with existing management;
- local management capacity and group orientation;
- financial and technical feasibility.

Each irrigation scheme can be ranked high, medium or low for each factor (numbered 1 to 3 points) and given an overall average (see example in Table 5 below). Planners can work with local officials or NGOs to operationalize the ranking method.

**Table 8-4 Example of ranking technique for feasibility of organizing WUAs**

| Indicator | Scheme 1 | Scheme 2 | Scheme 3 | Scheme 4 |
|---|---|---|---|---|
| Economic motivation | Low | Low | High | Medium |
| Dissatisfaction with existing mgt | Medium | Medium | High | High |
| Management capacity | Low | Medium | High | High |
| Financial viability | Low | Low | High | Medium |
| Overall | 1.2 | 1.5 | 3 | 2.5 |

* Low = 1 point; Medium = 2 points; High = 3 points

Typically, systems that are identified as easy to transfer or having a high likelihood of success are transferred first. Systems that are thought to be difficult to transfer may be postponed until there is more experience with transfer. This is so that early successes will generate more support for the programme and provide a useful learning experience that will help with later and more difficult transfers. Experienced farmers and WSP staff from early transfers can be active later on for peer training with more difficult cases. The above ranking system facilitates this prioritizing.

**What are the key principles for facilitating development of an effective WUA?**

Specific tasks and techniques for organizing cannot be prescribed universally. This must be worked out to fit local circumstances, objectives and wishes of participants. The following, however, are generally accepted principles for organizing community-based groups for management of natural resources.

- Make sure that relevant stakeholders have a voice in the process.
- Give attention to identifying valid representatives of farmers and other stakeholders (such as women, non-agricultural water users, village government officials, etc.).
- If needed, use community organizers (COs) to move forward the process of organizing WUAs.
- The COs should play a limited role of facilitating organization. They do not take the lead, make decisions or create dependence on themselves. Their focus is to help empower the group. In some cases, they may only be needed to introduce to farmers options for creating a WUA or developing an existing one, after which farmers organize themselves. In more problematic cases, they may be needed more intensively.
- COs should encourage early group identification of members, management problems and assessment of whether a new organization or merely the modification of an existing one is required.

- The group should forge consensus about the organization's basic purpose, service definition, policies, rules and procedures.
- Field walk-throughs and inspections, participatory analysis of options, extension inputs, development communications support and possibly experimentation can be helpful in organizational development.
- Taking on a preliminary small task, such as a maintenance or repair job, can help build organizational commitment, especially if it is an agreed activity and involves investment by prospective members of the organization.
- When consensus is achieved, the articles of association and by-laws should be drafted, reviewed and approved by all necessary authorities.
- A formal establishment ceremony, attended by senior officers and politicians, can help demonstrate the importance and official status granted the organization by the authorities.

The basic options for who should take the lead in establishing and developing water users' associations are:

(i) farmer organizers: Involvement of selected and trained farmers or members of the local community has the advantages of utilizing local knowledge, social networks and respected leadership. This will also normally be cheaper than hiring organizers who are external to the community. However, sometimes social divisions and extreme poverty and illiteracy may make it difficult to rely on local people to take the lead in organizing water users' associations.
(ii) other organizers from the local community: idem to previous ones.
(iii) external community organizers from NGOs: extension or development communication agents may be needed, but ideally their role would be to train local people to take the lead in organizing
(iv) civil servants such as extension or development communication agents: idem to previous ones.

When establishing the WUA, farmer representatives and community organizers generally formulate, prepare documents and obtain approval from members of the WUA for the following components of WUA development:

- statement of mandate and basic founding documents;
- organizational structure;
- basic policies, rules and sanctions;
- method for selection of leaders;
- relationship of the WUA to external organizations;
- formal establishment of the organization.

**What are the key organizational characteristics of successful WUAs?**

The internal characteristics of water users' associations that are most often noted in the literature to be found in successful water users' associations are now considered. This list is meant as a guideline to assist planners in designing viable water users' associations. Not all of the following may be necessary or feasible in all locations. These characteristics are:

- participatory approach in decision-making procedures;
- full control over irrigation infrastructure and rights of eminent domain;
- full control over O&M, financing and dispute resolution;
- primary responsibility for financing O&M, rehabilitation and modernization;
- agreed and measurable definition of an irrigation service;
- clear definition of who are the members of the association;
- means for excluding non-members and/or non-payers from receiving services;

- leaders who are elected and can be removed from office by the water users;
- clear policies and rules subject to approval by the water users;
- transparent administration, operations and performance;
- service charges based upon actual service delivery and strict accounting practices;
- financial and technical audits performed by the government or other independent entity;
- power to impose strong incentives and sanctions to ensure:
    - adherence of water users to agreed rules and policies,
    - accountability of WUA leaders to the assembly of water users, and
    - accountability of hired management staff to WUA leaders.

The above list can be considered a vision of the ideal. Some WUAs may be viable and effective without all these features, but experience suggests that the more of these characteristics that are present, the more successful and sustainable the WUA is likely to be.

**How is membership in the WUA to be determined?**

This is a matter that is often not resolved very clearly. If it is not, it is likely to create problems in the future. Water users can be landowners, renters, sharecroppers, squatters, sub-tenants and so on. Should all such users be eligible for membership in the WUA? What about landowners who own multiple parcels in the same scheme? Should they receive multiple memberships? Should only one person per parcel be permitted to be a member of the organization? Should only one person per household be permitted to be a member and, if so, should it normally be the male adult in the household (unless, as is often permitted, a widow runs the farm)?

At the local level, farmers and COs should make agreements about these issues before the WUA is established. COs should encourage the participation of women in these discussions, because they often play important roles in cultivation and water use but tend to be left out of such proceedings unless a conscious effort is made to include them.

A few basic principles are stated which seem to be generally accepted worldwide:

- eligibility for membership should be determined through clear rules about who should have a right to receive the water service and have an obligation to pay for it;
- it may be necessary to restrict membership to landowners or tenants with a relatively stable attachment to receiving and paying for the water service;
- normally only one membership per household is permitted.

Membership in a WUA may or may not involve a water right. It normally includes a right to vote in WUA meetings. Land ownership, long-term leasehold status, making an investment in capital development, payment of a membership fee and agreement to follow rules and pay a service fee are common eligibility requirements for membership. In cases where a landlord grants a long-term lease to a tenant to cultivate a farm, membership may be granted to the landowner or the tenant. This may be decided between the two parties concerned or there may be a WUA rule which decides this. Eligibility requirements should be established by consent of all water users and be based on locally accepted principles of fairness. WUAs should have the power to exclude non-members from the irrigation service or to remove from membership any who seriously abuse their privileges or consistently refuse to pay for service.

