Irrigation

Contents

1. Scope

It is not just in arid climatic zones that irrigation and drainage are today increasingly coming to play an essential role in **agriculture**. Sprinkler systems or other types of irrigation schemes are also used in **rain-fed farming** to raise production and/or provide a safeguard against unfavourable weather conditions. Irrigation is the only way of permitting arable farming in some places at all; it has made it possible, for example, to reclaim what was once desert or steppe in countries such as Egypt, Israel, India and Mexico.

Apart from the demands of the market and the progressively more monetary nature of rural trade, it is above all rapid population growth that is making it necessary to introduce or improve (artificial) irrigation as one means of **raising production** on land which is in some cases in increasingly short supply. High growth rates are thus likely in this sector, which means that the **importance of providing a water supply** and the **quantity of water required** will both **increase dramatically**.

While in many places totally **unutilised water resources** are still to be found or existing resources are used on only a moderate scale, the **provision of a water supply** has already led elsewhere to immense and generally **irreversible ecological damage**.

Just as **wastewater disposal** plays a significant role in drinking-water or process-water supply systems (cf. environmental briefs Wastewater Disposal and Urban Water Supply), irrigation must always be accompanied by **drainage** measures. Although efficient drainage is often guaranteed simply by the natural structure of the terrain, planning of water conveyance systems frequently also has to address the question of drainage.

Failure to implement drainage programmes immediately after the introduction of all-year irrigation can lead to **irreversible damage** - primarily as a result of soil salinisation - and to a rise in the groundwater. Even small-scale irrigation projects have given rise in many countries to **salinisation problems** (= adverse influence on the soil's nutrient balance) in cases where no drainage system exists. Depending on soil type, between 10% and 20% of the irrigation water should be drained off in order to prevent long-term damage from salinisation.

In the light of the increasing demand for irrigation water and the related **water supply and conveyance costs**, there is a risk that drainage measures may be spread over a lengthy period of time or realised on as small a scale as possible. There is also a tendency for water-saving but more expensive conveyance systems to be over-hastily rejected on the grounds of cost in favour of open, unlined or overstrained low-tech systems. **Insufficient use has been made to date of "appropriate" solutions** which are not only inexpensive but also effective and thus help to conserve resources.

Irrigation covers the following **areas**:

- provision of a water supply through storage in small reservoirs, use of river water and tapping of groundwater
- conveyance and distribution of irrigation water by open channels and pipelines
- application systems of irrigation water by means of flooding, basins, border strips, rills, sprinkling, drop irrigation and subsurface
- drainage by means of open and concealed systems

This environmental brief is concerned only with small and medium-sized irrigation projects. It deliberately excludes large-scale dam projects and irrigation schemes for entire regions with measures involving entire river systems.

2. Environmental impacts and protective measures

Given that water resources are limited, water consumption is rising and irrigation and drainage systems are often inappropriate to their context, priority should be given to

- considering the question of water supply, as projects entailing large-scale utilisation of natural resources generally involve major environmental risks;
- making sure that irrigation and drainage measures are well matched;
- establishing whether the technology of the measures implemented is geared to the financial capacity of the country concerned and to other specific conditions (e.g. available technical know-how) and thus ensures that potential environmental hazards can be reduced or ruled out.

2.1 Impacts on components of the natural environment

2.1.1 Supply, conveyance and distribution of water

Depending on the activity involved, every aspect of the environment (soil, water, air/climate, species, biotopes/landscape) may be affected. Impacts on the **soil** vary in nature. The embankments of small reservoirs and open channels for conveying water can create **erosion risks**. All construction measures change (destroy) the soil structure, while irrigation itself alters the soil dynamics. The risk of erosion can be counteracted by stabilising embankments, for example with ground-covering plants having a dense root system.

A wide variety of impacts on **water** can be observed. Although small reservoirs improve the **availability of surface water**, they may also - depending on the subsoil - cause groundwater resources to become contaminated. In addition, small reservoirs too are liable to exhibit impairment of **surface-water quality** and the **nutrient balance** (particularly as a result of warming and eutrophication). It should be borne in mind that impounding measures in a particular area can reduce the available water supply in the lower reaches of the watercourse concerned. If rainfall is highly seasonal, however, the opposite effect is likely. If **river water** is used for irrigation the amount of available surface water will be reduced, while if the groundwater is tapped groundwater resources will be depleted. In the case of groundwater the quantity withdrawn depends not least on the **tapping method**. The easier (or in economic terms, the less expensive) it is to raise the water, the more wasteful the use of water resources may be.

The effect which **tapping of groundwater** has on the **dimensions of water resources** is of particular significance. This may apply even to small-scale schemes or micro-projects (e.g. where cropping areas are situated primarily on geological basement formations, often with few water reservoirs, or in wadi systems on the fringes of the Sahara). Tapping of **fossil groundwater** with no natural inflow will by definition exceed the available quantity. It thus constitutes **destructive exploitation** of a vital resource and should be permitted only in exceptional justified cases.

