Operation and Maintenance of Small Irrigation Schemes

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The quality and organisation of maintenance can be the single most important factor in the success of irrigation schemes. This short, practical manual to be used in conjunction with the author's *Small-scale Irrigation*, deals with the problems of operation and maintenance at the source of supply and in the conveying of water in pipes or open channels. Water distribution is described both on- and off-farm and the maintenance of irrigation systems and devices — and advice is given on drainage, health and general management problems.

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Preface

This book has been written to supplement the author's *Small-scale Irrigation* which was first published in 1979, and is intended for those who are concerned with the development of irrigated cultivation on a small scale, with limited technical and financial resources. Currently world-wide attention is being given to the poor performance of so many irrigation developments, including both well-established schemes and new projects. The Overseas Development Institute of London, appointed by the World Bank to carry out research in the organization and management of irrigation projects, found that while the original design of schemes was sometimes at fault, usually the significant causes of poor performance lay in the problems of management and operation. In a paper on the Bank's own experience in post-project evaluation, presented at the Special Session of the Eleventh Congress of the International Commission of Irrigation and Drainage in 1981, John M. Malone and others pointed out that projects which featured small-scale irrigation were generally less costly in relation to results achieved than larger-scale, single-purpose, classical irrigation projects. I hope that this little book will make some contribution to the continuing success of small-scale irrigation.

Peter H. Stern
1987

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Chapter 1
OPERATION AND MAINTENANCE PROBLEMS

Organization

The satisfactory operation and maintenance of an irrigation scheme depends upon the successful organization and co-ordination of human activities. Certain organizational problems can be attributed to bad planning and design. A badly-designed system will produce many more operational problems than a well-designed system which has taken into account all the necessary factors for smooth running.

Good organization is crucial not only to large irrigation schemes but also to irrigating on a small scale, where activities may need to be co-ordinated with other members of the community over the use of land and water, over rights of way, access to resources and in the course of harvesting and marketing.

The need to regulate irrigation activities has been recognized in countries where irrigation has been traditionally practised for several thousand years. The Hammurabi Code, which dates from the Babylonian era about 2300BC, is an ancient document on the laws of society which has an extensive section relating to irrigation and agriculture. Article 53 of this code states:

> If a man has been too lazy to strengthen his dyke, and has not strengthened the dyke, and a breach has opened in the dyke, and the ground has been flooded with water, the man in whose dyke the breach has opened shall reimburse the corn he has destroyed.

The proper management of large-scale irrigation schemes involves a great deal of co-ordination, and a certain amount of discipline which is not always easy for authorities to impose under modern conditions. For small schemes the types of activity which need to be regulated and co-ordinated are:

(a) Matters affecting the source and delivery of the water.
(b) The distribution of the water within the scheme.
(c) The control of surplus water and drainage.
(d) The maintenance of supply channels, drains, ditches and pipes.

(e) The operation and maintenance of pumping machinery, channel regulators and structures.
(f) The maintenance of roads and tracks.
(g) The implementation of agricultural operations which do not conflict with the interests of neighbours or the general interests of the community.

For the individual small-scale irrigation farmer, organizational problems are confined mainly to the on-farm activities, usually involving members of his family and occasionally hired labour. Where several farmers share a source of irrigation supply, a common roadway or track, equipment or buildings, some form of association in which common interests are regulated is essential.

Farmers' and water users' associations exist in many countries where irrigation is practised. The organization and structure of these associations vary from country to country and with different operating conditions. Some, in regions where irrigation has been practised traditionally for centuries, are part of the pattern of rural society with strong traditional rules. Others have evolved from the more recent modernization of old irrigation works. Some of the most acute problems of organization and management occur in countries or regions where irrigation has not been practised before and is

Irrigation from Ma'afar Spring, near Mahweit. N. Yemen (Stern).

being introduced for the first time, calling for major changes in the traditional activities of rural people.

Responsibility

In many old-established small irrigation schemes the responsibility for certain functions may be shared between the local people and a central or regional government organization, and this itself can be a cause of poor service and performance. It may be that the local community fails in its commitment to provide funds or labour for maintenance, or that the government agency does not fulfil its obligations to fund and supervise. Dr Waheeduddin Khan[1] describes the organization for controlling 'tank' irrigation schemes in Andhra Pradesh, India, in the following terms:

> There is no clear-cut pattern of control of tanks now [1978], although prior to the abolition of intermediary rights in land, they could be classified as private and public or government tanks. In the latter case they were controlled and operated either by the Public Works Department or the Revenue Department. Private and public tanks were distinguishable on the basis of the responsibilities for their construction, maintenance and operation. With the abolition of intermediary rights in land the institution of private tanks has become extinct; almost all tanks are now public or government tanks. However various public authorities now share the responsibilities among themselves for construction, maintenance and operation. The pattern of sharing of responsibilities between the PWD, the local self-government institutions . . . and the Revenue Department is intricate and the locus of control is often intractable.

A study in Pakistan[2] into the causes of poor water course performance and management came to the conclusion that 'the major reason for inadequate watercourse maintenance has been and continues to be the lack of effective farmer organization'. The report pressed for the motivation and education of the farmers, but did not go into possible causes for this lack of motivation.

There are many examples of problems occurring on small farms in a major irrigation supply system, arising from the bad management and administration of the major scheme. In schemes where farmers are supplied from a canal in rotation, it often happens that the farmers near the head of the canal take water at the expense of those at the tail. Syed Hashim Ali[3] quotes a case where tail-end farmers on one canal system in India in 1980 'had not seen their legitimate share of water for more than 20 years'. This situation arose because the irrigation authority's responsibility ended with releasing water into the canal, there was no system of rotating deliveries to outlets and no organization responsible for efficient and equitable distribution to the farmers.

Response to Change

In places where irrigation is introduced to farmers who have never cultivated with it before, performance is often much worse than in countries where irrigation has been a traditional method of cultivation for generations. This is often owing to a failure in the initial plan and design to take into account the changes to be expected of the people who will be engaged in the new development.

The Las Majaguas Project was part of the Venezuelan Land Reform Programme and was planned to resettle landless peasant farmers on 10- and 15-hectare family farms in a large-scale irrigation scheme, the first stage of which comprised a gross area of 30,000 ha. The scheme started to be operative in 1962 and José L-Méndez Arocha[4] wrote in 1970:

> After nine years of development of the Las Majaguas area, the fact is that there is a considerable lag between programmed goals and present [1970] achievements . . . Practically all of the farmers settled in Las Majaguas are typical, under-educated (illiteracy 40 per cent) Venezuelan peasants with low to very low standard of living, former shifting cultivators or *latifundia* labourers or both, skilled only in primitive agricultural or cattle raising practices. The project development plan has not as yet been able to overcome such human factor limitations; thus the formation of a modern, skilled, efficient irrigation farmer still remains a goal. The general agreement is that the lack of ambition of the peasant coupled with poorly oriented government action — paternalism instead of participation — are much more to be blamed for the situation than the economic or engineering deficiencies. . . . Peasants have to learn not only how to irrigate but all the complex practices of modern farming, in addition to operating and maintaining farm machinery, developing co-operatives and other social and community structures etc. . . . So far no water users' associations have been organized so contact between personnel from the Ministry of Public Works, which operates the system, and the individual farmer is on an individual basis . . . In spite of the

economic situation not being as good as desired, the majority of Las Majaguas farmers think they have improved their standard of living and are not willing to abandon the system. But the Government's paternalistic policy has to be changed to improve the attitude of farmers towards the system. As things now stand, they regard the Government as the owner of the irrigation system and also the lands.

An interesting example of change which was initially acceptable and the consequences of insensitive outside assistance comes from Senegal and is reported in notes prepared by Tony Barnett[5] on small-scale irrigation in 1982. He describes the Jamaane Village Scheme:

> The scheme began when a local man returned to his area (for a visit) in the early 1960s after many years working in France. He returned to France with a central aim in view; to acquire some means of improving farming at home. In 1973 he returned once again to his village bringing with him a cultivator and a small pump, together with the promise of an agricultural technician. In 1974 the technician arrived, funded by two British non-government organizations. A group of 40 people established a *champ collectif* of 1 ha and dug a well. By 1975 this group had increased to 270 members — 200 men and 70 women. By mid-1975 all the villages along the river from Balou to Monderi had formed irrigated farming groups. The villagers had been somewhwat wary of the plan at the outset; but it was presented to them by someone they knew and trusted, and came to seem something they themselves could control. Wariness turned to hope, in some cases to enthusiasm.
>
> An application to USAID for $60,000 for purchase of equipment led to the project being put under the aegis of the SAED (Société d'Aménagement et d'Exploitation des Terres du Delta et de la Vallée du Fleuve Sénégal et de la Falémé), who would channel the aid. The peasant response was that if they were going to lose control of what they had built, they would do it without the aid and continue with their collective fields of millet and maize until they could finance their own purchase of equipment.

The note on this project ends with the comment that government involvement can be a disincentive if its objectives differ from, or are perceived as differing from, those of local people; and large-scale aid donors, bilateral or multilateral, by working through government may actually stifle local initiative.

Rice field, Indonesia (Stern).