It is increasingly realized that women often play key roles in using and managing water and should therefore have a voice in decision-making, even when a spouse is the official member of a WUA. It may be helpful to make arrangements to encourage women to participate in meetings. In some cases it may be useful to grant voting rights to both male and female adults in households for some issues, such as for water use and scheduling questions or group labor activities for maintenance which involve men and women.

**What is an agreed and measurable water service?**

Public irrigation agencies often do not specify the service they are supposed to provide. They tend to operate according to administrative rules and quotas, sometimes corrupted by local influences. It is of fundamental importance that management transfer programmes use the reform as an opportunity to define clearly the water service the new local organization is going to provide. This is the first step towards making an irrigation organization accountable to its clients – the farmers.

A service definition should include the following four elements:

- what is the service area for water delivery and disposal;
- what amount of water will be diverted and delivered;
- when will the water be delivered and removed;
- how will payment for water service be arranged.

The service definition should be concise. Details about procedures and targets are left for subsequent O&M manuals and reports, if necessary. The service definition should delineate clearly what area will have a right to the service and also the basis for determining this area. If there are any differences in class of service among units within the area, this should be specified.

The amount of water to be diverted and delivered may be defined in categorical terms, such as

- a share, proportion, or right.
- It may be defined relative to demand, qualified by supply constraints.
- Or where feasible, it may be defined volumetrically.
- Timing of the service may be defined relative to cropping schedules, supply conditions or to an on-demand system.
- Payment should be related to service delivery. This can be according to volume or share of water delivered, or area served, per season or annually.

The service definition should also be:

- measurable;
- clear and transparent to farmers;
- agreed to by the assembly of farmers.

The following is a hypothetical example of a service definition for a small-scale irrigation system:

*The Reka Water Users' Association will provide the services of diverting water from the Reka weir, located in Reka township, and delivering it to the agricultural land which can be served by it for irrigation (NB: map for delineation of the service area should be attached). Water will be diverted during the first and second cropping seasons up to the maximum amount of the water right (namely, one-fourth of river flow at the weir), to be decreased if demand is less than this amount. The Association also provides the service of drainage of agricultural lands irrigated by water diverted from the Reka weir.*

*Water is allocated by the Association on a strict parcel-size share basis except when supply constraints require rotational irrigation. During rotational irrigation, water will be allocated to rotational units according to fixed schedule, ordered from the tail end of canals and moving upwards.*

*Farmers will pay a service fee based on the amount of the total estimated annual budget of the Association divided proportionately by area of the parcel and number of seasons served.*

After there is a clear definition of the water service, the WUA should then specify its other services, including maintenance, conflict resolution and possibly other agricultural support services. In the resolution of policy issues in the planning phase, it should have been decided, at least at the national or state level, whether the WUA would be a single-purpose irrigation management entity or whether it would have the right to take on other functions as well, such as provision of agricultural services. If this option was left open in the IMT policy, then newly-created WUAs may be faced with the choice of whether they want to retain their focus on the water service or become multi-purpose organizations which also provide agricultural and other services. This decision should be made clear in the mission statement and by-laws of the organization, described below.

**Functions of a WUA board of directors**

For WUAs that establish a water service provider (WSP) as a distinct entity, the board of directors of the WUA will normally have various supervisory responsibilities over the WSP. The following are typical tasks of WUA boards of directors:

- prepare legal documents of incorporation. (this may not be required if the entity is a division within the WUA);
- determine the organizational structure of the WSP and hire the general manager or chief executive officer;
- provide direction to the WSP manager in preparation of a personnel policy and job descriptions;
- advise the manager in hiring staff for the WSP;
- provide advice on and approval of the O&M plan;
- advise the manager in development of facilities and purchase of equipment and supplies;
- provide advice and approval to the manager to prepare a budget and financial management system;
- provide advice to the manager to perform a training needs assessment;
- provide advice to the manager to set up a performance monitoring and evaluation and management information system.

Members of boards of directors of WUAs are frequently unaware that they need to perform these responsibilities. This should be clearly stated in the by-laws of the WUA and training should be provided to new board members in how they should conduct their oversight duties in a way which ensures quality control but does not result in micro-management by nonprofessionals who sometimes have political motivations. This is an important matter and requires special attention in organizing and training activities.

### *ISSUES TO BE CONSIDERED BY THE WATER SERVICE PROVIDER (WSP) AND WUAS AFTER TRANSFER*

**What is involved in establishing the water service provider (WSP)?**

After the WUA is established, the first task of its directors will be to set up the water service provider. Depending on scale and complexity, this may involve hiring only a few individuals or it may involve setting up an entire district office or company with a specialized staff. In any case, the directors of the WUA must be able to govern the service provider. This will involve providing direction for operationalizing the service agreement, preparing seasonal service plans, adopting new policies and procedures and regulating the service. WUA directors should have full authority to hire and fire staff and oversee all personnel matters of the WSP.

The tasks involved in establishing a WSP will depend largely on what type of service provider it is. Two types are relatively easy: the self-contained WUA and the contracted service provider. Where the WUA handles both governance and management directly, the WUA may only need to appoint or hire a few individuals to

directly implement water distribution, channel cleaning and collecting water charges. No matter how simple the arrangement, the WUA should make work expectations clear and retain the ability to remove poor workers.
Sometimes the WUA may not be active year around (perhaps because of a winter season when there is no irrigation). The WUA may lack capital to purchase equipment needed for O&M or it may find it too inefficient to hire full time staff for the WSP if they are not needed for several months of the year. In such cases, and where there is a market for O&M service providers, WUAs may choose to contract for service for the following tasks:

- preparation of a contract which clearly specifies all management tasks, terms and conditions (including for contract extension or cessation);
- specification of qualifications required and selection criteria. This may include skills and experience, availability, possession of certain equipment and supplies, agreement with WUA philosophy, etc.;
- invitation for competitive bidding;
- firm measures to ensure open and merit-based selection, consistent with selection criteria;
- assurance that the selected contractor understands WUA principles of accountability, lines of communication, protocol vis-à-vis the farmers and how much discretionary power they will have to solve problems in the field;
- sufficient financial resources available to pay the contractor once work is completed.

