PRINCIPLES OF THE WATER DEVELOPMENT

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PRINCIPLES OF THE WATER DEVELOPMENT

- water development is essential for food security
- focus on low-cost solutions and development models which stimulate self-reliance and management responsibility at local level
- holistic approach addressing constraints at technical, institutional and economic levels

Background

FOOD FOR ALL

Women farmers transplanting irrigated rice in Hyderabad District, India

Without irrigation, there would not be enough food to feed the present world population of some 6 000 million people.

IRRIGATED VERSUS RAINFED FOOD PRODUCTION

Farmer distributing the water from an irrigation canal to his fields

Forty percent of all crops produced are grown under irrigation on ten percent of the total area under cultivation.

Increasing the **productivity of rainfed agriculture**, which still supplies some 60 percent of the world's food, would make a significant impact on global food production.

However, the potential to improve yields depends strongly on **rainfall patterns**. In dry areas, rainwater harvesting can both reduce risk and increase yields.

Rainwater harvesting often has double or triple benefits:
- not only does it provide more water for the crop but
-it also adds to the recharging of groundwater and
- helps reducing soil erosion.

Risk management is crucial in rainfed agriculture. The higher the risk of crop reductions from droughts and dry spells, the lower the likelihood that farmers will invest in inputs such as fertilizers, improved varieties and pest management.
In situ soil and water conservation contributes relatively little to reducing risks in rainfed agriculture.

Water development and irrigation

are essential to increase food security and to reduce the variability of food production in most food deficit countries.

It is said that most of the production increase required to feed the world population in the next 30 years, has to come from irrigated agriculture.

WATER USE

Irrigated rice terraces in Indonesia

The irrigation subsector is the largest single water user on earth. Some 70 percent of surface water and groundwater abstraction worldwide is used for irrigation purposes; in semi-arid countries, the figure can be as high as 90 percent. The total water use for irrigated rice production alone amounts to some 1 500 000 million m^3 annually.

Background

IRRIGATION TRADITION

Traditional irrigation (foggan) in Timinoun, southern Algeria

Over 5 000 years ago, runoff irrigation was practised in Yava, Israel. At the same time, so-called hydraulic societies developed in large river valleys, such as the Yangtse in China, Indus in India, Euphrates in Iraq and Nile in Egypt. Laws and by-laws regulated the distribution of irrigation water, which dominated the life cycle of farmers and citizens alike.

Some 1 500 years ago, the Marib dam in Yemen raised the water level of a non-perennial river to divert floods for irrigation purposes.

Water development and irrigation

Three critical preconditions are required to bring this about and to close the threatened gap between food production and consumption:

investment in water development,

good government policies, and

an educated labour force with high quality technical support.

Investment in water development

- Water shortage vs. Water resources
- Rainfall must be better managed and used more efficiently
- Water management techniques, including full-scale irrigation, are required to unleash the potential of modern agronomy.

Good government policies

- Transparent and enforcable property laws
- Maintenance of local and regional security
- Sound management of the macro-economy
- Governments can create or ruin the enabling environment

Educated labour force

Productive agriculture requires a wide range of **technical skills**, either in the public or the private domain.

Statistics show that ….

… global irrigation expansion has declined in recent years and now stands at about 0.7 % per year as against 2.5 % in the 70^{s}, however, with large regional variations.

Among the reasons for the **decline in irrigation** expansion are the exhaustion of suitable sites in major irrigation countries in Asia and the increasing costs of new developments.

In Africa irrigation development has been, for a variety of reasons, very expensive.

Small-scale irrigation developments ….

…. allow for more participation and decision-making of farmers are generally most successful.

Whilst large schemes have economics of scale, the larger the scheme the more anonymous the decision making process, the higher the overhead and administration costs, and the greater the chances of conflicts between farmers and management.

