LOWLAND TECHNOLOGY INTERNATIONAL Vol. 1. No. 1, 47-58, June 1999
International Association of Lowland Technology (IALT), ISSN 1344-9656

INTERNATIONAL MISUNDERSTANDING IN IRRIGATION ENGINEERING

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ABSTRACT: The exchange of knowledge between irrigation engineers is quite hampered by misunderstanding. Misunderstanding can be avoided when first terminology, development concepts and fundamentals of an irrigation scheme are mutually agreed, before the technical matters are discussed. Typical topics for misunderstanding are elaborated here and include: need for large-scale development, farmer-managed or dual managed schemes, function of the tertiary unit, role of cost-recovery, need for a 'highest authority', productive and protective irrigation, design for dry-season and for wet-season irrigation, equitable and flexible supply, how is the instruction to the operator of the tertiary offtake. Most of the infrastructural, operational and managerial matters of the irrigation scheme follow directly from choices on these topics.

INTRODUCTION

Since long, irrigation is a local activity where farmers take all initiatives. But also local governments started the construction of large-scale irrigation systems in historic times.

Some 150 years ago, irrigation development became a multi-cultural activity in many tropical countries during their colonial period. For instance, the population of India and Indonesia had tremendously increased and had moved into deltaic areas. Famine and frequent starvation was experienced, because these low-lying areas lacked good water management. The colonial governments modified European engineering, and developed new engineering techniques for irrigation in Asia.

The setting in many countries changed as the colonial rules ended after the Second World War. The national governments became solely responsible, and they continued the prevailing irrigation techniques and design standards of their colonial era. Often, less-than-optimum results were obtained because the required management disciplines did not fit under the new rule, and because of lack of operation and maintenance budgets.

Consequently, the irrigation systems in many Asian countries could not meet the requirements of the further increasing population. International financiers such as the World Bank and the Asian Development Bank, and donor countries such as the Netherlands and Japan, became involved in rehabilitation and modernization programmes on the deteriorated irrigation systems (Ankum 1994).

Thus, irrigation has evolved from a single-country activity, via a two-countries approach under the colonial rules, towards the present multi-countries engineering arena. Now, irrigation is an international activity, and engineers from many different countries have to cooperate.

NATIONAL PREFERENCES

The exchange of knowledge between irrigation engineers is quite hampered by misunder-

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Note: Discussion on this paper is open until December 25, 1999.

standing. Choices on irrigation concepts are often more based on educational background and on national preferences, than on well-defined objectives and a clear understanding of the consequences. Some examples are presented here.

An agricultural engineer may blame civil engineers, who design 'large-scale schemes' that never will work well. A sociologist may urge that 'farmers participation' in design is a must. A project officer of a development bank may insist that farmers have to repay the investment costs through 'cost-recovery'. A Dutch engineer may stress that the 'water board' approach solves all managerial and financial problems, while a USA engineer proposes a water organisation based on the concept of the 'public-management'. French engineers like to promote the 'downstream control' concept, where other nationalities would apply 'upstream control'. Etc., etc.

AN INTERNATIONAL TERMINOLOGY

Discussions on irrigation concepts are made difficult by lack of definition of terms, and lack of clarity about which parts of systems and whose points of view are being considered. Furthermore, classifications and categories used for describing types are still at a primitive stage (Chambers 1988).

An international forum where a standardization in planning, design and operation is discussed, is not yet existing. The International Committee on Irrigation and Drainage, ICID, is not yet taking up this challenging role, although their congresses and working groups focus on certain aspects, and a technical dictionary has been prepared (ICID 1996). The International Water Management Institute, IWMI, is focusing on problems in individual countries, e.g. Pakistan, Sri Lanka. The World Bank undertakes some initiatives on the state-of-the-art, but these efforts are often dominated by the French view (Plusquellec et al. 1994) or by the Indian view (World Bank 1986).

TYPICAL TOPICS FOR MISUNDERSTANDING

International communication on irrigation engineering requires that all engineers are understanding the different terminologies and are recognising the different development concepts. Otherwise, misunderstanding will arise.

This paper discusses typical topics that may lead towards misunderstanding between irrigation engineers during international cooperation. The paper is written by a civil engineer and deals with dual-managed irrigation systems as widely applied in South Asia and in South-East Asia for paddy and other crops. It is based on many years of experience in projects and in teaching.