It is important that members of the WUA board of directors not weaken the ability of the general manager of the WSP to manage, by stepping over him or her and giving instructions directly to the subordinate staff. The WUA board of directors should focus on policy and oversight and deal directly with the general manager. Otherwise they will weaken the accountability of WSP staff to the general manager and the general manager to the WUA board of directors.

**What changes might need to be made in operations after transfer?**

Sometimes after management is transferred to a farmer organization, farmers identify new agricultural or irrigation service priorities. Whereas the public agencies might have lacked incentives to optimize productivity of water, the WUAs may now have these incentives. This should be so if they have assumed primary responsibility for financing irrigation, linked service delivery to payment for service, set priorities according to the group interest and gained full control over water management within their service area. The following are examples of possible new priorities that a WUA might have:

- expand the irrigation service area;
- improve equity of water distribution;
- reduce amount of water delivered per hectare;
- increase cropping intensities through better irrigation efficiency;
- increase crop production per unit of water delivered.

Such priorities may require land levelling or shaping, crop choice restrictions or zoning, changes in water application practices and technologies, changes in water scheduling and delivery and changes in how service payment is linked to service delivery. WUAs should seek advice from agency or private sector engineers and from agricultural extension services to determine which combination of operational procedures will best lead to achievement of their new objectives.

**What changes might need to be made in maintenance?**

Before transfer, the government was probably responsible for maintaining canals and control structures. Under-financed public irrigation agencies generally do not engage in preventive maintenance. Damages,

deterioration and siltation accumulate over time until the problem becomes serious enough to merit investment from special funds, such as those for rehabilitation or modernization.
After transfer, it may be that farmers no longer obtain funds from the government for maintenance. They may also be responsible to finance future rehabilitation. Under these circumstances, it is important that the WUA break away from the previous practice of deferred maintenance.

Farmers are generally aware that deferring small repairs only results in more costly major repairs later on. Special training in the advantages and methods of preventive maintenance should be provided to WUA directors and WSP staff by irrigation agency technicians or staff of other experienced local WSPs. Agency technicians themselves should be given training in preventive maintenance before they attempt to train the new WSP.

**How should the WSP obtain equipment?**

One of the first priorities for preparing the WSP to take over management is ensuring that it has the necessary equipment to handle routine maintenance and incremental improvements. There may be some works that are only occasional and require specialized skills and equipment. For these it may be more cost effective to engage contractors when needed rather than obtain the skills and equipment “in-house”.
The first question is: which government owned equipment at the scheme should be transferred to the WUA? With technical advice from the irrigation agency and in consultation with the WUA board, the WSP will need to assess its needs for equipment and compare this with what may be available from the transfer of equipment from the government. The government will need to establish a policy about how it will dispose of its O&M equipment in transferred systems. This should include resolution of the following issues:

- Should equipment be transferred free of charge, leased or sold to the WUA?
- Should ownership or only use rights be transferred?
- If sold, how should the prices be set (replacement cost, fair market value, concessionary, nominal)?
- If sold, would payment be by instalment; would it be taxed?
- What recourse will the government have if the WUAs fail to pay for the equipment?
- What training is needed in proper use of equipment?

**What changes might need to be made in water fees and financial management?**

In the future, there are three forces that are likely to require WUAs to become more involved instandard financial management practices. The first is the need for a more aggressive participation in the markets (inputs, agricultural products, etc.) of irrigated agriculture, the second is increasing competition for water from even more commercialized sectors (industry, urban water supply and energy) and the third is the “scaling up” process of IMT through enlargement or federation of devolved units.

Where educational levels are higher (up to the secondary level) and where appropriate water control and measurement structures exist, it will be preferable to use more sophisticated financial management practices. This should be done from the moment of establishment of the WSP, in order to set a precedent for achieving high levels of efficiency and accountability. The following are financial practices which may be more appropriate in this kind of environment:

- Arrange training in agreed financial practices for the treasurer of the WUA and the chief financial officer of the WSP (if required). Also, provide some training in bookkeeping practices to all WUA directors and WSP administrative staff.
- Ensure that financial transactions are only made with at least two authorized witnesses and a record of the transaction.
- Make financial records of the WSP available for inspection by farmers.

- · Base the amount of water fees levied on WSP budgets.
- · Base water fees on the volume of water delivered.
- · Arrange for an independent financial auditor to work with the WUA and WSP.
- · Manage a long-term capital reserve fund to prepare for future emergencies, rehabilitation and needs for modernization

In some cases, farmers were accustomed to paying water fees to the government before transfer. After transfer, fee collection is done by the WUA. Only adjustments in rates or charging mechanisms were needed.
In other cases, farmers had not paid water fees to the government before transfer. In these cases, it has been up to the water users' associations after transfer to decide whether to begin collecting fees or not. Where only a small service area is transferred, fee collection may not be required and periodic labour mobilization or collection of materials, such as sand and stones, may suffice.

In locations where the level of education among farmers is low and where water control or measurement structures are few or non-existent, the basis for payment of service, and financial management in general, will have to be kept as simple and transparent as possible. Farmers in such areas may not be accustomed to having a permanent group treasury. They may feel reluctant to entrust such funds to their new organization. It may be wise for WUAs in such areas to minimize the number of financial transactions required through such measures as mobilizing labour from WUA members for maintenance. Where water charges are required, payments can be based on simple criteria which are easily understood and measurable, such as size of parcel irrigated, crop type, cropping intensity and/or number of irrigations delivered in a season. In such cases it may take time for new associations to build trust among farmers in WUA financial management.
Financial management is probably the most difficult and sensitive challenge new WUAs face. The risks are many, and considerable skill, discipline, vigilance and transparency are required. The following is a typical situation where new farmer organizations attempt to establish and collect annual water charges:

- the WSP estimates the next year's total cost of operation, maintenance and administration;
- the total cost is divided into shares or units upon which fees are based (e.g., hectare or cubic metre);
- the WSP submits the proposed fee for the next year to the WUA board of directors or the general assembly of the WUA for approval;
- the WUA often rejects the initial proposal as being too high and approves a lower amount;
- in practice some farmers may refuse to pay the fee, in part or in full.

There is a tendency sometimes for directors of WUAs to exert pressure on the WSP to keep water fees as low as possible, even to the point of deferring maintenance and permitting deterioration to occur.