Conclusions from Recent Experience

1. Insufficient attention to the institutional environment in which irrigation takes place creates built-in defects in operation and maintenance.
2. The practice of irrigation imposes physical linkage among farmers along a watercourse. This necessitates specially designed management systems in order to achieve the goals of efficiency and equity, with the authority resting either with an external (government) body or with the irrigating community itself.
3. In large schemes discipline is invariably imposed, often with inadequate consultation with the irrigators.
4. There is a significant difference in achievement between extending irrigation among people who are accustomed to irrigating, and introducing irrigation to people for the first time. In the latter case much more attention needs to be given to training, education and gradual development.
5. Where responsibilities for operation and maintenance are shared, problems arise from:
   (a) Vague or indefinite regulations or instructions about the share of responsibilities.
   (b) Lack of co-ordination between different public authorities sharing responsibility.

(c) Absence of a common meeting point for discussing and settling differences.
(d) Absence of an effective association to represent the farmers' and cultivators' interests.

6. Large schemes with smallholders are the most difficult to manage and are therefore the least likely to be successful.
7. The most effective motivation in rural development usually springs from the rural people themselves and this can easily be stifled by interference from a central government or external agency.

Tasks in Operation and Maintenance

It will be evident from the foregoing sections that where several farmers are carrying out irrigated cultivation on adjacent farms or plots of land, using a common source of supply and draining to a common drainage system, certain tasks and activities must be properly co-ordinated to ensure the smooth running of the scheme and to avoid friction and disagreement. This is why it is essential to have some sort of farmers' or cultivators' association. Even in schemes where there is an overall authoritarian management which is able to enforce co-ordination, it is still important to have an association through which the farmers can communicate with the management, and in which they can air and resolve their differences. In a scheme which is independent of external authority and is self-managed by the farming community, it is absolutely essential to have an association for organization and self-management.

The tasks in operating and maintaining an irrigation scheme at the farm level fall broadly under the following heads:

(a) Maintaining the source of supply.
(b) Maintaining the supply system to the farms or plots.
(c) Sharing the water.
(d) On-farm distribution.
(e) Controlling flooding and maintaining drainage.
(f) Health protection.

Where several farmers are involved in a joint enterprise all these tasks except for (d) have to be shared. These tasks will be covered in the following chapters.

Further Reading

Juan A. Sagardoy, *Associations of Irrigation Water Users*, Irrigation Management Workshop (Canterbury, UK), FAO, Rome, 1976.

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Chapter 2
SOURCE OF SUPPLY

Rainfall Catchment

Natural Catchments

The best natural catchment surface is bare, hard rock, which gives a high yield and requires little or no maintenance. Attention however will need to be given to the collecting arrangements at the sides and bottom of the catchment, which are liable to damage and wash-out during storm rainfall.

In a catchment area consisting of erodible soil and vegetation, silt and vegetable matter may create obstructions. These obstructions will have to be removed from time to time, particularly if they cause unnecessary ponding and consequent evaporation, or if they cause run-off to be diverted out of the catchment area. Intensive human activity in the catchment area, such as tree felling or cultivation, will tend to increase erosion which, in turn, will increase the tendency for run-off to be obstructed by silt and debris.

Mountain rainfall catchment, near Mahweit, N. Yemen (Stern).

Small Artificial Catchments
Catchment surfaces may be constructed in many different materials, some of which are much more durable than others. Good concrete is comparable with hard rock and will require little attention apart from the repair of sealed joints which may deteriorate and leak in time. Paving with flagstones or concrete slabs on soft material may be displaced or broken by water underneath and the movement or settlement of the bearing material, and this will result in losses through leakage.

Some of the plastic-type waterproofing materials deteriorate quite quickly if exposed to sunlight and weather, and may have to be repaired or replaced. Wind can damage light sheet material.

Storage

Small Dams
Small dam storages sometimes fail because of bad design, but failure as a result of neglected maintenance is much more common. The proper functioning of the spillway is vital to the preservation of a dam. A properly designed and maintained spillway will ensure that, even under extreme rainfall conditions, the height of the water will never rise and overtop the dam, and it will also ensure that the surplus flood water will

'Ionides' rainfall catchment tank, Kordofan, Sudan (Stern).

be carried away downstream without endangering the foundations of the dam.

The spillway of a dam is usually protected with concrete or masonry because it acts as a weir which must be sound and stable under flowing water. Spillway systems fail in two ways. Because the spillway channel carries intermittent flow which at times is heavily silted, it may be partially blocked with vegetation and silt, thereby reducing its capacity to carry a high flood discharge and causing the reservoir to overfill and the dam to be overtopped. A spillway system may also fail through erosion of the spillway channel bed at high discharge, breaking up the bed material and in due course cutting back to the foundations of the dam itself.

In countries where herds of livestock are brought to reservoirs for watering, earth dam structures can be damaged by the continual trampling of animals' feet, breaking up the earth material which is either blown away by the wind in dry weather or washed away during the rains. Masonry dams in mountainous areas can be damaged by prolonged exposure to rainfall which may disturb the abutments or displace mortar in masonry joints.

A small dam and reservoir system should be regularly inspected, at least once a year and always after conditions of extreme rainfall and excessive flooding. Following inspection,

Road construction causing massive soil erosion, Honduras (Stern).

any urgent repairs and attention should be put in hand as soon as possible, and in any case before the next wet season.

Storage Reservoirs

The accumulation of silt is a problem which affects all dams and reservoir systems collecting water from natural catchment areas. In all but the smallest of these, the total removal of silt is a major problem which few large organizations, and certainly no small community, can undertake. However, the local removal of silt near headworks, supply outlets or pumping intakes is feasible and should be done as required.

Working in wet silt is not easy. If dredging equipment is available, the silt can be dredged. It is usually impossible to get tracked excavating machinery near enough to reach the silt, and if the work is done manually it is very arduous. Working conditions are much easier if the reservoir water level can be lowered and the silt dried out (as at the end of a dry season).

Where reservoirs, tanks or cisterns have been excavated in permeable material and provided with a waterproof lining, the lining may deteriorate with time giving rise to leakage. Serious leakage will generally be self-evident, but quite extensive leaks may occur unobserved. Checks for leakage can be carried out by measuring the inflow, outflow, evaporation and variations in storage over a period of time. As up to 1m depth of water may be lost to evaporation in six dry months in arid conditions, seepage losses of up to 50mm depth of water in the same period will not be significant.

If tanks or cisterns are covered to reduce evaporation, the covering and roofing material will need to be checked periodically and repaired or renewed. If the water is stored in sand as in the 'beehive' type of tank, silt and vegetation will need to be cleared from the surface and the top sand renewed as necessary.

Leaks from a reservoir constructed wholly above ground will be obvious as soon as they appear. Repairs will usually have to be done from the inside, with the water drained out to uncover the leaking area. If the construction is masonry or concrete, cracks and fissures can be repaired with cement plaster or bitumen. If the deterioration of the material is serious but the walls and base are structurally sound, the reservoir may be lined with synthetic rubber sheeting, which can be either prefabricated or supplied in rolls and joined on site. Metal tanks in which holes have developed can also be lined in this way.

Stream Diversions

Diversion works in torrential streams are particularly vulnerable to damage and usually require regular annual maintenance. Small diversions often consist of weir structures which create head ponds for offtakes. Even 'permanent' concrete or masonry structures are liable to damage under extreme weather conditions. Where catchment areas are wooded, trees and branches may be washed down during a storm, obstructing the weir or offtake, and these will have to be removed. Gated controls on offtakes are also liable to damage and if the moving parts of these contain a screw mechanism or metal bearings, they will require periodic greasing.

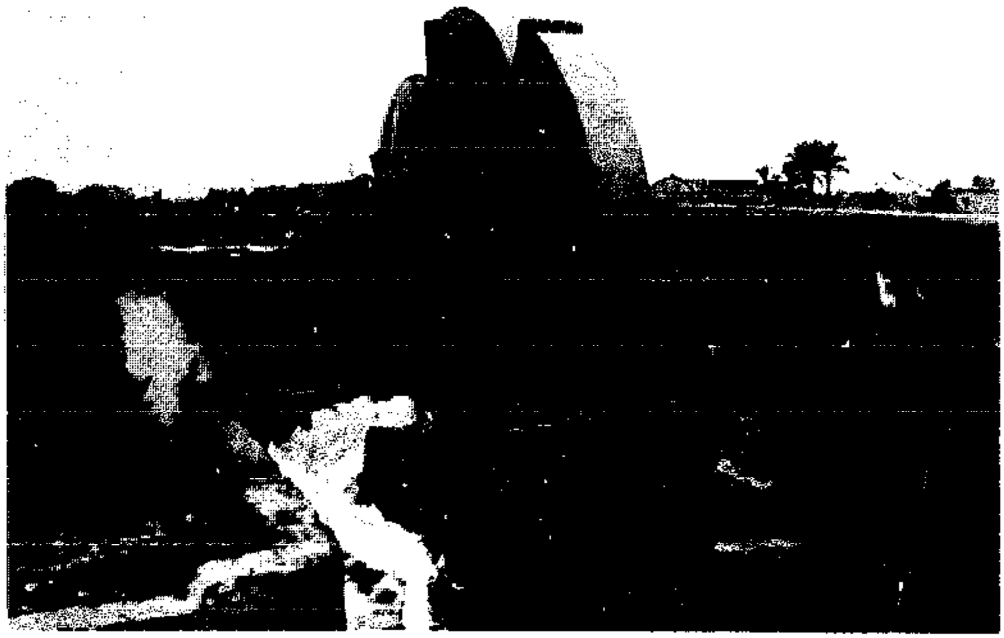
Temporary or semi-permanent diversion structures will have to be rebuilt or repaired every year. Mountain streams flowing into sandy plains have unstable channels which change course from year to year. These cause special problems for diversions. Sometimes it is possible to confine the stream by training works, but these can be expensive both to install and to maintain.