There is a **danger** that the groundwater may become **contaminated** if the **sites where water is raised are left unprotected** and/or if substances such as faecal matter or oil are discharged into the water.

In addition to having effects on the **microclimate, small reservoirs** also have an influence on the range of **species** found in the area. However, the precise nature of their impacts in the latter sphere is **not clear**. Certain species of flora and fauna may be destroyed or displaced, while the water and its surroundings may favour other species or indeed attract them. A (negligible) **reduction in dry biotopes** must be set against **the creation of new aquatic biotopes**. Wetlands may increase (above all around the edges of the reservoir) or decrease (as a result of reduced flow in the lower reaches of the watercourse). Increases and decreases in the presence of particular species may have **both positive and negative consequences** for man and nature. Particular attention must be paid to the effects of **fluctuations in the reservoir's water level**. It can be assumed that small reservoirs make for a more varied landscape.

Open water conveyance and distribution systems lead to **water losses** on account of **evaporation** and have a (slight) influence on the **microclimate**. Water conveyance systems in the form of earth cross-sections may have effects on flora and fauna; as is the case with small reservoirs, however, the precise nature of these effects is not clear. Depending on context, open water conveyance and distribution systems may enhance or mar the varied nature of the landscape.

Unless installed above ground, **enclosed systems** generally have only **minor impacts** on the natural environment.

2.1.2 Water application and drainage

Depending on the method used, water application - in other words the actual process of **irrigation** - can affect the **soil** to varying degrees. It is also likely to have impacts on **water, species** and the **microclimate**. The main problem encountered with many irrigation methods is that of **soil salinisation**, particularly if the system is poorly managed and there is no drainage. In simplified terms, salinisation can be defined as an **extreme nutrient imbalance** (excess of salts) and **damage to the soil structure** (puddling, crusting, compaction).

Traditional irrigation methods often involve **water dosage problems** (e.g. flood, basin, border-strip and furrow irrigation). The possibility of **erosion** cannot be ruled out where such techniques are used. Sprinkling and in particular drop irrigation may also lead to **salinisation** if not carried out properly.

Particular attention should be paid to methods in which **modern components** have been inappropriately **added** to **traditional techniques**. Water conveyance systems or application methods that gave rise to no problems in the past can cause **erosion or scouring** if the **introduction of power pumps** changes the way in which the water is supplied. It may be necessary for the entire system to be modified at considerable expense.

All irrigation methods can have adverse effects on the soil microflora and microfauna. When **geared to local conditions and properly managed**, however, irrigation can also **contribute to the nutrient balance** and **benefit microflora and microfauna**.

Drainage can do much to counteract the problem of salinisation. It thus **contributes to the nutrient balance** and to **stabilising the soil structure**. Water application methods can be used to achieve at least partial desalinisation.

Drainage ditches in the form of earth cross-sections create a **risk of erosion**. Impacts affecting water are likely to take two forms. Traditional irrigation methods, sprinkling and open drainage systems cause **surface water to be lost** through **evaporation**. However, traditional methods and drainage ditches in the form of earth cross-sections can also induce **recharging of the groundwater**. Where over-irrigation recharges the groundwater, the crops may be adversely affected because the groundwater level is too high.

In arid regions, **seepage** represents a **waste of water** and can lead to over-exploitation of resources. Priority should therefore be given to **lining the water conveyance systems**. Evaporation losses in conveyance systems tend to be negligible (e.g. 1 - 2% in desert regions compared to seepage losses of up to 85% from unlined water conveyance systems in sandy terrain). Traditional irrigation methods, sprinkling and open drainage systems can all have an influence on the **microclimate**. Depending on local conditions, their effects may be **beneficial** (e.g. as regards oasis ecology) or **detrimental**.

All water application methods are likely to have an influence on **flora**. The natural balance of species will generally be disturbed, while the **number of species** may either **increase** or **decrease**.

As only relatively **small irrigated areas** are involved, there are still enough **refuges** available to the local **fauna** to prevent permanent changes in the balance and number of species. The fauna are more likely to be affected by the enlargement and use of the cropping area per se and by the type of crop growing practised (cf. environmental brief Plant Production).

Open drainage ditches in the form of earth cross-sections can have **influences on flora and fauna**. As is the case for water conveyance systems and small reservoirs, however, the **precise** nature of these impacts cannot be defined. The same applies to the potential influence of such drainage systems on the diversity of the landscape.