Farmers may be more concerned with immediate cost savings than the future cost of deferred maintenance. They tend to speculate that they will be able to pressure the government to return in the future to sponsor repairs, emergency damages or rehabilitation.

It is likely that the WSP will have a more technical perspective than the board of the WUA, which may have a more political orientation.

The government may need to create certain incentives to motivate the WUA to avoid deferring maintenance. The most logical option would be for the government to link WUA eligibility for subsidies (for special maintenance, emergency assistance and rehabilitation) to its compliance with agreed standards of

maintenance and development of a capital reserve fund. The government can provide or commission technical and financial audits and act as a guarantor for a long-term capital reserve fund.
A logical solution to the problem of failure of farmers to pay water fees is to cut off the service to farmers who are in arrears in their payments. This requires a high degree of political discipline. A highly effective measure used in several irrigation districts of Peru is "payment against delivery": every single irrigation must be paid for before water is actually delivered.

WUAs in the United States have the legal power to take over ownership and re-sell farms belonging to owners who fail to pay the irrigation fee after several seasons. In other cases, in Latin America and parts of Asia, cessation of water delivery is a common sanction. But political commitment to such sanctions is sometimes lacking and farmer failure to pay water fees is widespread in many countries.

Planners should be aware of the kinds of problems that can arise in the developmental stages of WUAs and rigorous steps should be taken by organizational facilitators and WUAs to avoid serious problems. IMT is not likely to be effective unless there is strong political commitment to support local financial sustainability of irrigation schemes.

**PHASE 4 OUTPUTS: PLANNING AND IMPLEMENTATION**

Outputs for the planning and implementation phase are the preparation of a basic plan of implementation, establishment of water users' associations and water service providers and infrastructure improvements. The plan should also include the basic assistance strategy for infrastructure improvement, including terms and conditions for eligibility, financial procedures, technical aspects and the mode and schedule of implementation. This plan should be based on the clear position of the government regarding its role for financing the rehabilitation works. The main output for creating an effective water users' association and preparing it to govern is the formal establishment of a water users' association. The WUA should have:

- agreed and legally-recognized articles of association and by-laws;
- an agreed definition of the service to be provided;
- a set of officers duly selected and trained;
- a general sense of commitment to the organization among its members.

Establishing the water service provider and preparing it to manage the service should, in general, include the following outputs:

- legal establishment of the WSP;
- hiring of WSP staff, purchase of equipment and provision of training;
- preparation of a financial plan, budget and O&M plan;
- creation of a capital reserve fund.

A basic plan of implementation is needed to bring together all essential components of the reform, to forge consensus and to show that the plan is comprehensive and consistent. The plan should make a persuasive case that implementation will be efficient and practical and will achieve expected outcomes. The plan should normally include the following components:

- necessary policy and legal changes;
- requirements for agency restructuring;
- organization of new support services;
- creation and development of water users' associations;
- creation and development of water service providers;
- improvement of irrigation infrastructure;
- implementation of a system of monitoring and evaluation.

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# 10 ANNEX 1 WATER DISTRIBUTION METHODS PRACTICAL EXAMPLES

**Main System Operation Procedures**

**1) Simple proportional distribution**

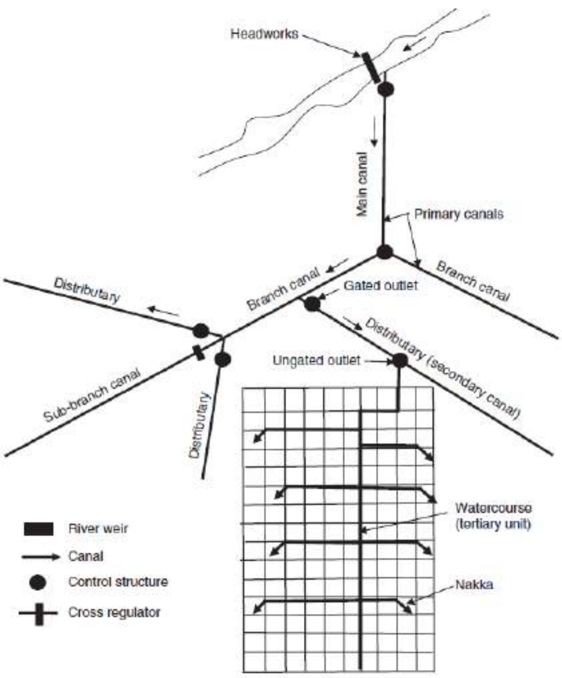
The simplest main system water distribution method is proportional division. With this method water is divided automatically by the control structures located at division points in the irrigation network. The most common division is in proportion to area, so the width of an offtake serving 10 ha will be one-tenth of the width of the structure opening in the main channel serving 100 ha downstream.
There are no operation procedures for the fixed proportional systems, and maintenance is limited to ensuring that there are no obstructions to the flow through the structure.

2) **Warabandi system of water allocation and distribution**

This method was developed of the Indo-Gangetic Plain in the 1850s. The objective for development of the available resources of water, land and labour was to extend the irrigation area to support as large an area as possible, thus a greater number of farmers would benefit from the irrigation water and production would be at a maximum per unit of water.

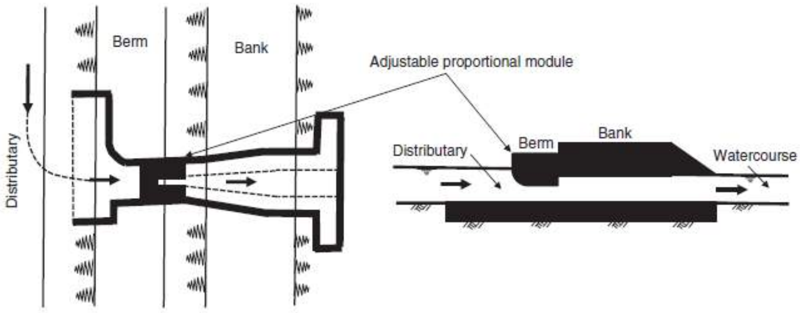
In its modern form Warabandi method involves the rotation of water supplies between distributaries on the main system, and between farmers' fields within the watercourse. Within the watercourse, allocation is based on time shares that are proportional to the area of a farmer's fields,

Warabandi is a system of equitable distribution of the water available in the scheme by turn according to a predetermined schedule specifying the day, time and duration of supply to each irrigator in proportion to their holding in the outlet command. The cardinal principle is that available water, whatever its amount, is allocated to cultivators in equal proportion to their holdings, and not only to some to meet their total demand. It attempts to guarantee equity of distribution. it is low-cost to build, easy to operate and straightforward for farmers to understand. It is probably the best possible method of water management for the huge schemes that exist in the Indo-Gangetic plains, and has stood the test of time.
The Warabandi system, by obviating the need for data collection and regular setting of gates, may achieve a more stable and equitable pattern of water distribution than more sophisticated methods.