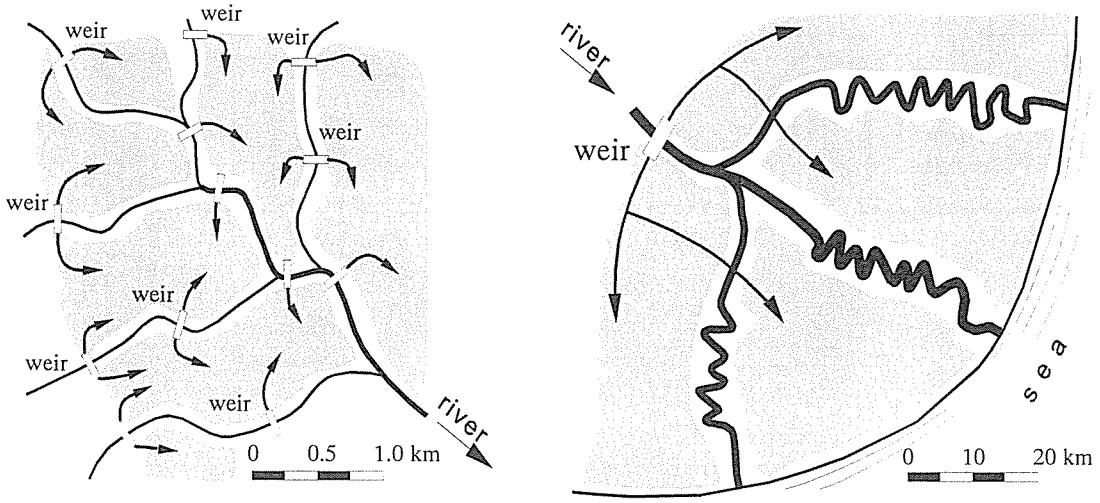
SMALL-SCALE OR LARGE-SCALE DEVELOPMENT?

Some critics state that large-scale irrigation schemes can normally be considered as failures. These schemes require a too sophisticated irrigation infrastructure and a complex management structure, and they fail in supplying tail-enders and in cost recovery. Therefore, they conclude that large-scale schemes should be avoided, and that irrigation development should focus on small-scale irrigation only. Indeed, small-scale irrigation schemes are found in many areas of the world, and are generally successful. Examples are the systems in the mountainous

catchment areas where supplying rivers are abundantly available, such as the Subak systems on Bali, see Fig. 1.

Basically, these critics are correct in their observation that it is difficult to make large-scale irrigation projects successful. Therefore, planning of agricultural development should follow a sequence of choices:

1. First, consider 'rainfed agriculture'. Such a development is simple, as it mainly involves a good agricultural extension services to the farmers. It requires a minimum of government involvement, and most of the activities can be financed locally. If the rainfall is not enough, the next choice in development has to be considered;
2. Consider 'small-scale' irrigation development. In small-scale schemes, the population solves their irrigation problems within their social context. Problems like financing the works, the day-to-day management, the conflict-handling, do not differ from the other activities at village level. Input by the government can be limited to agricultural extension. These schemes are also called: 'communal schemes', or 'indigenous schemes'. Small-scale development is normally limited to an irrigation area of 200 ha, as larger areas require a professional staff for management (Sardagoy 1986).
3. Finally, consider 'large-scale' irrigation development. Large-scale development is widely applied in the vast alluvial plains and in deltas. Here, weirs on large rivers can only be constructed on a few locations and are very costly. It implies that large discharges are to be diverted into small portions, that many control structures are needed, and that long canals have to be applied, see also Fig. 1. Moreover, the management of large-scale systems is complex. But it should be remembered that when large-scale development is unavoidable, all shortcomings have to be accepted.



SMALL-SCALE DEVELOPMENT IN CATCHMENT AREAS

LARGE-SCALE DEVELOPMENT IN DELTAIC AREAS

Fig. 1 Small-scale and large-scale irrigation development

FARMER-MANAGED OR DUAL-MANAGED IRRIGATION?

The day-to-day management of irrigation systems can be charged to one or more different parties. An accepted classification is not yet available, and the international terminology is not consistent (Jurriens 1989). The following classification can be used, see Fig. 2:

- 'Farmer-managed schemes' are, per definition, the small-scale irrigation schemes (Sagardoy

1986). These schemes do not require technical staff for operation and maintenance, and all activities are done by the farmers themselves. These schemes are also called: 'communal schemes', 'communally-managed schemes', and 'indigenous schemes'.

- 'Private-managed schemes' are schemes where the farmers are only labourers, and all activities are controlled by the staff of the commercial estate. These systems are also called 'commercial-managed schemes'.
- 'Dual-managed schemes' are divided in 'tertiary units' and in the 'main system'. The tertiary unit is under management of the population through a 'water users association', and can be compared with the small-scale schemes under farmer-management. The main system is under management of an Operation & Maintenance agency, and its technical staff diverts the flow through the main system to supply the tertiary units. These schemes are also called: 'jointly-managed schemes', and 'mixed-control schemes'. Moreover, the above terms 'public schemes', and 'bureaucratic schemes' are sometimes used here. Large-scale schemes under dual-management will be discussed in the following.
- 'Public-managed schemes' means that the owner of the irrigation system supplies the individual farms directly. The owner of the system is single responsible for all aspects of the system construction, water distribution, like in the public drinking water and electricity companies. Often, the owner of the system is paid by the beneficiaries for the services on a cost-recovery basis. These schemes are also called: 'bureaucratic-managed schemes' and 'government-managed schemes'.