2.2 Impacts on the socio-economic environment resulting from water supply, conveyance, distribution and application as well as from drainage

2.2.1 Factor requirements, labour, income and distribution

General assertions regarding impacts on the socio-economic environment are bound to be fairly vague, if indeed they are possible at all. In order to reach any conclusions, it is essential to **analyse the circumstances of the particular case in question**.

Technically sophisticated systems generally not only call for a sizeable input of capital but may also require a great deal of **energy**. Attention must be drawn to the possibility of using small reservoirs and water conveyance systems in generating energy and of meeting energy requirements by using renewable energy sources. One way of reducing the amount of external energy required is to make use of the available **water power** in cases where irrigation water is obtained from rivers (water wheels with a lift ranging from 0.5 m to over 20 m).

The major problem encountered in **operating irrigation schemes** involving new technologies is generally that of meeting the considerable **training and management needs**. Introduction of irrigation systems is usually also accompanied by a move in the direction of technically more sophisticated and more intensive forms of agriculture, which are not automatically accepted everywhere. A great deal of **advice and encouragement is required** if this difficulty is to be overcome.

Women are often **excluded** from discussion, extension services and training measures, even though they may be responsible for certain areas of farm work or may be farmers in their own right. This factor is of particular significance when traditional **technologies** are to be **replaced** by new ones.

Construction and operation of irrigation systems necessitate a considerable amount of **extra work**, particularly when labour-intensive techniques are used, and in many societies it is primarily women who bear this additional workload. Income levels are satisfactory, however, especially in the case of capital-intensive methods. **Social disparities** may be increased.

The introduction of irrigation frequently brings **financial disadvantages for women**. It is often only the **men** who are registered as the **owners** of the land covered by irrigation schemes; in other cases, men may simply appropriate the irrigated land, which is considerably more valuable than that used for rain-fed farming.

Farmers may run into **serious economic problems** on account of the fact that **operating, maintenance and monitoring costs** and expenditure on **renewal of irrigation systems** are often inadequately calculated at the planning stage, or as a result of sudden changes in government support policy (cuts in extension services, equipment subsidies and even water subsidies). It should be established whether the technical design and dimensioning of irrigation systems allow the systems to be **used profitably** by the farmers even under **changed conditions**.

It can generally be assumed that irrigation makes for **more reliable yields and incomes.** This is not the case, however, where workers are paid only for work performed over a **limited period**, for example during system construction or for **seasonal work**, the volume of which varies considerably. If women participate in this seasonal work their **workload** may be **increased** at the expense of other activities (feeding the family etc.).

Irrigation is likely to influence the **distribution of income** (and not just the relative incomes of men and women). Capital-intensive methods can place less prosperous farmers at a disadvantage and cause income distribution to become **more unbalanced**. Women are often excluded where conversion of land to irrigation is carried out on the basis of a loan scheme. **Social distinctions** generally increase in proportion to the technical complexity and cost of an irrigation system. **Titles to land** should therefore be **distributed** as widely as possible or **upper limits** set for ownership of land within specified areas covered by irrigation schemes.

It is important to make sure that **women's traditional land-use rights** are taken into consideration, for example by making certain that women too are entered in the cadastral register as **land owners**.

2.2.2 Health

Irrigation schemes are likely to create a variety of **health risks**. The main problems are caused by **waterborne diseases**, particularly schistosomiasis and onchocercosis, whose foci may be located at different points within the irrigation system (stagnant/flowing water). By virtue of the way in which it is transmitted (via human excretion), schistosomiasis in particular may well occur in areas being irrigated for the first time. Irrigated farming can also **promote** the spread of hookworms (Ankylostoma duodenale) and eelworms (Ascaris lumbricoides).

Malaria, which often spreads in areas where large irrigation schemes are being realised, can also constitute a problem in small-scale projects using open reservoirs and water conveyance systems. The possibility of rheumatic ailments and accident risks must likewise be taken into account. Health risks are liable to arise in cases where irrigation systems are also used to provide a **drinking-water supply** (see environmental brief Rural Water Supply). It is particularly important to raise women's awareness of these risks by means of targeted **information and education measures**, as it is usually women who are responsible for providing the family's drinking-water supply. **Vector control** measures (using chemicals) in turn create environmental hazards.

2.2.3 Subsistence, housing and leisure

Unless the land is used exclusively for **growing non-food crops**, irrigation schemes generally **contribute to subsistence** in that land owners grow food **for their own consumption** or workers are **paid in kind**. Particular efforts must be made during crop planning to **ensure** that food crops are grown (cf. environmental brief Plant Production). Irrigation in arid regions generally increases the range of food crops that can be grown.

Irrigation can cause damage to the **fabric** of houses where construction materials such as lumps of clay, tamped earth, air-dried clay bricks or materials of plant origin have been used. Houses on irrigated land can be protected against rising damp by being built with stone **foundations**.