Heavy silt loads during flooding are common in streams and rivers in most arid and semi-arid regions. As the flows subside after the floods the silt is deposited and this can interfere with diversion works by blocking the entrances to offtakes or shifting the dry season channel in the river bed. This silt will have to be cleared. Even where silt exclusion devices have been included in an offtake structure the system may not be entirely trouble-free.

Pump Intakes

Pump intake works on rivers and streams are very similar to river offtakes in that they are liable to damage during flooding and silting after floods. Pumping machinery in large, permanent installations is usually protected from flood inundation, but small portable pumps are highly vulnerable if they have to be moved up and down with varying river levels.

In some pumping stations on large rivers with a wide seasonal range of water level the pumps are mounted on floating pontoons with flexible pipe connections to the river bank. These systems are safe from inundation but can be



Noria at Baltim, Egypt (Stern).

damaged by floating tree trunks and other debris during a flood.

Pumping Machinery

Pumping machinery, like all other machinery, only works satisfactorily if properly operated and maintained. During an irrigation season the pumps will be required to run continuously for long periods. Modern machinery can run for quite long periods without attention provided that it is safeguarded from damage. Small mechanical pumps left unattended can soon run into all kinds of problems which can quickly damage the pump and its prime mover (which is usually an internal combustion engine or electric motor). Examples of these problems are:

(a) The suction strainer gets blocked with debris.
(b) The pump draws water down too quickly at the intake so that air and sediment are sucked in.
(c) Engine vibrations disturb the position of the pump and suction line.
(d) The engine overheats and runs short of lubricating oil.

Where a group of farmers is sharing a common pumped supply it is essential that there is a very clear understanding about the responsibility for operating and maintaining the pumping equipment.

Groundwater Sources

Springs

If the source of irrigation water is a spring with a gravity supply to the area of cultivation, the problems of operating and maintaining the source are minimal. As a spring source may be used by a community for purposes other than irrigation, such as domestic water and water for livestock, it is essential that there should be full agreement by all the parties concerned with regard to the use of the source.

If the spring has been protected by some structure which collects and divides the water supply, this structure will have to be maintained in good order and repaired when necessary. Again responsibility for this must be clearly understood by all those concerned.

Wells and Boreholes

Where the groundwater supply has to be raised from below ground, the operation and maintenance of the supply amounts to the operation and maintenance of a pumping system. Well and borehole pumps are not liable to flooding in the same way as river pumps, but in most other respects the operational and maintenance problems are the same.

Spring protection, Soroti District, Uganda (Stern).

Chapter 3
CONVEYANCE OF WATER

Pipelines

The conveyance of water by pipeline is the most efficient and trouble-free method of bringing water from a source to an irrigated area. Provided the pipeline is well constructed in sound materials, maintenance may be required only occasionally to repair leaking joints, to replace cracked or damaged pipe sections and to flush out accumulations of sediment.

Where the inlet to a pipeline is in open water (such as a river, lake or reservoir) this will be protected by a grid or screen to prevent floating solid material being drawn into the pipe. These screens must be regularly inspected and cleared.

Where pipelines are laid above ground, leakage or external damage will be obvious and can usually be rectified easily. Sometimes, particularly in places where water is very scarce, a piped supply system may be damaged by vandalism or otherwise interfered with. While the damage may be repaired fairly easily, the prevention of a repetition of such interference may cause problems, as this type of interference usually stems from some grievance. A first step will be to understand and, if possible, alleviate the grievance. If the dispute is concerned with a monopolistic use of the source of water, it may be possible to arrange for the source to be shared more equitably. This might be achieved by providing one or two watering points for domestic and livestock use along the line of a pipe carrying water for irrigation.

Where pipelines are buried, faults and defects may not be so easy to locate. However, if there is a serious leakage, evidence of this will usually be seen on the ground. It will be more difficult to detect wilful damage or interference with an underground pipe system, but once discovered the solutions should follow the lines already described above.

Pipe Controls

A pipeline will usually have a control valve at the head or inlet end of the line and another valve at the discharge end or outlet. There may also be other control valves, air valves and washout valves along the pipe. All these controls have moving parts which will need regular inspection and if they are of a type requiring greasing they will need to be checked and greased at least once a year, depending upon their use.

Open Channels

Unlined Canals

Unlined canals through hard rock require little or no maintenance. In mountainous terrain silt and debris may be washed into a canal during and after heavy rainfall. The canal should therefore be regularly inspected and cleaned as required.

Unlined earth canals require constant maintenance. If the irrigation water is heavily silted at certain times of the year, deposits of silt may have to be cleared from the upstream sides of gates and regulators. Canal banks are damaged by the feet of animals brought for drinking, and these have to be repaired.

The growth of vegetation in the bed and banks of unlined canals is a constant problem. In areas where there is significant rainfall, either in a single season or in two seasons, and irrigation is only carried out in the dry periods, the problems of vegetation growth during the wet weather can be very severe. If a channel or canal is to carry its designed discharge, the vegetation must be removed. Not only does the vegetation obstruct the waterway, but in so doing it reduces the velocity of the water so that if it carries silt and sediment this is deposited more quickly, reducing the cross-sectional area of the waterway and thereby causing further obstruction.

The removal of weeds and vegetation in a small supply canal is best done manually and is a highly labour-intensive operation. Vegetation in canals can be dealt with in two ways. It can either be cut, which temporarily relieves the problem but does not prevent regeneration, or it can be dug out. Cutting is the only feasible method when the canal is flowing and cannot be drained and dried out. Floating weeds, i.e. those with roots on the bed of a canal but with their foliage floating on the surface, are best cut by raking from the bank. Grasses and reeds can only be cut with a knife or similar tool and if done by hand this involves the operators standing in the water, which

Irrigation su,ply channel.

will expose them to schistosomiasis infection where this is present. If bushes and shrubs have taken root in the bed of the canal they too must be cut down as far as possible below the water level.

If a canal is full of weeds and is heavily silted, excavation of the silt will remove most of the weed growth complete with its roots at the same time. This cannot be done by hand labour in a canal carrying water, but it can be done by a bucket-type excavating machine. If de-silting has to be done by hand labour, the canal must be drained and dried out first.

In most areas where irrigation is practised there is some rainfall. Heavy rainfall can damage earth canal banks by erosion which, if not checked and repaired, may eventually lead to canal failure. If a canal bank is wide enough to take a vehicle, drivers will often use the canal bank in wet weather when the public road or track is flooded. The use of canal banks in this way during wet weather can also cause serious damage, leading eventually to failure.

Lined Canals

Where canals are lined the lining is usually carried over the bed and sides of the channel up to 200-300mm above full supply level. Lined sections, if properly designed and constructed, require little maintenance. But the earthworks carrying the lined channel, which include the earth banks, are liable to the same problems with erosion and use by vehicles as the earthworks of unlined canals. With time, the lining also sometimes requires attention if there has been earth movement or settlement under the lining.

Structures and Regulators

A long supply canal will follow the natural ground slope as far as possible, but because land slopes are variable and often fall more steeply than required by the hydraulic design of the canal, drop structures are introduced. These structures, which dissipate energy, are liable to damage with time, and need to be inspected regularly and repaired as necessary.

A supply canal will have a control regulator at its head and a control system at the tail for regulating the distribution of the water. The brickwork, masonry and concrete of control structures, if properly designed and constructed, will require little maintenance for many years. There may, however, be erosion of rainfall of bank material adjacent to structures, and this will need to be checked and made good. The metalwork of regulators will need regular inspection and periodic repainting while any moving parts requiring greasing should be regularly maintained.

Overflow Escapes

A long supply canal is usually provided with an overflow escape to protect structures in the canal in the event of a sudden shut-down at the tail. This overflow may take the form of a weir in the canal bank, delivering to an escape channel. Overflows and escapes are only used rarely, and because of this they can easily become obstructed with branches of trees, vegetation growth and other material. To be maintained in good order they should be inspected regularly and cleared as necessary.

Operation of a Supply Line

The operation of a water supply line requires co-ordination between events at the head of the line and at the tail. The behaviour of water in a pipe flowing full differs from the behaviour of water flowing in an open channel in virtue of the fact that a pipe provides an enclosed boundary to the water. In both cases if the supply is closed at the head and not at the tail, the water will run out of the tail until the system is empty. If, however, the system is closed at the tail but not at the head, the water in the pipe will remain full and overflow the head, but in the canal the water will overflow at the tail. If the pipeline is supplied by gravity from a reservoir no harm will be done by stopping the flow at the tail. If it is supplied by a pump the effect of closure will become immediately apparent at the pumping station. If the pump delivers direct into the pipe, closure at the tail will immediately increase the pressure in the pipeline and overload the pump and prime mover. If the pump discharges into a head tank before delivering to the pipeline, a tail closure will cause the tank to overflow which may flood the pumping station.

If a canal is closed at the tail while the head remains open, water will continue to flow down the canal and overflow at the tail. Prolonged overflow, even if there is an escape, can do serious damage by flooding and erosion, and is very wasteful of water. Nothing will be known about this at the head until a message is received from the tail.

Conversely if the supply system is empty at the beginning of an irrigation period, start-up at the head without proper communication with the tail can have similar damaging consequences. In the case of a pipeline and pumping station the effect of starting delivery at the head without opening the tail (apart from air lock problems) will be felt at the head and can therefore be more easily controlled. In the case of the open canal the effect of opening the head while the tail remains closed will, after filling the channel, result in overflow at the tail.