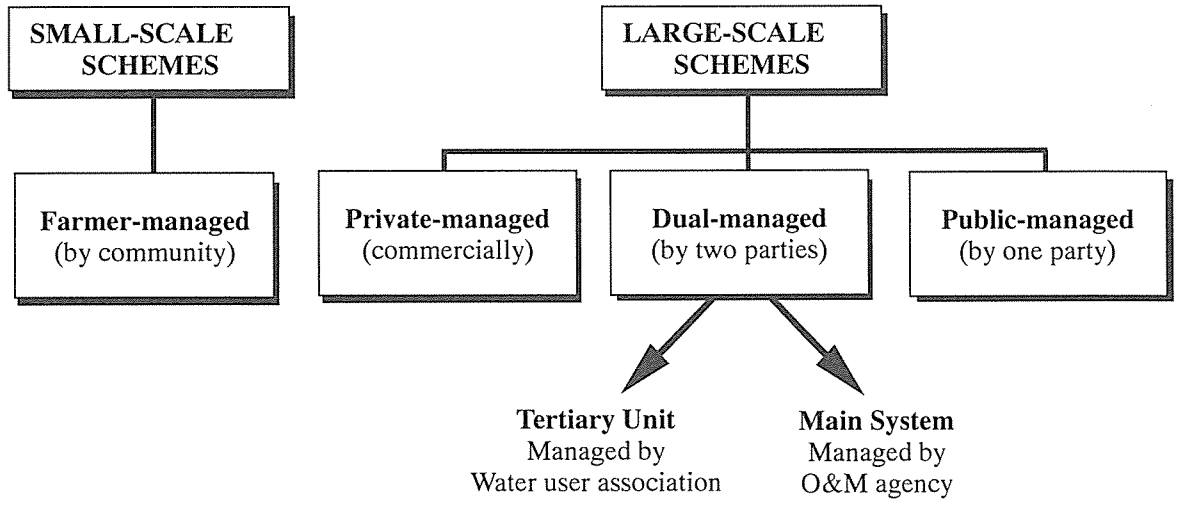


Fig. 2 Day-to-day management of irrigation schemes

THE TERTIARY UNIT IN A DUAL-MANAGED SYSTEM

Dual-managed systems are divided into the irrigation main system and tertiary units. The 'tertiary unit' is the international name for the unit where the population is fully responsible. Such a unit is also called: 'farmers unit', 'end unit', 'terminal unit', 'chak', 'field level', 'farmer service area', 'block of farms', or 'unit command area'.

The name 'tertiary' unit is quite confusing, as it suggests that there is also a 'primary' unit and a 'secondary' unit. The name 'primary unit' is never used, as it just refers to the whole system. The use of the name 'secondary unit' is only practical when operational decisions are also made at such a level, e.g. a rotation over secondary units. Otherwise, such a name is not

used. It is not necessary that a 'tertiary unit' is supplied by a secondary canal. It is even common practice to supply a 'tertiary' unit directly from a primary canal, without first passing a secondary canal, see Fig. 3.

The meaning of 'tertiary unit' is differently used in various countries. For instance, the term 'chak' in India, Pakistan and Bangladesh refers to the above defined tertiary unit that is under responsibility of the water users. Their tertiary unit is part of the main system and belongs to the responsibility of the O&M agency. Obvious, the name 'tertiary' unit should be phased out gradually, and should be replaced by a more correct name like the 'farmers' unit.

The structure that diverts the water from the main system into the tertiary unit is called here 'tertiary offtake'. Other names are 'turnout', 'outlet', 'inlet' and 'mogha'. The tertiary offtake is the official point at which water passes from the control of the O&M agency to the water users association. But it is also the site of struggle between the water users and the staff of the O&M agency.

Sometimes, farmers operate the tertiary offtake themselves. This is wrong in concept. The tertiary offtake is an integral part of the main system, and the O&M agency is responsible for the delivery to the tertiary unit. Therefore, a representative of the O&M agency, i.e. the gate operator, should operate the tertiary offtake.