**Details of the method**

A typical layout of a distribution system where Warabandi is practised is given in the figure. The main canal feeds two or more branch canals, which operate by rotation. This primary distribution system runs throughout the season with varying supply. Large numbers of distributaries take off from the branch canals, these run at full supply level (FSL) by rotation. The distributaries supply water to watercourses through ungated, fixed discharge outlets (adjustable proportional modules, APMs). Watercourses run at the design discharge when the distributary is running and water is allocated between farmers on a watercourse time roster. The Irrigation Department manages the main system down to the watercourse intake, below which the farmers manage the water. Design of distributaries is based on the culturable command area (CCA), which is allocated a water allowance of about 0.17 l/s/ha. For rice areas the duty is 0.5–0.7 l/s/ha. The watercourse intake is designed for about 0.17 l/s/ha, with the supply into the watercourse being regulated by an APM as shown in the next figure




The throat width and cross-sectional area in the throat of the APM is fixed in proportion to the CCA, assuming FSL is maintained in the distributary canal. No distributary operates for all the days of the growing period. The ratio of days operated to crop growth period is the capacity factor. This is 0.8 for summer crop, and 0.72 for winter crop.

Thus each distributary may receive water supply for about 144 in summer and 129 days in winter.
Not all the land can be irrigated at once. The ratio of irrigated land to the CCA is called the intensity of irrigation, this is typically about 60% (see Equation (a)

$$\text{Water duty (l/s/ha)} = \frac{100\ \text{ha}}{\text{Water allowance for 100 ha}} \times \text{Intensity (\%)} \qquad \text{(a)}$$

All distributaries are run at FSL for periods of 8 days. Each watercourse runs at full supply for 7 days, so that farmers receive their water at the same time, and for the same duration each week. The additional day is for filling the canal. The discharge in the watercourse generally varies between 30 and 85 l/s.

Roster of turns
The roster of turns or schedule (Table) is calculated based on the 168 hours available for irrigation during 1 week (see Equation (b).

$$\text{Flow time per unit of area (FT)} = \frac{168 - \text{total Bharai} + \text{total Jharai}}{\text{Total area}} \qquad \text{(b)}$$

$$\text{Flow time per farmer} = (\text{FT for unit area} \times \text{farmer's area}) + (\text{farmer's Bharai}) - (\text{farmer's Jhara})$$

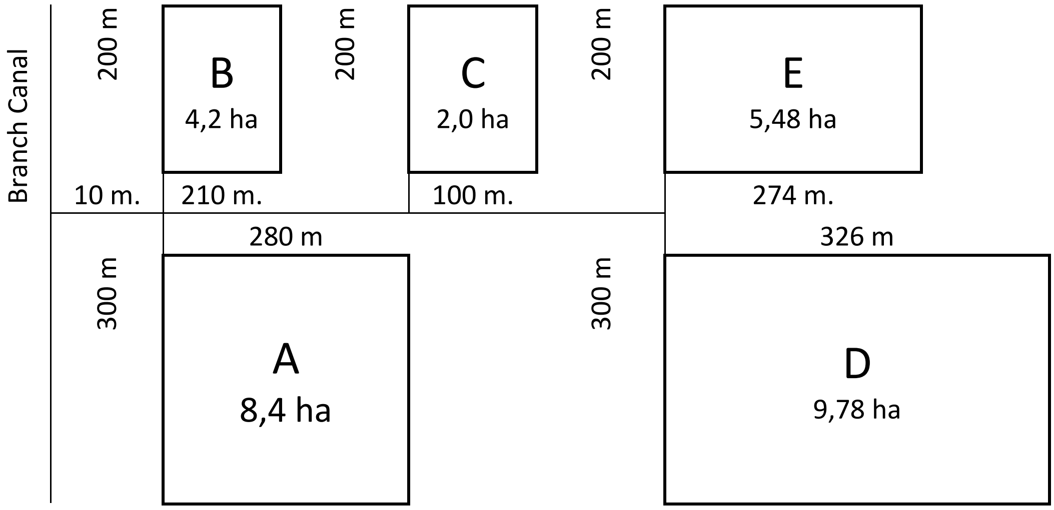
*Bharai* is the time a farmer must spend filling up the empty watercourse from the point of previous abstraction. Its value is 4–5 min per 67 m in good soils. This time is deducted from the common pool and added to the individual farmer’s time.

*Jharai* is a term related to the ponded water remaining in the watercourse when the supply has been cut off at the watercourse intake. This water can only be taken by tail-enders, so a deduction is made from their flow time to account for this additional water. It is difficult to determine the correct value of time to ascribe to this water as it does not flow at a constant rate.

No allowance is made in these calculations for losses due to seepage. The calculation of the rosters is a formal procedure; once calculated and agreed it is posted for all farmers to follow.

**Example of Warabandi Method**:

Let's suppose a distributary or secondary canal that irrigates five farmers(A,B,C,D,E) with a total of 29,86 ha.




| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Intensity of irrg= Irrigated land/CCA= | | | | 1 | | water allowance 100 ha = | | | 0,900 | [l/s/ha] |
| | | | | | | | | | | |
| Water Duty [l/s ha] = 100ha/water allowance 100 ha * Intensity = | | | | | | | 0,900 | [l/s] | | |
| | | | | | | | | | | |
| Intake designed for | | 0,900 | l/s/ha * | 29,86 | ha = | 26,874 | l/s | > 30 l/s, <850 l/s | | |
| | | | | | | | | | | |
| Flow time per unit of area= ((7 days*24 hrs) - Tot Add + Tot Ded)/CCA= | | | | | | | 5,63 | hrs | | |
| | | | (168 hrs) | | | | | | | |
| Theorical Flow time per farmer area = FT per unit area * Farmer area | | | | | | | | | | |
| Net Flow time per farmer = FT per unit area * Farmer area +Additional time filling - Deduction time remaining water | | | | | | | | | | |
| | | | | | | | | | | |
| velocity filling the canal= | | 0,25 | m/s | | | velocity empting the canal= | | | 0,125 | m/s |

The secondary canal will have an adjustable proportional module (APM) that will allow to distribute the available water at the intake to the different secondary canals. The Irrigation operator will manage the APM to distribute the available water to all secondary canals proportional to the irrigated area. The secondary canal will receive water continuously (No rotation)

Farmers will manage the water in the secondary. They will take all the available water (26,87 l/s) during a time calculated according to the farmers' irrigated area, the additional time needed to fill the canal from the previous intake to the farmers intake and the last farmer will be reduced its time due to the remaining water in the canal when the last turn is finished.