Thus it will be seen that it is important that there should be proper communication between the head and tail of a supply system. Over a short distance of, say, up to 1,000m this is not a serious problem and can usually be done visually by signals. But over longer distances more effective arrangements will have to be made. In a simple system this can be done by someone on a bicycle and by working to some pre-arranged plan for opening and closing. Over greater distances it is very desirable to have telephone or radio communication.

Generally changes in the flow in a pipeline can be effected simultaneously at the head and the tail. If, for some reason, the pipe is drained after closure, then time should be allowed for it to refill on reopening before fully opening the tail. In the case of an open canal changes should always originate at the head and time should be allowed for the change to travel down the canal at the rate of velocity of the water in the canal before the corresponding change is effected at the tail. For example, if a canal is 3km long and carries water at 1m/s the timelag between adjusting the discharge at the head and the tail would be 3,000 seconds or 50 minutes.

Chapter 4
WATER DISTRIBUTION

The fair and equitable distribution of water is crucial to the successful operation of an irrigation scheme. More disputes arise from faults in distribution than from any other cause. In some cases distribution problems are a direct result of bad or unimaginative design, but even if the design is sound, trouble can occur if planned water schedules are not followed, if the quantities of water delivered are short-supplied or if, in a shared system, the more powerful members of a community take excess water at the expense of others. These problems are always most acute at times of maximum demand when the scheme is running at full supply.

Off-farm Distribution — Surface Irrigation

Where several farms or farm units are supplied with water from a common source, the supply has to be shared between the users and this can be done in two ways: either by *divided continuous flow* or by a system of *rotation*. Take the example, shown in Fig.1, of a small communal gravity irrigation scheme consisting of a weir diversion W with a supply canal WPQR delivering water to six holdings, A to F. At times of maximum demand the designed full supply discharge will be diverted into the supply canal WP.

Divided Continuous Flow

If the scheme is designed for divided continuous flow, one-sixth of the total supply (after allowing for losses) should be delivered to each of the farm outlets and these outlets will deliver their correct quantities if the water levels in the canal at P, Q and R are maintained at their correct design levels. A reduction in the common supply will clearly reduce the amount of water available for each holding. This could arise from obstructions at the river diversion W, from damage to the weir causing a drop in water level at the intake or from silting in the canal section WP, reducing its carrying capacity.

In a fully-regulated scheme, a reduction of say 10 per cent in

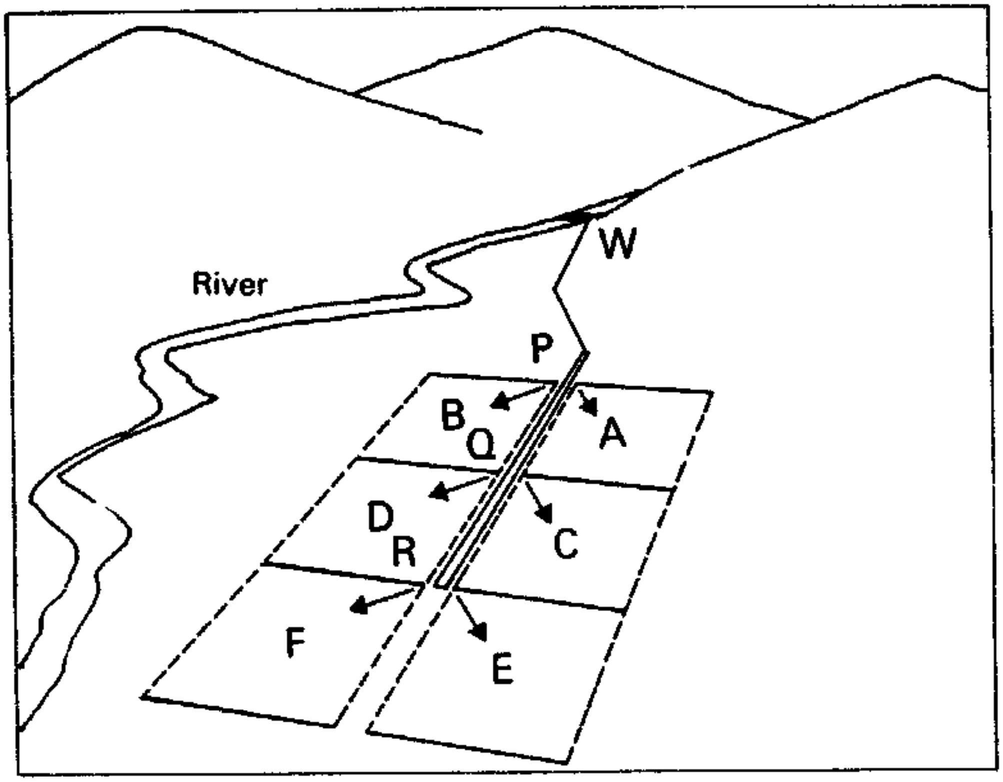


Fig.1. A communal gravity irrigation scheme.

the common supply should result in equal reductions to each of the six farm off-takes. In practice this usually does not happen. If there are no cross structures in the canal at P and Q a reduction in flow will result in a flattening of the water surface slope in the canal, causing ponding at the tail. This reduction of water slope will result in a greater reduction of water level (and hence discharge) at the farm outlets at the head (P) than at the tail (R) of the scheme. Thus the 10 per cent overall loss might in fact be distributed as a loss of only 5 per cent to holdings E and F, 10 per cent to C and D and 15 per cent to A and B. Immediate grounds for dispute appear and this can lead to the owners of holdings A and B taking matters into their own hands and building some sort of structure at P to ensure better command of their off-takes. This inevitably has an adverse effect on supplies downstream of P.

Rotation

In a rotation watering system each of the six farm holdings (Figure 1) will follow a prearranged programme for receiving water at fixed times. The rotation system will depend on the type of crop grown, the soil characteristics and the design of the

Furrow irrigation, Egypt (Stern).

scheme, and there are various ways in which the supply could be rotated between the six holdings. One would be for each holding to take the full supply for the scheme for two days, thus completing a cycle of watering in twelve days. Alternatively, the holdings might share the full supply, two at a time, for four days each, again completing the cycle in twelve days. To enable all the supply to be delivered to one or two holdings it is usually necessary to have regulating structures at P and Q which can cut off the downstream supply completely when water is being delivered upstream of these points.

Whatever rotation system is adopted it is clear that if the water is to be distributed equably, each holding must keep to a pre-arranged programme. Trouble occurs if the supply falls short. This will mean that the full watering of a holding cannot be completed in the allotted time. This situation need not create serious problems if all the farm holders reach agreement on the procedure to be adopted. There would be two options: either for each farm holding to keep to the agreed programme and receive less water than their full demand; or to extend each watering period from say two to two and a half days per holding and increase the period of the cycle from twelve to fifteen days, accepting that there would be some water stress during the last three days.

In practice what tends to happen is that the farmers at the head of the system insist both on taking water for longer than their allocated time and on keeping to the original cycle period. Clearly this can only be done at the expense of the other farmers on the scheme.

Solutions

If there is a design defect in the scheme this should be rectified as soon as possible. It should be mentioned that the original designers may not always be responsible for defects in design. Changes can sometimes occur which cannot be foreseen, such as a change in the regime of a river at a diversion point. Also, as hydraulic designs of earth channels are based on the best available information about the physical characteristics of the materials being used, there may be differences between design and actual performance.

A properly designed system may still give trouble if it is not adequately managed and maintained. In a communal scheme this calls for proper co-ordination between the farmers and cultivators and agreed procedures for (a) maintaining the common supply system, and (b) action to be taken in the event of a loss of supply which cannot immediately be rectified.

Off-farm Distribution — Piped Irrigation

The proper distribution of irrigation water to piped systems, which may be of sprinkler, drip or trickle type, depends on maintaining the supply at the correct pressure for the correct time. In any piped distribution system the pressure is of paramount importance and a reduction will have serious consequences on deliveries, and hence on water applications. The loss of pressure at a hydrant or delivery point may be caused by (a) bad design, (b) failure at the source of supply (e.g. pumping), (c) leakage in a pipeline, or (d) over-drawing from another delivery point on the supply system.

Because piping and valves are expensive, false economy may have been practised at the design stage in specifying pipe and valve sizes without adequate allowance for head loss. Losses in pressure from pumping may arise also from false economy over the capacity of the pumping installation, or from poor maintenance of the machinery. Leakage in a pressure main is clearly a defect which should be corrected as soon as it is detected.

Loss of pressure through over-drawing at another delivery point could be either a design defect or a fault in operation. If a distribution system is designed to supply farm units in rotation, then any departure from the rotation involving the opening of extra hydrants or deliveries will clearly cause a drop in pressure and reduced supplies.

As with surface irrigation the satisfactory operation of a communal system will depend on proper co-ordination between the farmers and cultivators in the system and on agreed procedures in the event of losses in pressure or shortages of supply.

On-farm Distribution

There are two methods for distributing water on the farm, just as there are two methods for distribution to the farm: divided continuous flow and rotation.