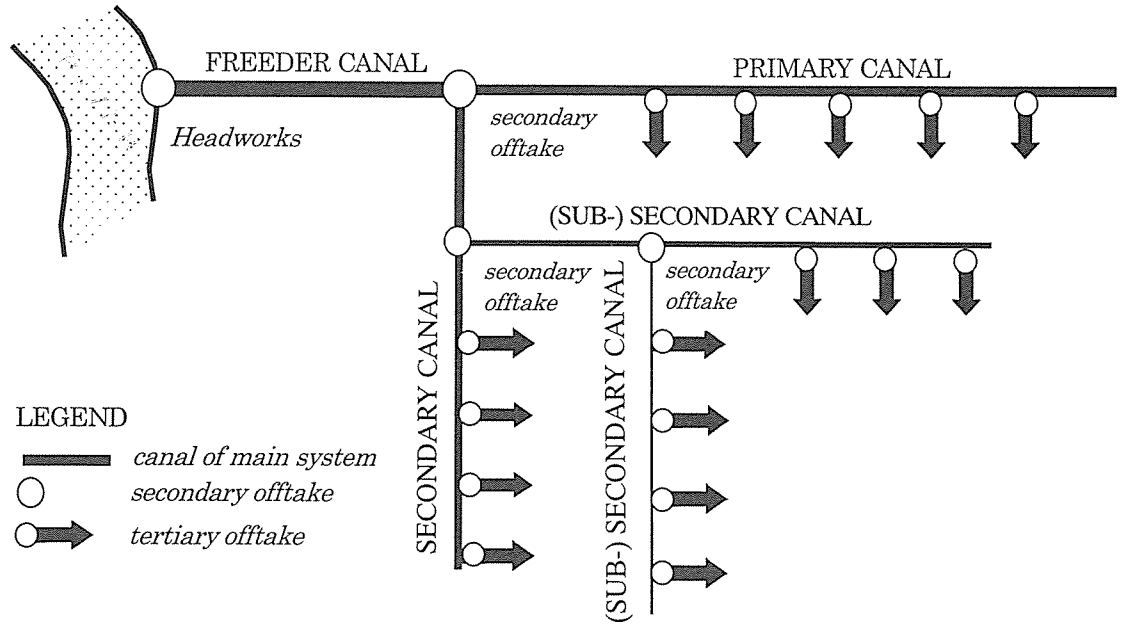


Fig. 3 Typical layout of a dual-management irrigation scheme

COST RECOVERY OF IRRIGATION DEVELOPMENT?

At present, the international banks require feasibility studies for new irrigation projects and the prove of an attractive investment through a cost-benefit analysis. Moreover, they require clear guarantees on the cost recovery from the beneficiaries (Gittinger 1982). This is a new concept, as irrigation development was originally seen as a government activity that would not yield direct benefits, similar as road construction, town building, etc.

Many large-scale irrigation systems in India were constructed in the 19th century as 'protective' works. The capital for these works was not borrowed, but provided out of the revenues of the government (Buckley 1905). These 'protective' works have usually proved as financial failures, but they are still successful in their function as to avoid famines.

The attitude towards new irrigation projects in Indonesia during the 1920's was also not based on a cost-benefit analysis. The international price of rice was so low that it could not justify the construction of irrigation projects. However, it was acknowledged that these rice prices would increase immediately when Indonesia would start to import rice from Thailand (van Maanen 1931).

In addition to the above 'cost-recovery' concept, an international discussion has started whether the users should pay at least an 'irrigation service fee'. Such a service fee would give the users a means of pressure on the performance of the main system by a direct payment for the services. The motto is "no water? - no money!", which means that the O&M agency is only paid by the water users when water is delivered (Gerards 1992). The idea behind is also found in the 'water board' of the Netherlands, the 'basin agency' of France, the 'water bank' in California USA, and the 'farmers irrigation associations' in Japan.

WHO IS THE OWNER OF THE IRRIGATION SYSTEM?

Another international discussion concerns the ownership of the dual-managed irrigation system. Usually, the government has financed the construction of the irrigation main system by taking a loan from a development bank as a 'mortgage' that will be paid back by the future generations. Repayment of the investment costs by the users is often below expectations.

The choice of the 'ownership' depends to a certain extent on the source-of-budget. There are two options for the ownership in dual-managed irrigation systems, see Fig. 4:

- Government, through the 'local administration', when the financial support of the government remains essential, like in Indonesia;
- Water users, through a 'water board', when cost-recovery from the beneficiaries is effected.

In fact, the ownership determines also the 'highest authority' of the system.