Background

e.g. PLANNING PROCESS

Visualization of land and water resources in a villagers' meeting

From the outset of any irrigation development or scheme rehabilitation, all the farmers concerned should participate in the planning process without gender bias. Suitable communication tools are available to ensure farmers' participation in resources assessment, decision making and fund raising.

Increase of agricultural production

1) Improved management of all agronomic inputs (fertilisers, water)
2) Sound techniques combined to knowledge
3) Critical assessment of potentiality and limitations

Background

e.g. OPERATION AND MAINTENANCE

Farmers clearing weeds and other detritus from irrigation canals

The organization of operation and maintenance (O&M) activities should be based on the cultural traditions of the target population, best established through a water users' association (WUA) without any gender bias.

On-farm irrigation technology

When selecting the irrigation method it is important not only to consider the technical suitability for prevailing crop-soil-water conditions but also the ability of farmers to use and **maintain** the equipment.

Presence of local manufactures are a precondition for the use of mechanical irrigation equipment.

e.g. POOR DRAINAGE

Abandoned field due to salinization

Poor drainage, as well as over-irrigation, can lead to waterlogging, which is the main cause of salinization of irrigated soils. It is estimated that, worldwide, the irrigated area lost due to salinization every year exceeds the new area brought under irrigation.

Techniques for water supply and distribution

SURFACE WATER RESOURCES

- Direct abstraction from rivers
- Storage reservoirs

e.g. TOTAL STREAM FLOW DIVERSION FOR IRRIGATION PURPOSES

Intake weir to command 150 ha for rice production and 250 ha for food production, such as maize and beans in Mahango village, Mbeya, Tanzania

Total stream flow diversion should be avoided, otherwise negative impacts on water availability downstream of the diversion dam will occur, such as:

- no drinking water for villages situated downstream along the river;
- no, or far fewer, fish;
- no water for riverine vegetation downstream of the diversion dam.

Techniques for water supply and distribution

SURFACE WATER RESOURCES

Rain water harvesting

table 8.3 **Rainwater management strategies and corresponding management options to improve yields and water productivity**

Aim	Rainwater management strategy	Purpose	Management options
Increase plant water availability	External water harvesting systems	Mitigate dry spells, protect springs, recharge groundwater, enable off-season irrigation, permit multiple uses of water	Surface microdams, subsurface tanks, farm ponds, percolation dams and tanks, diversion and recharging structures
	In-situ water-harvesting systems, soil and water conservation	Concentrate rainfall through runoff to cropped area or other use	Bunds, ridges, broad-beds and furrows, microbasins, runoff strips
		Maximize rainfall infiltration	Terracing, contour cultivation, conservation agriculture, dead furrows, staggered trenches
	Evaporation management	Reduce nonproductive evaporation	Dry planting, mulching, conservation agriculture, intercropping, windbreaks, agroforestry, early plant vigor, vegetative bunds
Increase plant water uptake capacity	Integrated soil, crop and water management	Increase proportion of water balance flowing as productive transpiration	Conservation agriculture, dry planting (early), improved crop varieties, optimum crop geometry, soil fertility management, optimum crop rotation, intercropping, pest control, organic matter management

Forms of rainwater harvesting 1/3:

- **in situ water conservation** : **by using microstructures in the field to direct water at specific plants or plant rows**

In dry areas, poor land management can greatly reduce crop yields, even to below 1 t/ha. One reason is that land degradation often affects the soil surface, leading to crust formation and other phenomena that prevent infiltration by rainwater. Most rainfall then simply runs off the land surface, collects in silt-laden torrents and produces severe gully erosion. Crops benefit little.

Alternative forms of tillage — such as turning the soil only along plant lines, deep ploughing to break up soil crusts, building raised ridges that follow the contour, growing crops in pits, and building eyebrow terraces round trees and shrubs — can improve crop yields and reduce erosion. They lead to a much more efficient use of limited rainfall.