Surface Irrigation

The divided continuous flow method in surface irrigation requires a continuous delivery to the farm and is appropriate primarily to the cultivation of paddy rice in which the fields are kept flooded from the time of transplanting seedlings to about two weeks before harvesting — a period of about five months. The most common practice, found all over Asia where the land is sloping, is to grow the rice on levelled terraces, and to direct the water in cascade from terrace to terrace down the slope. On flat land the water may be delivered continuously to the paddy fields from supply channels, or it may be delivered to fields in rotation from supply channels flowing continuously.

Where there is continuous flow throughout, there is little to be done to regulate the water during the growing season, except during rainfall when supplies have to be reduced to prevent fields overfilling and overtopping their bunds (boundary embankments). This means that irrigation continues day and night and the farmer and cultivator have time for weeding and other activities.

For other field and vegetable crops which are irrigated by rotation, the supply to the farm may be either continuous or in rotation with other farms. The methods of distribution and rotation on the farm depend upon the crops being grown, the cultivation practice, the slope of the land, the nature of the soils and other physical conditions.

Irrigation at Kelem, Omo River, Ethiopia (Stern).

The successful operation of a surface system on the farm will be determined by the skill of the farmer, his family and assistants. During watering they will be fully occupied in guiding the water round the farm, ensuring that the furrows or basins are properly filled and that there are no obstructions to the supply or breaks in banks or ridges which might allow water to be wasted. The water will be supplied from field ditches on the farm, and these ditches (and any control structures on them) will need to be kept in good order.

Piped Irrigation

The on-farm activities in operating a piped irrigation system with sprinklers, trickle emitters or other forms of nozzle supply will consist of assembling, dismantling and moving portable equipment as required by whatever watering plan has been adopted.

Maintenance will cover the care and servicing of all the equipment, keeping jets and nozzles in sound working order and cleaning out any material such as sediment which may cause blockages.

Chapter 5
IRRIGATION OPERATION

Surface Irrigation

Suppose we have a farm with six hectares of net cultivable land in the form of a rectangle 300m × 200m with furrows parallel to the longer sides, as shown in Figure 2. Suppose also that the farm is one of a group of six similar farms supplied from a common water source, and that each receives water for four days in an irrigation cycle of twelve days.

The soil is a clay-loam and it takes about 12 hours to complete a full irrigation application. If watering is carried out continuously for 24 hours a day, the whole farm area can be covered in four days by dividing it into eight sections, each receiving water for 12 hours. The flow required to supply the farm, including field losses, has been calculated as 25 l/s, and this is delivered to each of the eight sections in succession.

There are various ways in which the supply can be fed to the furrows, depending upon the direction and slope of the land

Small-scale irrigation in sand dunes, Eastern Libya (Stern).

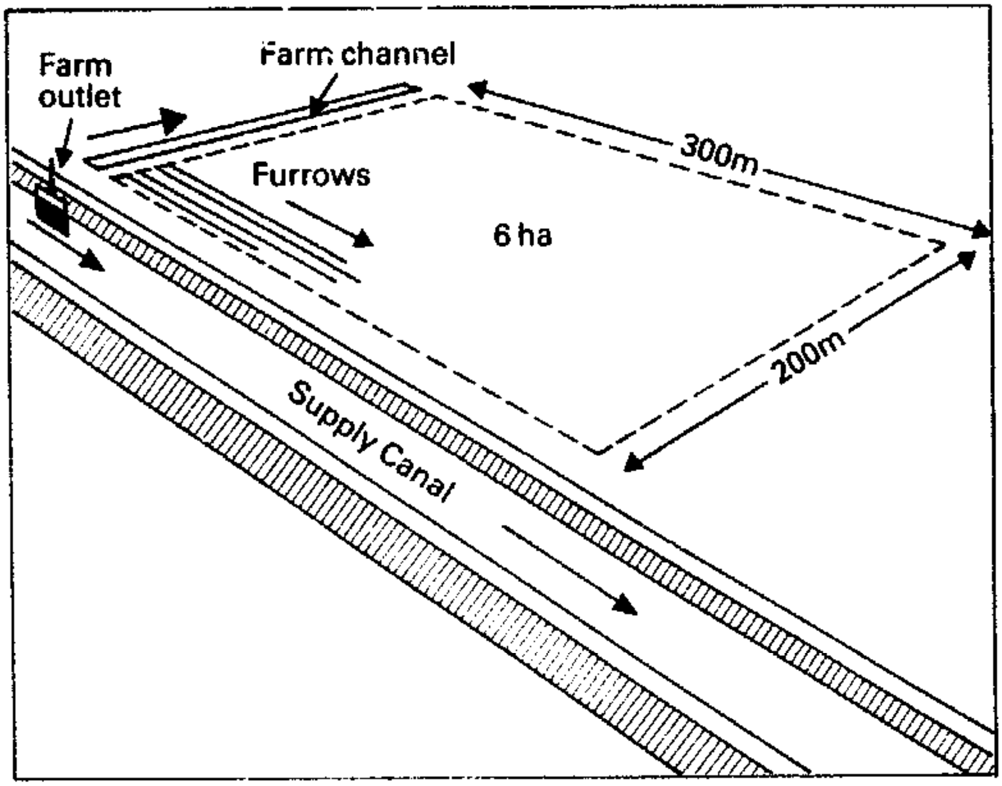


Fig.2. Six-hectare farm with surface irrigation.

and on other topographical features. Figure 3 shows some possible watering patterns. The simplest arrangement, shown in Figure 3(a), is to water eight equal furrow-length areas consecutively. Alternatively, if the land slope on the farm is not uniform or if it is more convenient for handling to divide the flow of 25 l/s, two parcels of land each one sixteenth of the total area can be watered simultaneously, as in Figure 3(b) and (c).

When irrigation supplies are provided for a fixed time in a rotation system it is important that the changes are made strictly to a pre-arranged timetable. If a four-day watering starts at, say, 0600 hours on the first day then it must be completed 96 hours later at 0600 hours on the fifth day. During watering the changes on the farm would then be made at 0600 and 1800 hours each day.

If irrigation is carried out for only 12 hours a day, during daylight, the area to be covered in each 12-hour period would then have to be one quarter instead of one eighth of the total area, and the supply to the farm increased from 25 l/s to 50 l/s, provided the soil could accept watering at the higher rate.

The operation of other surface irrigation methods will be similar to that described above. Water will be delivered to

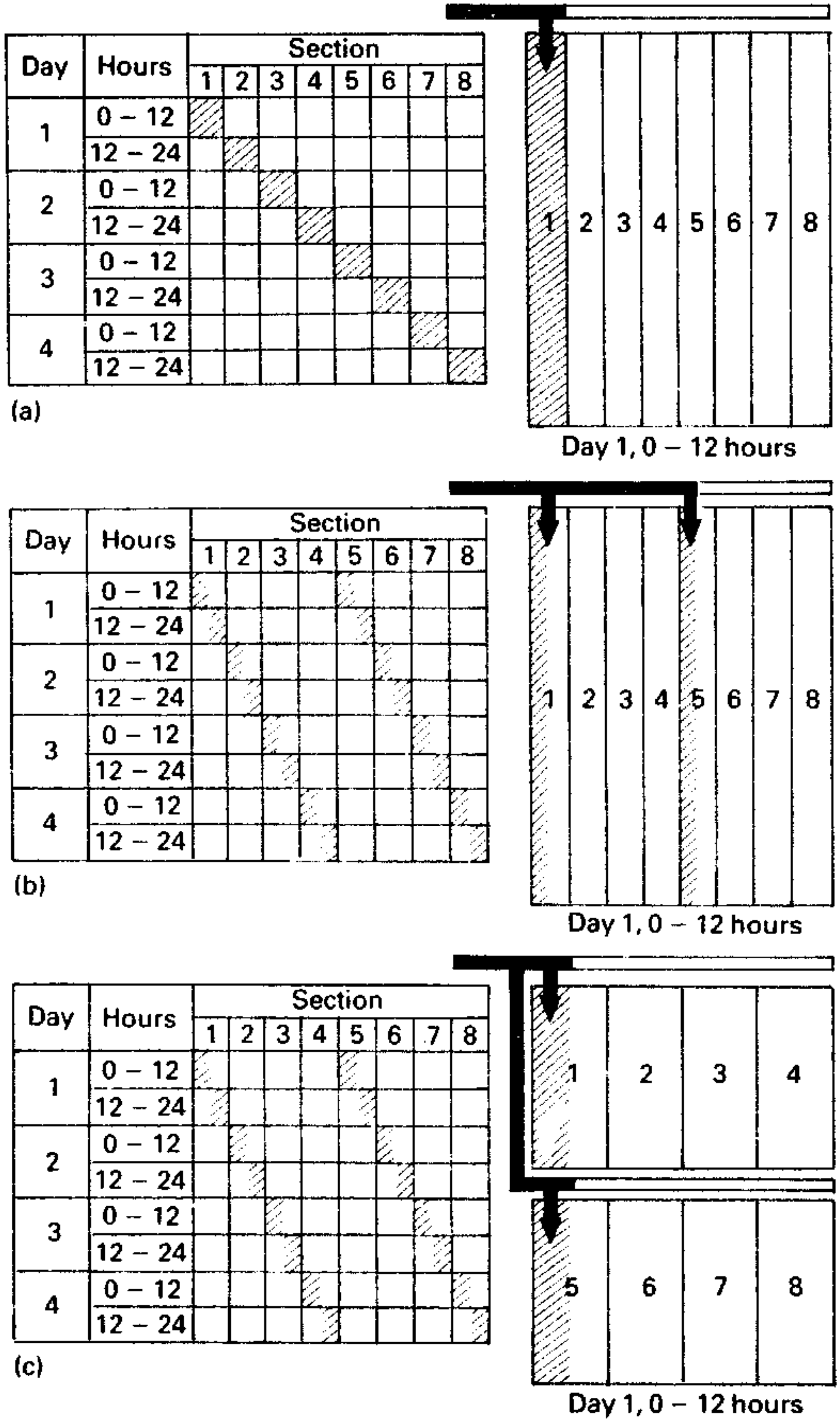
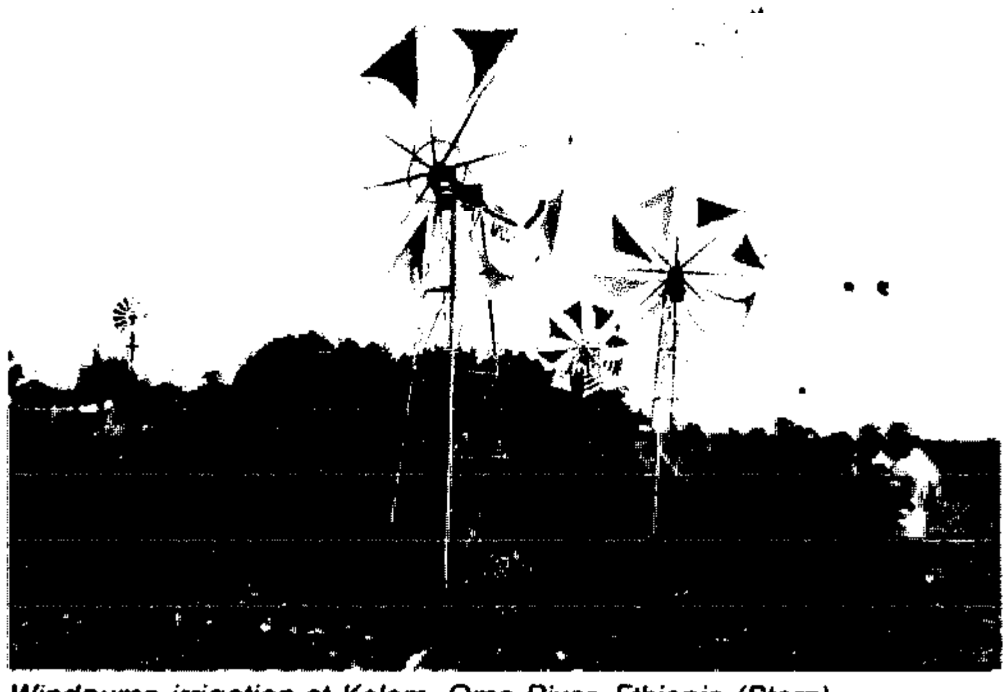