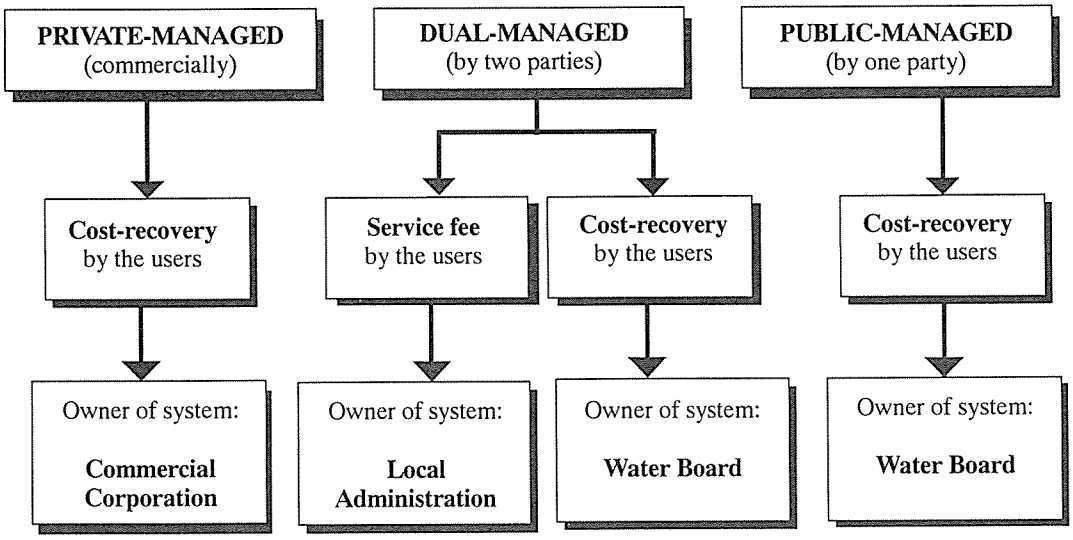


Fig. 4 The 'ownership' of the scheme depends on the source-of-budget

WHO IS THE HIGHEST AUTHORITY?

Dual-management schemes have two separate parties with each their own responsibility.

The 'water users association' has to supply the individual farmers within the tertiary unit, while the technicians of the O&M agency have to supply the tertiary units according to pre-set agreements. Such a pre-set agreement on water delivery has to be decided by the 'highest authority' of the system in Fig. 5.

It is a mistake to assign the technicians of the O&M agency as the highest authority. It is true that technical knowledge is available here, but the O&M agency should not implement decisions that are made by themselves. More important, the O&M agency usually cannot impose sanctions by means of a police involvement or juridical procedures. An example is the Ganges-Kobadak irrigation scheme in Bangladesh where the civil engineer, the 'project director', has the full power over water delivery, but fails to satisfy the different action groups. Moreover, he has no power to act against water theft. The result is that he and his family are threatened by angry farmers.

The choice of the 'highest authority' to a certain extent depends on the ownership of the scheme. There are two workable options for the highest authority in dual-managed irrigation systems, see Fig. 5:

- Local administration, through an 'irrigation committee', when the government remains the owner of the system, like in Indonesia. Such an irrigation committee can be chaired by the local administration and formed by representatives from different interest groups, like farmers, O&M agency, agricultural extension service, police;
- Water users, through a 'general assembly', when the water board is the owner of the system. The motto is: "he, who pays, has a say". An example is the autonomous farmers' irrigation associations in the Netherlands and in Japan (Satoh 1998);

In fact, the highest authority decides on the objectives of irrigation, whether 'protective' or 'productive' irrigation, with 'equitable' or 'flexible' supplies, with 'on-demand allocation', etc.

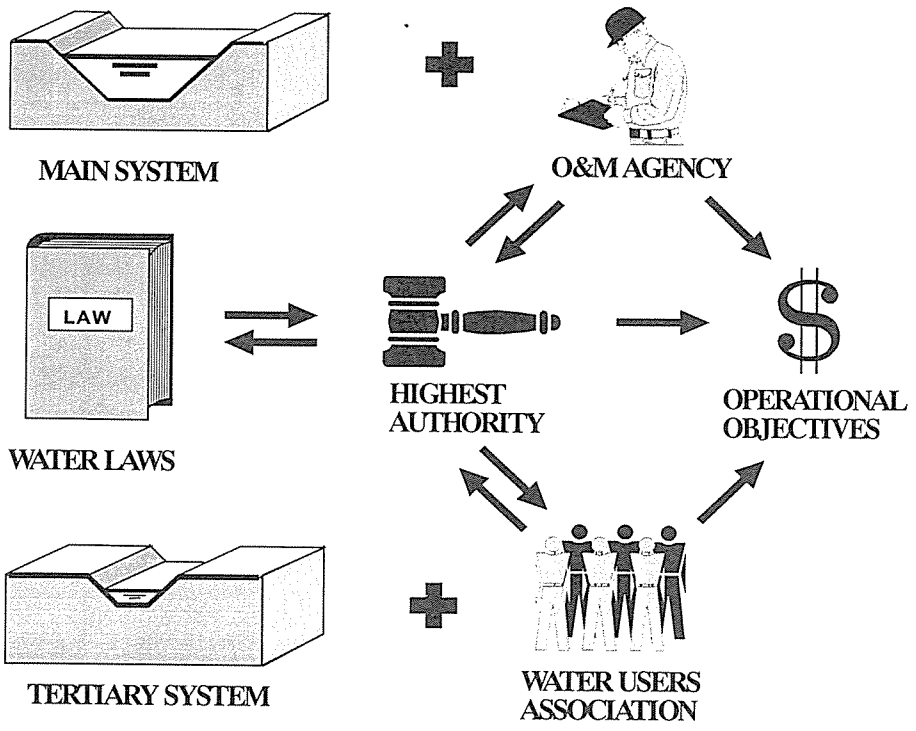


Fig. 5 The 'highest authority' in dual-managed schemes (Ankum 1994)

FARMERS PARTICIPATION

Financiers dictate often that 'farmers participation' has to be applied in all development stages of an irrigation project (World Bank 1993). The concept of 'farmers participation' also is a topic for misunderstanding, as it depends on the development stage of the project and on the management component of the dual-managed scheme.