Irrigation projects may have effects on leisure if they considerably **increase** the workload of the land owners and their families. This applies in particular in areas where only rain-fed farming was practised previously. It is often the **women and children** who are called upon to perform the extra work. In extreme cases this may prevent the children attending school or force the women to abandon other important activities.

Irrigation systems should not unnecessarily ruin the **natural landscape** or disrupt **communications**. The population should not be obliged to make long detours on account of changes in the landscape (e.g. pipelines installed above ground on supports or in/on embankments, or wide open channels). Adequate **crossing facilities**, including routes for driving livestock, should be provided (e.g. routes passing underneath system components, bridges).

2.2.4 Training and social relationships

Many irrigation methods or activities lend themselves to on-the-job **training**, although they often call for a high prior level of skill and know-how.

If activities can be organised and carried out on a **communal** basis, they can **encourage participation and social interaction**. Although irrigation can as a whole be seen as a communal task, it does not necessarily always help to consolidate social relationships. In many regions, irrigation establishes

unrestricted private ownership of land **for the first time**, with the result that neighbourly cooperation is increasingly replaced by a system of hired labour.

It is **above all women who are affected** by the decline in communal activities (e.g. fetching water or washing clothes together, possibly also communal field work). In Islamic countries, for example, such activities give women an important opportunity for communication not afforded in any other way because of the restrictions imposed by social norms.

3. Notes on the analysis and evaluation of environmental impacts

General guidelines on **quantitative water management** exist in the Federal Republic of Germany. With the exception of technical guidelines for hydraulic engineering measures, however, there are **no standards** governing activities in connection with irrigation schemes. Standards could nevertheless be laid down to cover aspects such as

- permissible changes in the groundwater level resulting from tapping (lowering), seepage (rise) and drainage (lowering);
- **reduction of flow** where river water is used for irrigation purposes;
- **limits on use** of surface water, in order to prevent adverse effects on and/or destruction of aquatic organisms (defining minimum water quantity and depth etc.);
- the **quality of the irrigation water**, e.g. in order to prevent soil salinisation;
- the **degree of salinity** of flowing water where it receives discharges from drainage systems, etc.

The following could also serve as the **starting points** for standards governing measures affecting the water balance:

- The **quantity of groundwater used** must not exceed the medium-term recharge rate (often difficult to ascertain).
- **Fossil groundwater** may be **tapped** only in cases of extreme need.
- The **low-water flow** represents the **critical factor** for surface water quality when water is drawn off.

4. Interaction with other sectors

The environmental brief **Plant Production** should be additionally consulted in order to assess the impacts originating from crops grown on irrigated land.

The **individual areas involved in irrigation** also **interact** with other agricultural subsectors, including the following:

- **Plant protection**, in respect of the need to ensure that irrigation and drainage water is free of pollutants, for drainage water particularly in cases where it is discharged into surface water or

groundwater
- **Livestock farming**
- **Fisheries and aquaculture**
- **Agricultural engineering**, e.g. in connection with use of organic manures and mineral fertilisers and their possible polluting effects

Use of water resources for irrigation purposes may **conflict** with other interests, above all in the light of the general demand for **conservation of natural resources**. Utilisation of artesian and/or fossil groundwater represents just one example of such a conflict. Other conflicts may arise with respect to the **wastewater and rainwater** subsector, leading to impacts on **health** in particular.

In certain cases there may also be links with

- **large-scale hydraulic engineering**, in connection with dams and weirs;
- **rural hydraulic engineering**, above all in connection with weirs (use of water for irrigation), contour canals and small earth embankments forming part of water storage facilities;
- **wastewater disposal**, in connection with disposal of wastewater by means of discharge onto agricultural land or into receiving waters (surface waters).

5. Summary assessment of environmental relevance

Irrigation systems of **virtually every degree of technical complexity** can be planned and constructed with a minimum of environmental (and social) impacts provided that the scheme incorporates **measures appropriate** from the ecological, technological, economic and social viewpoints. Caution must be exercised during assessment, as financial constraints and other criteria often restrict essential measures to a minimum. The **technical practicality** of an irrigation system must be established, since it represents an important prerequisite for success. Although raising technical standards may have impacts on the natural environment, it is above all within the context of the socio-economic environment that problems are most likely to arise.

The **small-scale irrigation projects** discussed here are bound to have **fewer impacts** than measures which involve large-scale hydraulic engineering schemes or raising large quantities of groundwater. The potential **technological solutions** are often **interchangeable**; in other words, a number of different options may produce the same result, making it possible to choose the soundest alternative from the environmental viewpoint. It should be remembered that **traditional irrigation technologies** may well be geared to the natural environment, but can cause **environmental problems** if used **in combination** with "modern" technologies. Where appropriate combinations of old and new technologies are used, however, they can help to prevent negative impacts on both the natural and social environment.

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