Fig.3. Six-hectare farm — surface irrigation watering patterns.

basins, border strips and corrugations in quantities and at rates determined from physical and agricultural requirements. The total flow to a farm will be apportioned to different parts of the cultivated area in succession until the whole area is watered during the time of supply. In the case of trickle irrigation, where lateral lines of small diameter plastic pipes take the place of furrows, groups of lines are watered simultaneously for as long as is necessary to wet the crop root zones. The number of lines which can be watered simultaneously depends on the design of the system and the supply available.

Maintenance of Trickle Irrigation Equipment

The main problem to be overcome in ensuring the satisfactory operation of trickle irrigation is the blockage of the fine apertures in the emitters. This can arise from sand and silt particles in the water, chemicals which precipitate in the emitters, algae growth, bacterial slimes and fertilizer deposit. As there may be between 12,000 and 15,000 emitters per hectare, cleaning them would be a formidable operation, and attention is therefore concentrated on maintaining the quality of the water source. This means, almost invariably, that the water is filtered before it is delivered to the laterals. Filters for this purpose are made easy to dismantle and clean. These filters



Windpump irrigation at Kelem, Omo River, Ethiopia (Stern).


Windpump at Kelem, Omo River, Ethiopia (Stern).

are usually installed at a control point where fertilizer may be injected into the water and where the pressure of the supply is measured. If the supply pressure drops 30 per cent from a working pressure of about $1kg/cm^2$, filters must be cleaned. This is usually done weekly but it may be necessary to clean daily.

Operation of Overhead Irrigation

A portable sprinkler overhead irrigation system is designed so that a lateral pipeline carrying sprinklers is moved in stages across the field or farm until the whole field has been covered, delivering the required irrigation application at each stage. Two possible arrangements for a two hectare field are shown in Figure 4. In both cases in this example it is assumed that a net water application of 60mm is required on a 10-day cycle. The soil intake rate is 8.5mm/h so that 60/8.5 or 7 hours are required for each application at the maximum soil intake rate.

In the first case, Figure 4(a), the equipment chosen can provide a net application after field losses of 8.5mm/h, requiring seven hours for an application as mentioned above. The sprinklers and laterals are spaced at 9m intervals with 13 sprinklers on the lateral and 18 lateral positions, delivering a total of 3.25 l/s through the lateral. Assuming one hour for moving and resetting the sprinkler line, the whole area will be covered in $(7 + 1) \times 18 = 144$ hours or 10 days of 14-15 hours each day. If there are 12 to 13 hours of daylight, a timetable would be worked out so that moving and resetting the line did not take place in darkness. Once set up and started, an application can continue in the dark since stopping it will be a very simple operation. An example of a timetable for this arrangement is shown in Figure 5(a).

If the sprinkler equipment chosen is that shown in Figure 4(b), with sprinklers operating at a higher pressure and therefore more widely spaced at 12m intervals with 12m between laterals, but giving a lower net rate of application of 7.5mm/h, an application of 60mm would take $60/7.5 = 8$ hours. In this case there are ten sprinklers on the line giving a total discharge of 3.7 l/s, and 13 lateral positions. With one hour for moving and resetting the line, the whole area will be covered in $(8 + 1) \times 13 = 117$ hours or ten days of 11-12 hours each day. A possible timetable for this arrangement is shown in Figure 5(b), from which it will be seen that there will be no operation during the hours of darkness.

Factors Affecting Performance

A sprinkler irrigation system is designed to provide an even application of water over the area being irrigated. This can be affected in various ways producing uneven water distribution.