It is often said that farmers should participate in the planning, design and implementation of new irrigation projects. This is not so easy, as (i) farmers have limited knowledge on the new technical irrigation aspects, such as the new cropping pattern, the concept of tertiary unit, when there is not an old irrigation culture in that area, (ii) time is the limiting factor for the design engineers to consult farmers on the planned civil works when the financier maintains a tight time-schedule.

However, rehabilitation projects for the modernisation of existing systems have a different setting. Now, farmers are well aware of the shortcomings in the existing infrastructure and its management structure. So, farmers participation is most essential for the effectiveness of the project.

Farmers participation in the day-to-day management of the system is, per definition, located within the tertiary unit, and not within the main system, see also Fig. 5. The main system is solely the task of the professional staff, following the guidelines of the 'highest authority'. They should not rely on unpaid labour by farmers for maintenance, or on farmers participation in their operational matters.

Farmers participation in the overall planning by the highest authority seems wise, and is even essential in the 'irrigation committee' and in the 'water board' structure.

LAW-AND-ORDER?

Irrigation systems fail when the participants do not follow the regulations. Farmers who steal water through illegal offtakes should be punished. Operators of the main system who do not supply the agreed water volume towards the tertiary units, should also be punished. In fact, irrigation systems do not differ from other public enterprises where the population has to cooperate according to strict laws and regulations.

Such a strict discipline was imposed in many irrigation systems under the colonial rules. Responsibilities and even the delivery of water to tertiary units were outlined in proper 'water laws' and 'system regulations'. The government made the rules, and the population did not participate much in any decision-making process. 'Law-and-order' was the motto.

Today, the discipline in many irrigation systems of South and South-East Asia is a problem. Water theft from the main system by farmers is often seen in periods of water stress. Gate operators who ignore the instructions from the operation engineers and follow the local pressure of powerful farmers, is common practice in many irrigation systems.

Most of the problems cannot be solved by the magic word 'farmers participation', or by 'training of water users', and even not by the slogan 'motivate the people'. It is obvious that 'law-and-order' is an essential condition for good irrigation management. Even in a democracy, law enforcement with summons and fines is essential for creating a good society. Basically, the law enforcement is outside the scope of the engineer, and has to be covered by the 'highest authority'.

PROTECTIVE OR PRODUCTIVE IRRIGATION?

Often, engineers assume that irrigation should satisfy the crop water requirement, and that the O&M agency should deliver sufficient water to the tertiary unit to avoid water stress for the crops. This is not always correct, as there are two main concepts in irrigation:

- 'Protective' irrigation, also called 'extensive' or 'supply-based' irrigation, was widely applied during the irrigation development in India during the 19th century. Some 24 million ha in South Asia were constructed as 'protective' works. They were constructed during famine times to give employment for the people, and to furnish sufficient water for irrigation during future droughts. The limited supply of water (0.3 - 0.7 *l*/s.ha) was distributed over an extensive area for famine relief. It was accepted that this supply would not meet the irrigation water requirement of the crop in the irrigated area (Buckley 1905; Jurriens et al. 1996).
- 'Productive' irrigation, also called 'crop-based' or 'demand-based' irrigation, focuses on the optimum production of the crop, and satisfies the irrigation water requirement (1.2 - 1.8 *l*/s.ha) of the crop. The design of a productive irrigation system starts with the assumption of the future cropping pattern, calculates the irrigation requirement at field level, and determines the required canal capacities by incorporating operational techniques and efficiencies.

A discussion has started in Pakistan and India whether existing protective irrigation systems can be reshaped into productive systems. In principle, this is not possible. Firstly, the relative canal capacities of these systems have to be increased drastically (e.g. from 0.3 *l*/s.ha to 1.2 *l*/s.ha). Secondly, the water availability in the rivers has to be substantial higher, which is only possible by the construction of enormous storage reservoirs.

WHEN IS THE IRRIGATION SEASON?

The timing of the irrigation season is also a topic for misunderstanding. The irrigation season in many tropical countries of South-East Asia is not the dry-season, but the wet-season. It is experienced that the tropical rainfall is not reliable enough for land-preparation and to grow high yielding variety paddy with a precise water management at field. Thus, productive irrigation is applied on a 'supplementary' basis in the wet season.