Example of calculation of turns in a secondary canal with the Warabandi Method.

| | | | | | | | | | | | | | | Needed values for whole season (5 month) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Farmer | Long. H al canal | Long. al canal | CCA | Flow time per area | Addional time filling | Ded.time remaining water | Net Flow time per farmer | Turn take over from | Turn hand over to | Time From | Time to | Volumen | Depth | Volumen | Nr of turns in5 months | Time bewteen turns | Total depth applied |
| | | m | ha | hours | hours | hours | hours | | | | | m3 | mm | m3 | | days | mm |
| | 10 | 10 | | | | | | | | **Sunday 6:00** | | | | | | | |
| A | 300 | 280 | 8,40 | 47,31 | 0,01 | | 47,32 | Main | B | 4-1-18 6:00 | 4-3-18 5:19 | 4578 | 54,5 | 97978 | 21,4 | 7,01 | 1144 |
| B | 200 | 210 | 4,20 | 23,65 | | | 23,65 | A | C | 4-3-18 5:19 | 4-4-18 4:58 | 2288 | 54,5 | 48989 | 21,4 | 7,01 | 1144 |
| C | 200 | 100 | 2,00 | 11,26 | 0,31 | | 11,57 | B | D | 4-4-18 4:58 | 4-4-18 16:32 | 1120 | 56,0 | 23328 | 20,8 | 7,20 | 1176 |
| D | 300 | 326 | 9,78 | 55,08 | 0,22 | | 55,30 | C | E | 4-4-18 16:32 | 4-6-18 23:50 | 5350 | 54,7 | 114074 | 21,3 | 7,04 | 1149 |
| E | 200 | 274 | 5,48 | 30,86 | | 0,71 | 30,15 | D | | 4-6-18 23:50 | 4-8-18 6:00 | 2917 | 53,2 | 63919 | 21,9 | 6,85 | 1118 |
| | | **TOTAL** | **29,86** | **168,17** | **0,54** | **0,71** | **168,00** | | | | **Sunday 6:00** | | | | | | |

VALUES OF SEASONAL CROP WATER NEEDS    INDICATIVE VALUES OF THE TOTAL GROWING PERIOD

| Crop | Total growing period (days) | Crop | Total growing period |
|---|---|---|---|
| Alfalfa | 100-365 | Millet | 105-140 |
| Banana | 300-365 | Onion green | 70-95 |
| Barley/Oats/Wheat | 120-150 | Onion dry | 150-210 |
| Bean green | 75-90 | Peanut/Groundnut | 130-140 |
| Bean dry | 95-110 | Pea | 90-100 |
| Cabbage | 120-140 | Pepper | 120-210 |
| Carrot | 100-150 | Potato | 105-145 |
| Citrus | 240-365 | Radish | 35-45 |
| Cotton | 180-195 | Rice | 90-150 |
| Cucumber | 105-130 | Sorghum | 120-130 |
| Eggplant | 130-140 | Soybean | 135-150 |
| Flax | 150-220 | Spinach | 60-100 |
| Grain/small | 150-165. | Squash | 95-120 |
| Lentil | 150-170 | Sugarbeet | 160-230 |

| Field Capacity | | |
|---|---|---|
| Light (sand) | Medium (loam) | Heavy (clay) |
| mm/m | mm/m | mm/m |
| 25 | 100 | 175 |

- Available water supplies will not match crop water requirements,
- Irrigation area will be as large as possible. A greater number of farmers would benefit from the irrigation water
- The production would be at a maximum per unit of water
- The production will NOT be

| Crop | Crop water need (mm/total growing period) |
|---|---|
| Alfalfa | 800-1600 |
| Banana | 1200-2200 |
| Barley/Oats/Wheat | 450-650 |
| Bean | 300-500 |
| Cabbage | 350-500 |
| Citrus | 900-1200 |
| Cotton | 700-1300 |
| Maize | 500-800 |
| Melon | 400-600 |
| Onion | 350-550 |
| Peanut | 500-700 |
| Pea | 350-500 |
| Pepper | 600-900 |
| Potato | 500-700 |
| Rice (paddy) | 450-700 |
| Sorghum/Millet | 450-650 |
| Soybean | 450-700 |
| Sugarbeet | 550-750 |
| Sugarcane | 1500-2500 |
| Sunflower | 600-1000 |
| Tomato | 400-800 |

### 3) Relative area method

The relative area method of main system management has been developed for use on irrigation systems in Indonesia. Its simplicity of use makes it worthy of consideration elsewhere (though it would require adaption to local conditions).
The method requires limited amounts of data, its calculation procedures are straightforward, and data can easily be analyzed and monitored. It is designed to ensure equitable distribution of water.

The method is a compromise between the relatively complex water balance sheet approach and the relatively simple Warabandi method. It takes into account crop areas, mixed cropping patterns and crop water requirements, yet requires little calculation.