Wind. Without wind the wetting pattern of a sprinkler is

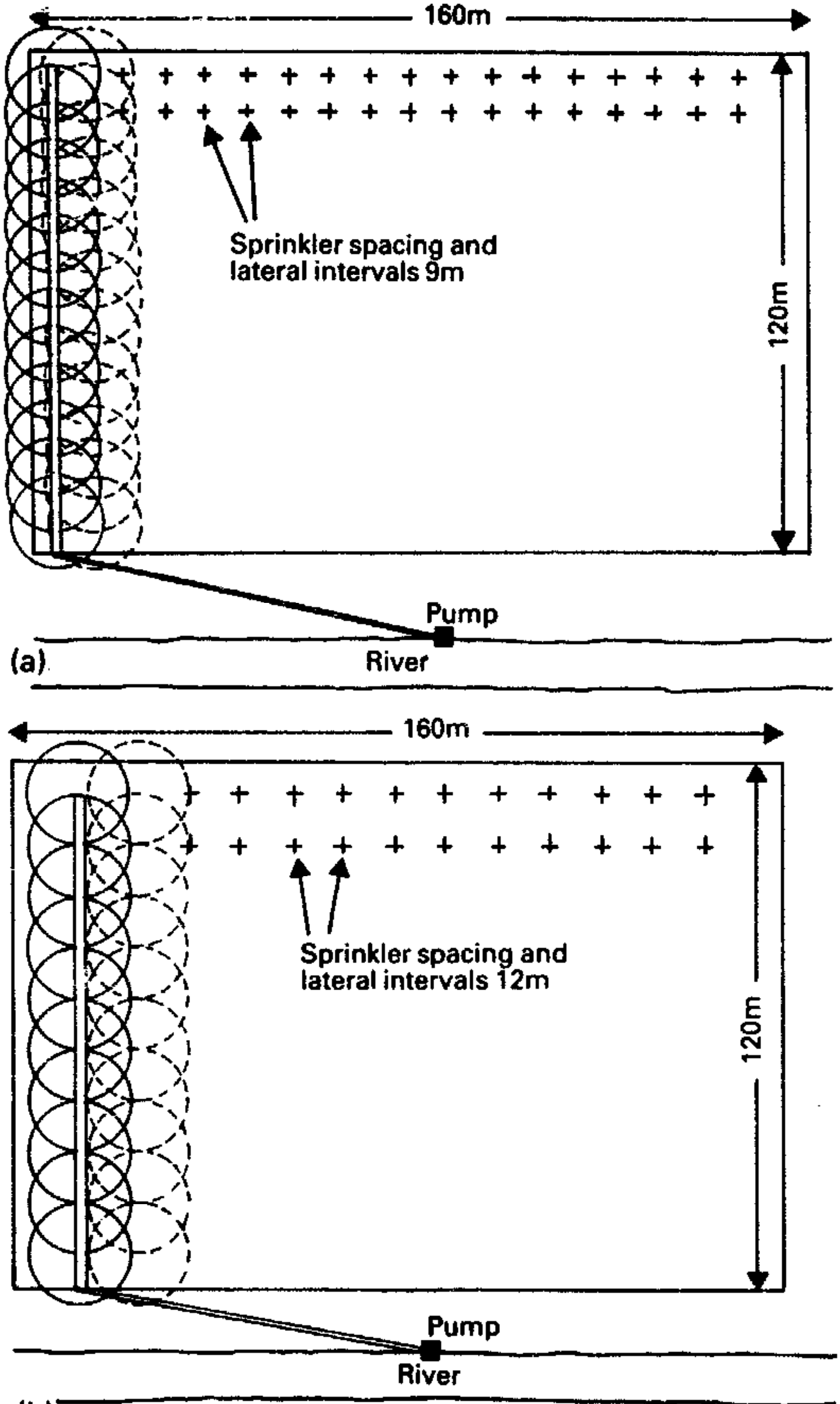
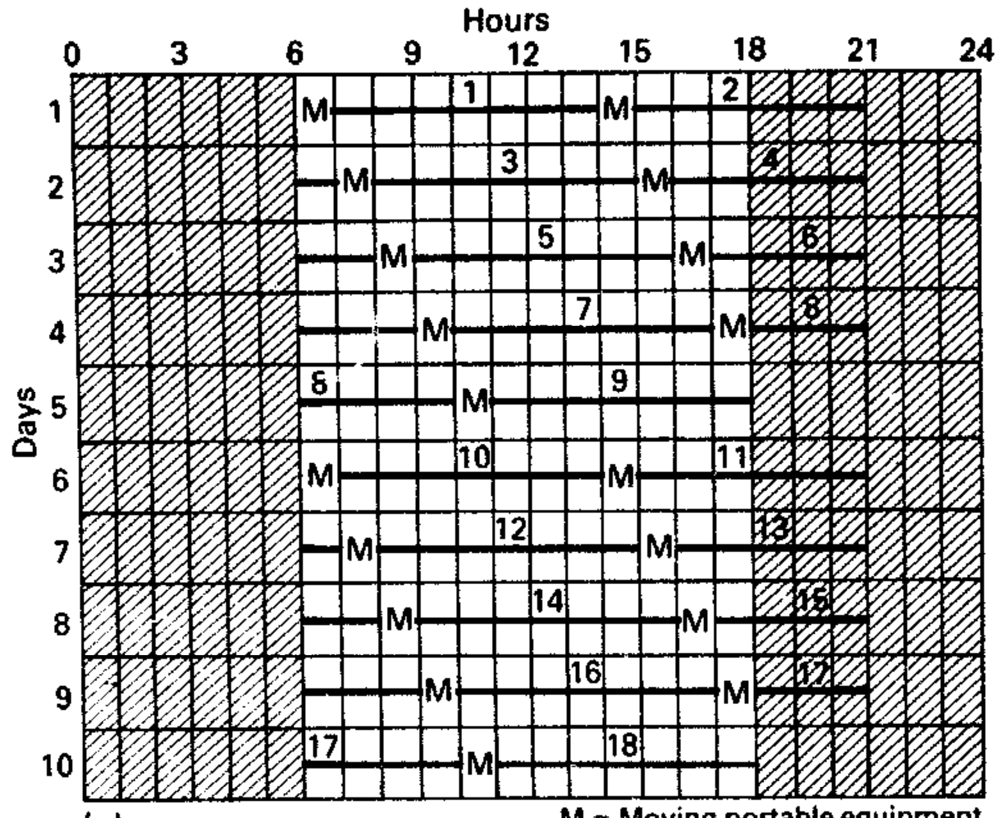
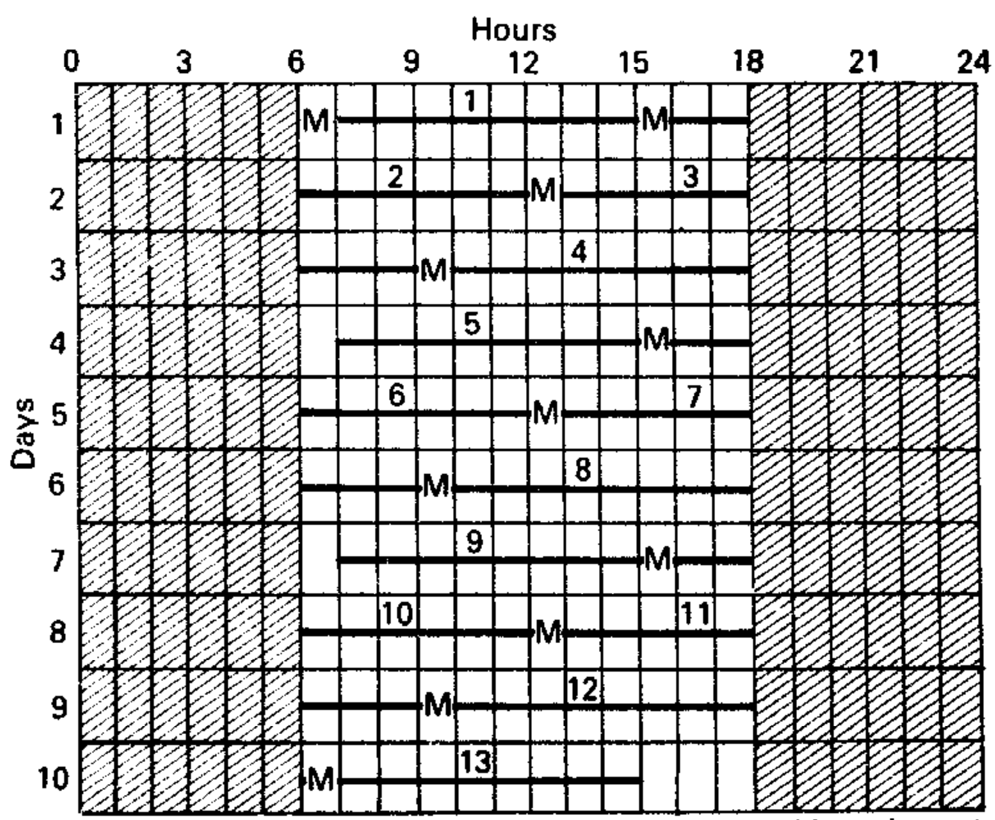


Fig.4. Possible arrangements for a small sprinkler irrigation system.



(a)



(b)

Fig.5. Timetables for the schemes in Fig.4.

circular with the sprinkler at the centre. The effect of wind is to distort this wetting pattern, as shown in Figure 6; the stronger the wind the greater the distortion. To reduce the effect of wind the sprinklers can be placed closer together.

Even light winds up to about 5m/s will seriously affect the wetting patterns of sprinklers. When wind speeds are 7m/s and over it is generally advisable not to use sprinklers, particularly if the winds are hot and dry. In many arid regions the first half of the day can be comparatively still with strong hot winds developing in the afternoon, dying away again at nightfall. Under such conditions it may be advisable to irrigate through the night and until about midday the next day.

Operating pressure. If the operating pressure of a sprinkler is significantly above or below its designed pressure this can seriously affect water distribution, giving an uneven application over the circular wetted pattern. If the pressure is too low the water jet does not break up easily and much of the water falls some distance from the sprinkler. If the pressure is too high the jet breaks up into too small particles and most of the water falls too near the sprinkler.

Pipe damage. Portable pipes can easily become damaged in use if they are not treated carefully. Dents will increase pipe friction, as also will pitting, rusting, chemical scale and bacterial slime.

Variations in ground level. If a sprinkler lateral is laid uphill or downhill the pressure in the lateral will be affected by the rise or fall along the line. On rising ground this will appear as a pressure loss increasing along the line. If the line is on falling

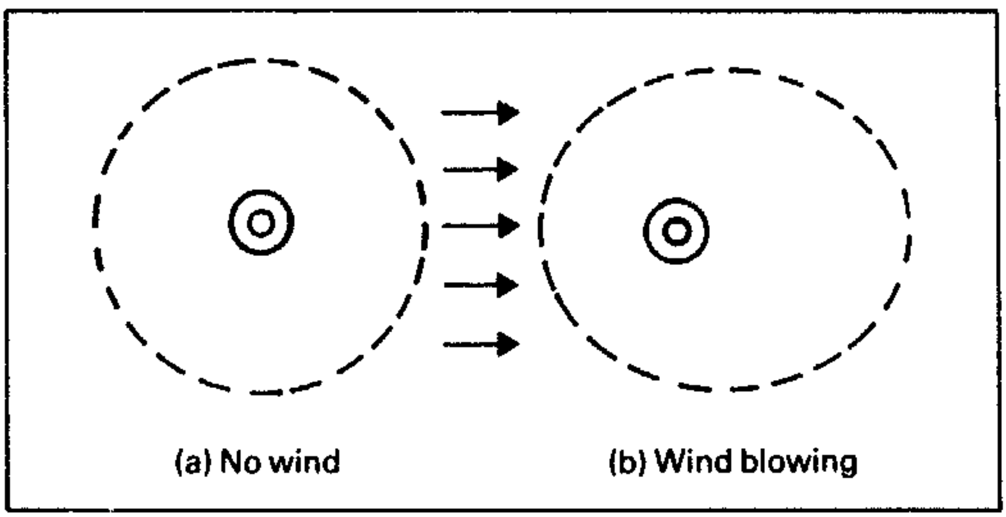


Fig.6. Wind distortion of sprinkler wetted area.

ground there will be a gain of pressure along the line.

Water hammer. Water hammer is a common feature in many pipe distribution systems. It is a vibration in the pipe system which is caused by a sudden change in the operation of the system. This can be brought about by starting and stopping a pump, by suddenly closing a valve or a hydrant, by a sudden blockage in the system or by a vehicle driving over a length of flexible hosepipe. Water hammer can be prevented by avoiding sudden changes in operation, and by starting and stopping the flow of water slowly.