Forms of rainwater harvesting 2/3:

•**flood irrigation** : **capturing and directing external water from the catchment area to the field in which crops are grown**

More needs to be done to cope with the effects of the dry spells that occur every year in semi-arid areas. Although these periods of drought often last less than three weeks, if they occur during sensitive growth stages — such as during flowering or grain filling — there is a high risk of serious yield reductions.

The best way of tackling the problem is to **divert rainfall** from the surrounding catchment area to the soil in which the crops are being grown. Providing the right infiltration conditions have een established, water can be stored in the soil around the crop roots for considerable periods - certainly for long enough to be of considerable use during a three-week drought.

Forms of rainwater harvesting 3/3:

•storage for supplementary irrigation :

collecting external water from the catchment area and storing it in reservoirs, ponds and other structures for use during dry periods

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collecting external water from the catchment area and storing it in reservoirs, ponds and other structures for use during dry periods

Small-scale farming can be productive in marginal rainfed areas if supplementary irrigation is available to overcome short-term droughts which are critical to the crop and reduce yield considerably. If there are cost-effective ways to store water before critical crop stages and apply it when the rain fails in these critical stages, crop production can be considerably increased.

Techniques for water supply and distribution

GROUND WATER

- Shallow groundwater
- Deep Groundwater

Background

e.g. OVERUSE OF GROUNDWATER RESOURCES FOR IRRIGATION

Pumping ground water in the arid area of Gujranwala in the Punjab, India

Over-exploitation of groundwater resources may lead to an irreversible depletion of aquifers, thereby preventing irrigated crop production. Where irrigated land is situated close to the sea and groundwater extraction excessive, seawater intrusion may force users to abandon their irrigation schemes.

Techniques for water supply and distribution

CANALS AND PIPES

- Open channels
- Pipelines

e.g. CONVEYANCE CANAL ALONG STEEP SLOPES

Conveyance canal in Qinghai Province, China

Shortage of irrigable land and deep incised valleys in mountainous areas necessitate the construction of conveyance canals over long distances along mountain slopes. This is feasible where the slopes are stable or can be stabilized at a reasonable cost. Otherwise, maintenance costs may be excessive, or mountain slides may lead to the destruction of the canals and, in the worst case, force farmers to abandon the irrigated land.

Techniques for water application

SURFACE IRRIGATION

Background

TRADITIONAL BASIN IRRIGATION

Traditional basin irrigation in Indonesia

Basin irrigation is the most widely used of all surface irrigation methods (on some 65 percent of all irrigated land) because of its simplicity. Basins can be adapted to suit many crops, soils and farming practices. Small basins are ideal for small farms growing a wide range of crops. Larger basins are well suited to large mechanized farms.

Techniques for water application

SURFACE IRRIGATION

- Basin irrigation
- Border irrigation
- Furrow irrigation

TRADITIONAL FURROW IRRIGATION

Traditional furrow irrigation

Traditional furrow irrigation is the most widely used method for row crops (on some 30 percent of all irrigated land). It is usually practised on gently sloping land, up to 2 percent in arid areas but restricted to 0.5 percent in humid areas because of the risk of erosion during intensive rainfall. Furrow irrigation is suitable for small and large farms.