An example is Java, where typical run-of-the-river schemes of 10,000 ha are irrigated by rivers with catchments of only 100 - 500 km^2. These rivers can only be used for wet-season irrigation as they fall dry in the dry-season. It learns us that already wet-season irrigation may justify the construction of an irrigation system for paddy.

The season for protective irrigation is, per definition, the wet season. The objective of protective irrigation is famine relief by supplying water during periods of droughts.

Irrigation planning in Bangladesh is an example of the discussions on the irrigation season. The present planning focuses on productive irrigation during the dry-season as a huge river flow in the Ganges river (1000 m^3/s) is available. But, this dry-season flow is not enough for fighting saltwater intrusion and for unlimited irrigation. Thus, the present Ganges-Kobadak project of 130,000 hectares is not extended to its original planned 1,000,000 hectares. Discussions should start whether the masterplanning in Bangladesh has to focus on irrigation during the dry-season, or on supplementary irrigation during the wet-season, like in Thailand and Indonesia. The latter objective opens up the development of the greater Ganges-Kobadak project and other projects for high yielding paddy.

EQUITABLE OR FLEXIBLE?

Many engineers promote the concept of 'equitable' supply of irrigation water, also called 'proportional' or 'equity'. It is based on the principle that all farmers are equal, and that all have equal rights on irrigation water. Some policymakers take the conclusion that it means that water should be supplied equally to people, so that the larger farmers should receive the same amount of irrigation water as the smaller farmers.

But normally, 'equitable' means that the irrigation supply is proportionally distributed to the size of land-holding. So, equitable supply fits well in a protective irrigation system where all farmers receive their share of water, see Fig. 6. Equitable supply may also be applied in productive irrigation for a uniform cropping pattern. The consequence of equitable supply is that the O&M agency 'dictates' the water delivery to the tertiary unit, and that communication with the farmers is not needed.

Other engineers promote 'flexible' supply of irrigation, which means that water delivery meets the changing demand of the crops. Flexibility is applied in productive irrigation systems with a complex cropping pattern, see Fig. 6. The effect is that some tertiary units receive, on purpose, more water per hectare than other units.

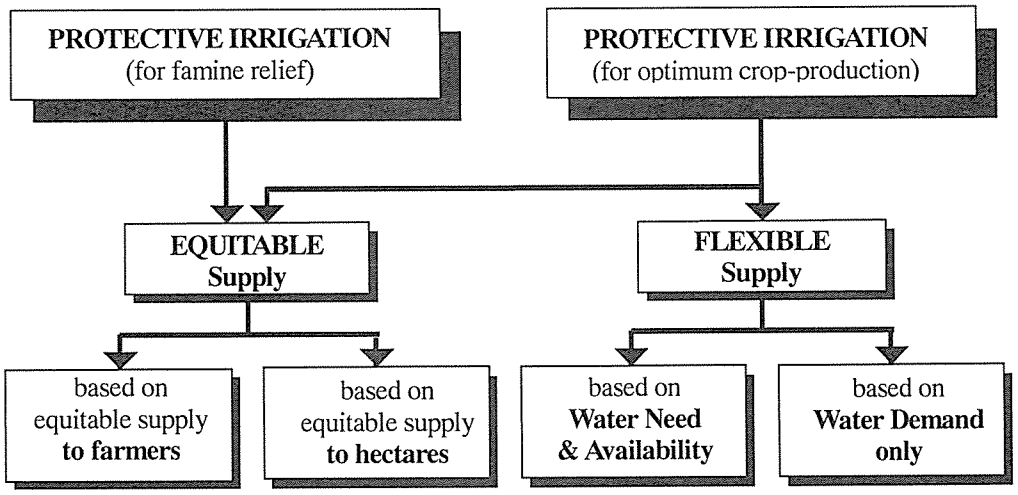


Fig. 6 Equitable and flexible supply to the tertiary unit

WHO DECIDES ON WATER DELIVERY?

A practical question is: who instructs the gate operator on the water delivery to the tertiary unit? There are three operational options, see Fig. 7:

1. 'Dictated' delivery, when farmers have no say and the O&M agency decides on the water delivery, either: (i) as an equitable supply, i.e. based on the size of land-holdings, or (ii) as a flexible supply, i.e. based on the water need of the crop;
2. 'On-request' delivery, when the water users associations make official requests on their supply, the O&M agency endorses the requests, and adjusts the system accordingly. A time-lag between request and supply is inevitable.
3. 'On-demand' delivery, when the water users association decides about the water delivery towards their tertiary unit and will receive the supply immediately.

The logic choice for flow control method in the main system (Ankum 1992) follows from three operational options at the tertiary offtake, see also Fig. 7:

- Dictated delivery on basis of an equitable supply requires 'proportional' control,
- Dictated delivery on basis of an flexible supply requires 'upstream' control with central system management,
- On-request delivery requires 'upstream' control with central system management.
- On-demand delivery requires 'downstream' control.