Care and Maintenance of Portable Equipment

Portable Pipes

Portable pipes are easily damaged with continual rough handling. They should always be handled carefully and not thrown about either in the field or when stacking, as they can be dented or bent easily. Pipes should not be walked on or driven over by vehicles.

At the end of an irrigation season pipes should be stored under cover if possible, clear of the ground, on storage racks. Pipes should be sufficiently supported so that they do not sag in the middle. Special care needs to be taken to ensure that pipe couplers are maintained undamaged and in good working order. The sealing rings of pipe joints should be regularly inspected. At the end of the season these rings should be removed from couplers and stored separately.

Valves

Valves should always be opened and closed slowly to avoid damage to the pipe system and pumps from water hammer. When valves are stored at the end of the season they should be left slightly open to prevent the rubber seal sticking to the valve seating.

Rotating Sprinklers

When rotating sprinklers are in use care should be taken to ensure that nozzles are completely free of any obstruction. On no account should obstructions be removed from a nozzle with a sharp metal object such as a screwdriver. The obstruction should be removed gently without damage to the bore of the nozzle. Sprinklers should also be checked to ensure that the swing arms are free to rotate and that the body of each sprinkler is free to rotate on its main bearing.

At the end of the irrigation season all sprinkler nozzles should be checked for damage and wear. Water carrying silt or sand can quickly enlarge a nozzle diameter and if wear is serious the nozzle will have to be replaced.

Other Overhead Irrigation Systems

The watering principles for operating other overhead irrigation systems such as rain-guns, rotating booms and mobile spray lines are the same as those for conventional sprinkler irrigation. These larger, more automatic systems which are best suited to large-scale plantation type farming, handle more water and distribute it over wider areas. But operating programmes are planned in the same way as for smaller systems, relating to cropping and soil characteristics and required water applications.

The maintenance requirements for this type of equipment are similar to those for sprinkler irrigation already described. Nozzles and jets must be kept clear of obstructions, pipes and other movable equipment must not be handled roughly and all working parts such as joints, valves and other components must be properly maintained in good working order.

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Chapter 6
DRAINAGE

Drainage is an essential feature of most irrigation schemes. In certain situations where land is sloping or where soils are light and sandy, much of the surplus water will be carried away naturally and drainage works may be necessary only to protect the soil from erosion. In areas where the natural water table is high and there are risks from soil salinity, drainage becomes a permanent operation. In other areas drainage may be necessary to reduce waterlogging and flooding occasionally after heavy rainfall. In all cases drainage begins in the field.

Field Drains

Field drains are usually open ditches which collect surface run-off from furrows, basins or paddy fields and shallow groundwater return flow from irrigation. Where irrigation is carried out on hillsides drainage works are needed to control the run-off so that it does not carry the soil with it.

On flat land blocked drains will soon cause flooding or waterlogging; this will damage standing crops and can interfere with many other agricultural operations on the farm. It is in the interest of every farmer or cultivator to keep his drains clear and in working order.

Collector and Main Drains

Where the drainage from several farms or holdings is discharged into a collector drain or a main drain, the responsibility for maintaining the shared system needs to be clearly defined and understood. This can present many problems.

In order to cater for extreme conditions a drain has to be excavated to a capacity far in excess of that needed for normal use. This results in slow-flowing shallow water in the drain for much of the time, creating conditions which encourage the growth of vegetation. Normally the drain works satisfactorily despite the presence of vegetation, and those who are responsible for maintaining it tend to forget their obligations to keep the waterway clear for the exceptional flow following storm rainfall. Then, under storm conditions, flooding results and crops and property are damaged.

The physical operation of keeping a drainage channel clear is similar to that required for any open channel. Maintenance operations are best carried out during a dry season when there is very little drainage water flowing. Grass, reeds and other vegetation have to be removed and if the drain is silted, silt clearance will also be necessary.

After heavy flood flows, drainage channels should be checked for erosion damage, blockage with tree trunks and other floating debris. If there are masonry or concrete structures on a drain, these also should be inspected for damage after flood flows and repaired as necessary.

The repair and maintenance of a drainage system can be expensive, particularly if earth-moving machinery is needed for channel clearance, or if masonry or concrete structures have to be repaired. The allocation of funds for this type of work is often given low priority by rural communities, with the result that when the work has to be done there is no money to pay for it. As serious damage is usually the result of poor maintenance, these heavy and costly repair works can be avoided by more attention to routine maintenance.

Further Reading

Bureau of Reclamation, *Drainage Manual*, US Department of the Interior, Washington, USA, 1978.

Chapter 7
HEALTH ASPECTS IN FARM IRRIGATION

Although irrigation under the right conditions is an agricultural, economic and social benefit, it may also create a health hazard through the distribution and use of water. A relationship between water and health has been known for many centuries but it is only a little over 100 years ago since this relationship began to be understood, and the causes of infection from certain diseases were identified with water.

Water-related Diseases

Infective diseases related to water may be classified into three groups:

(a) Water-borne, in which infective organisms are transmitted by water.

(b) Water-based, in which infections are transmitted through an aquatic invertebrate animal.

(c) Water-related, in which infections are spread by insects which depend on water.

Some of the more common infective diseases under these categories are given in Table 1.

Table 1. A Classification of Water-related Diseases*

Category and Disease	*Means of Transmission*
A. WATER-BORNE	
Typhoid Cholera Dysentery Infective Hepatitis	Faeces of infected person contaminate water — drinking contaminated water.
B. WATER-BASED	
Bilharzia (Schistosomiasis)	Faeces or urine contaminate water — skin-contact with, or drinking, contaminated water.
Guinea Worm	Infected blister bursting in water — drinking contaminated water.

C. WATER-RELATED INSECTS

(1) Breeding in water	
Malaria Yellow Fever	Mosquito biting infected person and then others.
(2) Habitat near water	
Sleeping Sickness (Trypanosomiasis)	Tsetse fly biting infected person and then others.
River Blindness (onchocerciasis)	Blackfly biting infected person and then others.

*After Richard Feachem *et al, Water Wastes and Health in Hot Climates*, p.82.

The water-borne diseases are usually transmitted by drinking water contaminated with the faeces of infected people. The water-based diseases are worm infections, in which the human body serves as the host for worms, the eggs or larvae of which pass into water with human excreta and then back into human beings. In the case of Bilharzia the larvae enter the bodies of freshwater snails where they multiply and are then returned to the water, re-entering the human body either directly through the skin, or by drinking contaminated water. In the case of Guinea Worm, transmission is by drinking contaminated water.

Water-related infections are transmitted through insect bites. The most common and widespread of these insect-borne diseases is Malaria which is transmitted from one person to another by certain types of biting mosquito, which breed in standing water. Yellow Fever and Filariasis (a group of worm infections which includes Elephantiasis) are also transmitted through the bites of mosquitoes which breed in standing water. Sleeping Sickness in Africa is transmitted by the Tsetse fly which lives in forest areas near water. River Blindness is transmitted by the Blackfly which breeds in flowing turbulent water.

The Effects of Irrigation

Irrigation can increase health hazards simply by providing conditions more favourable to the transmission of diseases which are related to water. This applies more to surface irrigation methods which cause water to stand, either in storage or in furrows or pools in the fields. Earth canal distribution systems provide conditions favourable to Bilharzia. Any activity near a river, such as the operation and maintenance of a diversion works or a pumping station and a supply canal, will expose people so engaged to any disease-carrying insects in the vicinity. The spread of diseases is not an inevitable consequence of irrigation, however, and the incidence of disease can be very much reduced by taking certain precautions.

Preventative Measures

In a warm climate it is very difficult to stop people washing, bathing in and drinking any water that is accessible. It is well nigh impossible to stop children doing these things. Any measures to reduce the incidence of water-related diseases must therefore concentrate on the elimination of contamination together with general health education.

Sanitation

With a number of these diseases (see Table 1) water is contaminated by human faeces or urine and this can be eliminated by improved sanitation. This is easier said than done because in most rural areas there are no sanitary facilities in the field, and people tend to defecate near water where they can also wash and where there is often more vegetation affording privacy. Even if latrines exist near their homes, these may be a long way from the fields in which they are working.

Weeding Canals

As the freshwater snail is an indispensable link in the life-cycle of the Bilharzia organism, destruction of the snail will greatly reduce the spread of infection. Chemical methods for doing this have been tried, but generally these have not been very successful because the chemicals themselves are a form of inorganic pollution to the water. The snails live in water weeds, and therefore keeping an earth channel clear of weeds destroys the snails' habitat and does much to eliminate these hosts.

A very serious consequence of weeding canals by manual labour is the direct exposure of the people doing the weeding to Bilharzia infection. This problem is particularly grave in the Gezira Irrigation Scheme of Sudan, where water is stored overnight in the minor (or secondary) canals. It is difficult to find an easy solution to this in existing schemes but it should be a priority consideration at the design stage of a new scheme.

Diamant[6] recommends a minimum velocity of 0.3 m/s for all irrigation channels, to reduce weed growth.

Drinking Water

As drinking contaminated water is the principal source of infection of many diseases the provision of safe drinking water and health education will do much to reduce infection. Even if people have access to safe water near their homes, this may be far from the fields, however, and after physical labour in a hot climate it may be very difficult to prevent people drinking from a nearby irrigation channel.

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