In the relative area method all crop areas are converted to a common equivalent crop area based on their relative crop water requirements. Typical conversion factors are:

| Crop | Conversion factor |
|---|---|
| Maize | 1 |
| Groundnut | 1 |
| Soybean | 1 |
| Rice | 4 |
| Sugarcane | 1.5 |

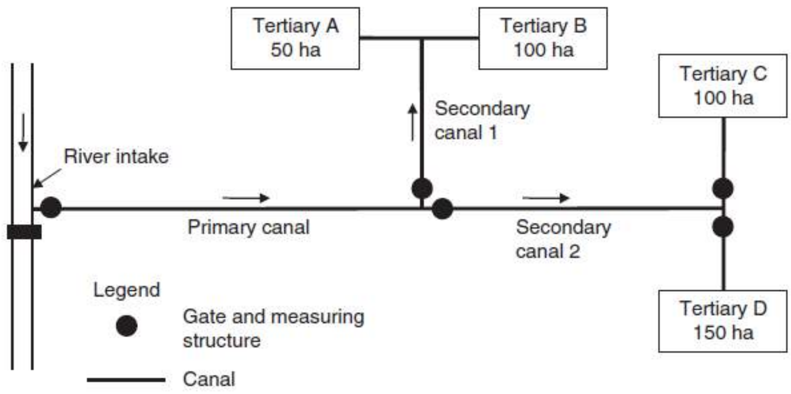
Thus a 1 ha field of maize would have a relative area of 1 (relative) ha; while a 1 ha field of rice would have a relative area of 4 (relative) ha. Thus, if a unit discharge of say 1 l/s was allocated to each relative hectare, the 1 ha field of maize would get 1 l/s and the 1 ha field of rice would get 4 l/s. Having converted all the different crop areas to a relative area, a unit discharge per (relative) hectare is applied and the total demand calculated. If the total demand exceeds the supply available at the system intake, the amount to be supplied at each control point is reduced by the ratio of the supply available to the calculated demand.

The method of calculation and associated procedures greatly simplify the calculations of crop water requirements and water allocation for schemes with mixed cropping patterns.

With this method the main system is operated by the Irrigation Service while the tertiary unit is operated by the water users (usually formed into a WUA). The Irrigation Service collects data on the cropped area from the water users each time period (either weekly or 10-daily) and uses this to calculate the water allocation.

Control structures comprise undershot gates with measuring structures, either weirs or flumes. Gates are adjusted to pass the required discharges at the start of each time period, with further adjustment during the time period in order to maintain the required discharge.

**Example of Relative area method.**




FORM 00A

| | | Conversion | Tertiaries (3rys) | | | | 2rys | | 1ry |
|---|---|---|---|---|---|---|---|---|---|
| **Item** | **Units** | **Factor** | **A** | **B** | **C** | **D** | **S1** | **S2** | **P1** |
| Command area | ha | | 50 | 100 | 100 | 150 | 150 | 250 | 400 |
| **Crop area** rice | ha | | 10 | 30 | 20 | 50 | 40 | 70 | 110 |
| **Crop area** maize | ha | | 30 | 60 | 60 | 80 | 90 | 140 | 230 |
| **Relative area** Rice (x4) | ha rel. | 4 | 40 | 120 | 80 | 200 | 160 | 280 | 440 |
| **Relative area** Maize (x1) | ha rel. | 1 | 30 | 60 | 60 | 80 | 90 | 140 | 230 |
| **TOTAL RELATIVE AREA** | ha rel. | | 70 | 180 | 140 | 280 | 250 | 420 | 670 |
| Relative area water duty (RAWD) at 3ry unit level | l/s ha rel | | 0,4 | 0,4 | 0,4 | 0,4 | | | |
| Discharge allocated to 3ry units (rel.area x water duty) | l/s | | 28 | 72 | 56 | 112 | | | |
| Discharge allocated to 2ry and 1ry units (Sum of 3rys&2rys) | | | | | | | 100 | 168 | 268 |
| Estimated losses in 2ry and 1ry canals | % | | | | | | 25 | 25 | 17 |
| Discharges required in 2ry and 1ry canals | l/s | | | | | | 125 | 210 | 404 |

1) The crop areas are measured in the field: for Tertiary A. The figures are 10 ha to rice and 30 ha to maize. There are 10 more hectares in the command area that in this opportunity are not cropped.

2) These figures are converted to their relative area by multiplying by the conversion factor 4 and 1 respectively (based on their relative crop water requirements) to obtain 40 ha and 30 ha, total 70 ha.

3) A relative area water duty (RAWD) of 0.40 l/s/ha is applied to this relative area to obtain the discharge required at the tertiary intake, which gives a figure of 28 l/s. The same with all 3rys

4) The tertiary unit discharges for all offtakes on a secondary are summated and the discharge required at the head of the secondary canal calculated after allowing for losses.

5) Similarly, the discharges required at the secondary canal intakes are summated and the discharge required at the primary canal intake calculated after allowing for the losses.

6) The RAWD has been determined from field measurements of crop water demands for different crops in different locations in Indonesia and is generally of the order of 0.35–0.45 l/s/ha rel. This gives an allocation 0.35–0.45 l/s to 1 ha of maize and 1.4–1.8 l/s to 1 ha of rice. This should be adjusted for another locations.

One of the great strengths of the relative area method is the ease with which it can be used to make water allocation in times of water shortage. Taking the above example, the desired RAWD at the tertiary gate is 0.40 l/s/ ha rel., which gives a required discharge at the river intake of 404 l/s. However, there may only be a supply available of 300 l/s at the river intake. The solution can be calculated following two approaches:

a) Water supply factor, WSF = QRa/QRr = 300/404 = 0.74. Thus, RAWD is recalculated at tertiary unit intakes = 0.4 × 0.74 = 0.30 l/s/ha rel.

FORM 00B

| | | Conversion | | | | | 2rys | | 1ry |
|---|---|---|---|---|---|---|---|---|---|
| **Item** | **Units** | **Factor** | **A** | **B** | **C** | **D** | **S1** | **S2** | **P1** |
| Command area | ha | | 50 | 100 | 100 | 150 | 150 | 250 | 400 |
| **Crop area** rice | ha | | 10 | 30 | 20 | 50 | 40 | 70 | 110 |
| **Crop area** maize | ha | | 30 | 60 | 60 | 80 | 90 | 140 | 230 |
| **Relative area** Rice (x4) | ha rel. | 4 | 40 | 120 | 80 | 200 | 160 | 280 | 440 |
| **Relative area** Maize (x1) | ha rel. | 1 | 30 | 60 | 60 | 80 | 90 | 140 | 230 |
| **TOTAL RELATIVE AREA** | ha rel. | | 70 | 180 | 140 | 280 | 250 | 420 | 670 |
| Relative area water duty (RAWD) at 3ry unit level | l/s ha rel | | 0,297 | 0,297 | 0,297 | 0,297 | | | |
| Discharge allocated to 3ry units (rel.area x water duty) | l/s | | 20,79 | 53,47 | 41,58 | 83,17 | | | |
| Discharge allocated to 2ry and 1ry units (Sum of 3rys&2rys) | | | | | | | 74,26 | 124,75 | 248,76 |
| Estimated losses in 2ry and 1ry canals | % | | | | | | 25 | 25 | 20,5 |
| Discharges required in 2ry and 1ry canals | l/s | | | | | | 92,82 | 155,94 | 299,76 |

b) Total losses in system = River intake discharge − Tertiary unit discharges = 404 − (28 + 72 + 56 + 112) = 136 l/s = 34%.
Expected losses with lower discharge at intake = 300 × 34/100 = 102 l/s.
Discharge available at tertiary unit intakes = 300 − 102 = 198 l/s.
Relative area of tertiary units = 670 ha rel.
RAWD at tertiary unit intakes = 198/670 = 0.30 l/s/ha rel.