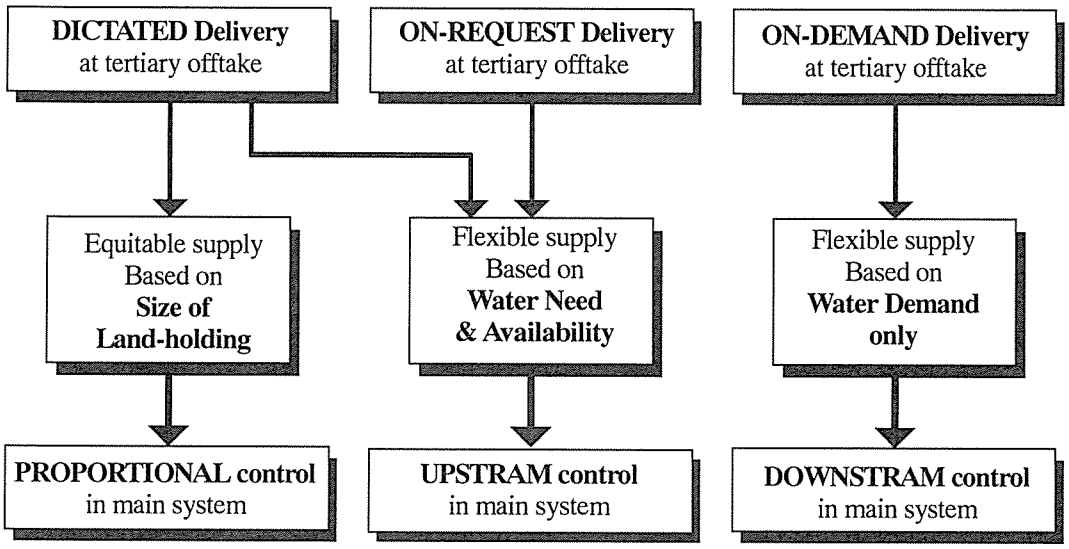


Fig. 7 Relation between decision-on-delivery and flow control system

CONCLUSIONS

Misunderstanding between irrigation engineers can be avoided when first the terminology, the development concepts and the fundamentals of the irrigation scheme are mutually agreed. Typical topics for misunderstanding have been elaborated above. A logic checklist may include the following questions:

1. Do we agree that small-scale development by a farmer-managed irrigation system was not possible here, so that a large-scale development was unavoidable. Check the command area of the scheme, as less than 200 ha allows a small-scale scheme under farmer-management, and more than 5,000 ha cannot be managed without technicians.
2. How is the day-to-day management of this large-scale irrigation scheme: (i) is it a private-managed scheme with farmers as labourers? (ii) is it a dual-managed scheme with an O&M agency who supplies the tertiary units? or (iii) is it public-managed scheme with an O&M agency who supplies the individual farmers? We assume that a dual-managed system is discussed.
3. What is the 'tertiary unit' in the irrigation system, and how is it called locally? Check the size of the tertiary unit, as 30 ha - 100 ha is realistic for management by a water users association. Check the existence of water users associations, as the dual-management concept fails without such a organisation.
4. Do farmers or water users associations pay for irrigation, by means of (i) 'cost-recovery' for the investments made, (ii) 'irrigation service fee' for the service received, or (iii) 'land taxation' for the local government. Cost-recovery may permit a water board as owner of the system, otherwise the role of the government remains unavoidable.
5. Who is the 'highest authority'? Check who defines the scheme objectives, who endorses

the seasonal irrigation plan, and who enforces the water laws.

6. What is the scheme objective in terms of 'protective' or 'productive' irrigation? Check the capacity of the main system, as 0.3 *l*/s.ha suggests a protective system for dryland crops, and 1.8 l/s.ha a productive system for paddy.
7. When is the irrigation season: (i) in the dry and wet season, or (ii) only in the wet season? Check the wet-season cropping pattern in and outside the irrigation area, as any differences may suggest that 'supplementary irrigation' in the wet-season is applied.
8. What is the scheme objective in terms of (i) 'equitable' supply to deliver proportionally to land-holding, or (ii) 'flexible' supply to match the water delivery with the water need and availability?
9. Who operates the tertiary offtake, and who gives the instruction for this operation? It is obvious that farmers should never operate the offtake themselves, as the O&M agency is responsible for water delivery. The instruction for operation can be given either (i) by the O&M agency as a 'dictated' delivery, (ii) by the O&M agency after request by the farmers as an 'on-request' delivery, or (iii) by the farmers as an 'on-demand' delivery.
10. Most of the infrastructural, operational and managerial matters of the irrigation scheme follow directly from the above choices.

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