In this case the RAWD at the tertiary unit intakes are the same, obviously Method 1 is quicker.

**Data collection, processing and analysis**

A major advantage of the relative area method is the very straightforward data collection, processing and analysis procedures. For data collection, the main data required are:

- canal discharges at all control points (primary, secondary and tertiary canal intakes);
- crop types and areas in each tertiary unit collected by village water masters or WUA every 10 days.
- river flows;
- drainage flows (if into canal or used for irrigation);
- abstractions for other uses from canals (industry, water supply, etc.).

Except the crop types and areas, all the other data are collected daily by the Irrigation Service water master. For data processing and analysis, the Irrigation Service staff meet each 10 days in the office to evaluate the performance of the previous 10 days and plan the water supply for the coming 10-day time period. The crop area and type are recorded on the previously used Form 00 and the crop area converted to relative area. Daily canal discharge is recorded on another form and averaged for each 10-day time period. Canal losses can be determined by analysis of previous periods' data.

FORM 01 DISCHARGE MEASUREMENT

Period: From 1 September to 10 September

| Measurement location | | Req. value | Day 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | Average discharge |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location: Penewon | H | | | | | | | | | | | | | |
| Type/width: ______ | | | | | | | | | | | | | | |
| Comm. area: 817 | Q | | 925 | 932 | 927 | 925 | 932 | 935 | 927 | 927 | 932 | 932 | | 928 |
| Comments: ______ | | | | | | | | | | | | | | |
| Location: Jambuwok I | H | | | | | | | | | | | | | |
| Type/width: ______ | | | | | | | | | | | | | | |
| Comm. area: 559 | Q | | 578 | 578 | 583 | 581 | 575 | 585 | 578 | 581 | 581 | 578 | | 581 |
| Comments: ______ | | | | | | | | | | | | | | |
| Location: Jambuwok II | H | | | | | | | | | | | | | |

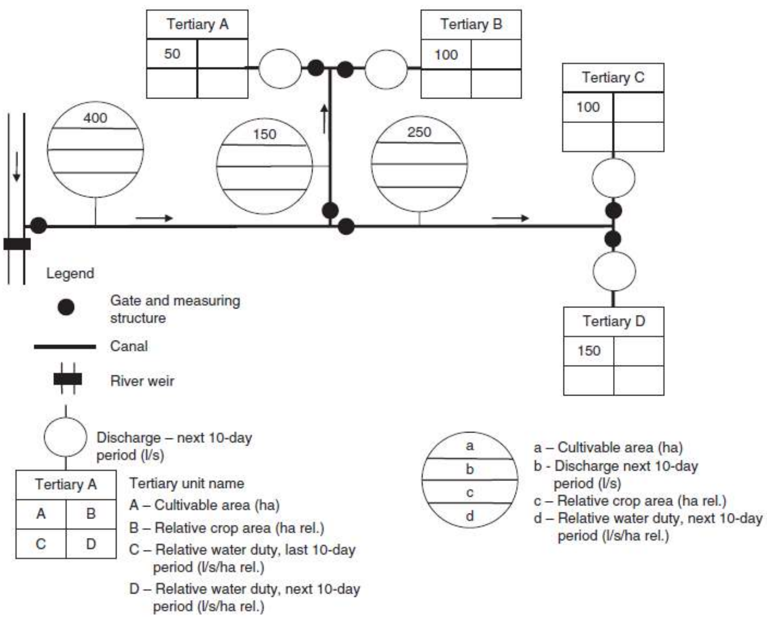
The relative area is transferred from previous Form 00A or 00B to Form 02, where the average recorded discharge is divided by the relative area to give the RAWD (in l/s/ha rel.) over the recorded time period.

FORM 02 CROP- DISCHARGE DATA FORM

Period: From 1 September to 10 September

| Canal (tertiary, secondary, primary) | Gross irrig. area (ha) | Authorized area for dry season paddy | PADDY – Wet season: Nursery crop | Wet season: Land preparation | Wet season: Main crop | Authorized dry season: Nursery crop | Authorized dry season: Land preparation | Authorized dry season: Main crop | Unauthorized dry season: Nursery crop | Unauthorized dry season: Land preparation | Unauthorized dry season: Main crop | DRY-SEASON CROPS – Dry season I: Soyabean | Dry season I: Maize | Dry season I: Cassava | Dry season I: Other crops | Dry season II: Soyabean | Dry season II: Maize | Dry season II: Cassava | Dry season II: Other crops | Sugarcane: Young cane | Sugarcane: Old cane | Tobacco | Fallow land | Total cultivated area (ha) | Total discharge (l/s) | Total relative area (ha rel.) | Relative factor (l/s/ha rel.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Penewon I | 817 | | | | | | | | | | | | | | | | | | | | | | | 817 | 928 | 1913 | 0.49 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Jambuwok II | 258 | | | | | | | | | | | | | | | | | | | | | | | 258 | 353 | 600 | 0.59 |
| Blendren I | 106 | | | | | | | 32 | | | 10 | | | | | 26 | 38 | | | | | | | 106 | 79 | 232 | 0.34 |

The RAWD values of each control point in the system are then compared and anomalies investigated. For instance, all tertiary units should have a similar RAWD value. If one unit has an RAWD of 0.4 l/s/ha rel. and another has 0.7 l/s/ha rel., the reason for the latter (higher) figure should be investigated. For planning for the coming 10-day period the procedures shown in Tables 00A and 00B are followed, recent surveyed crop areas are converted to relative areas, an RAWD is applied to each tertiary unit, the tertiary unit discharges calculated, summated and increased to allow for losses to give the secondary canal discharge, and so on up the system.




**Schematic maps:** Schematic maps for water distribution can be used in any irrigation system; they are particularly useful in the relative area method.