Techniques for water application

SURFACE IRRIGATION

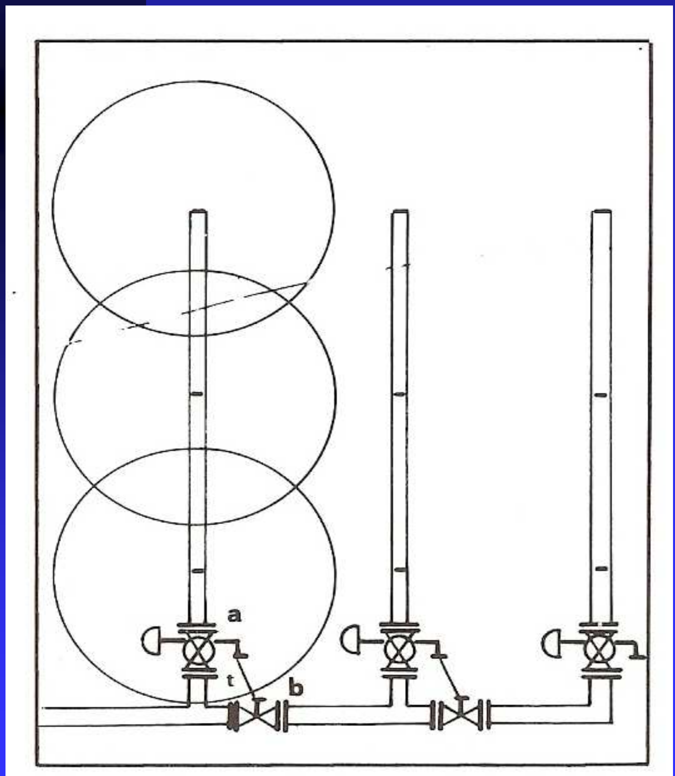
- Basin irrigation
- Border irrigation
- Furrow irrigation

TABLE 3.1 - Selecting Surface Irrigation Methods

Irrigation method	Land slope (%)				Soil infiltration	Field shape	Crops				Labour
	Humid regions		Arid regions		rate (mm/h)		Row crops	Sown, drilled crops	Flooded rice	Orchards	h/ha per irrigation
	Bare soil	Crop cover	Bare soils	Crop cover							
basin	level or <0.1% (steep slopes need terracing)				up to 30	any shape	yes	yes	yes	yes	0.5 - 1.5
border	0.5	2.0	2.0	5.0	up to 30	rectangular	yes	yes	no	yes	1 - 3
furrow	0.3	-	2.0	-	up to 30	rows of equal lenght	yes	no	yes	yes	2 - 4

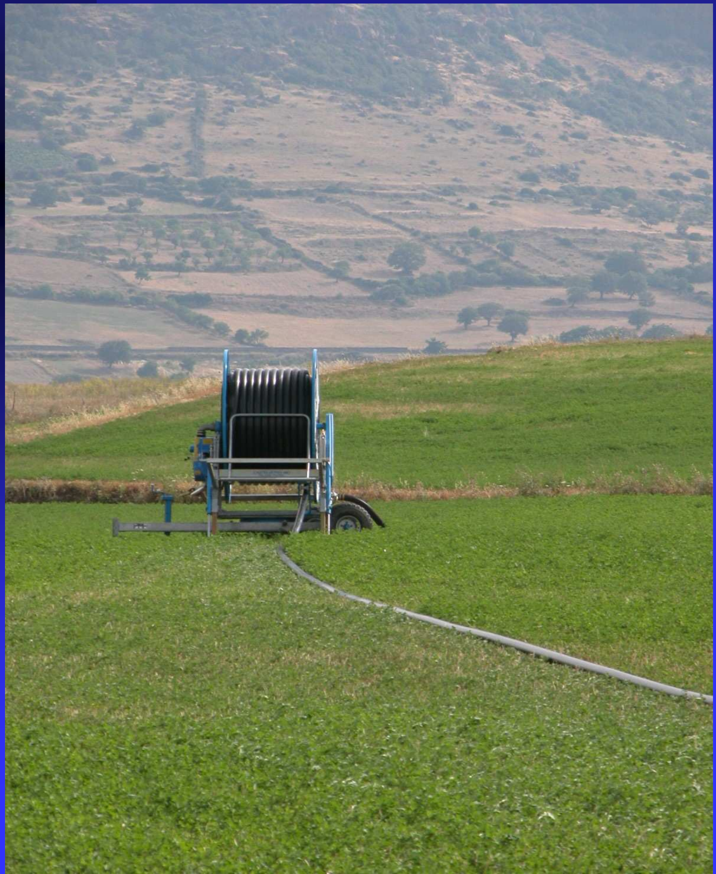
Techniques for water application

SPRINKLER IRRIGATION conventional



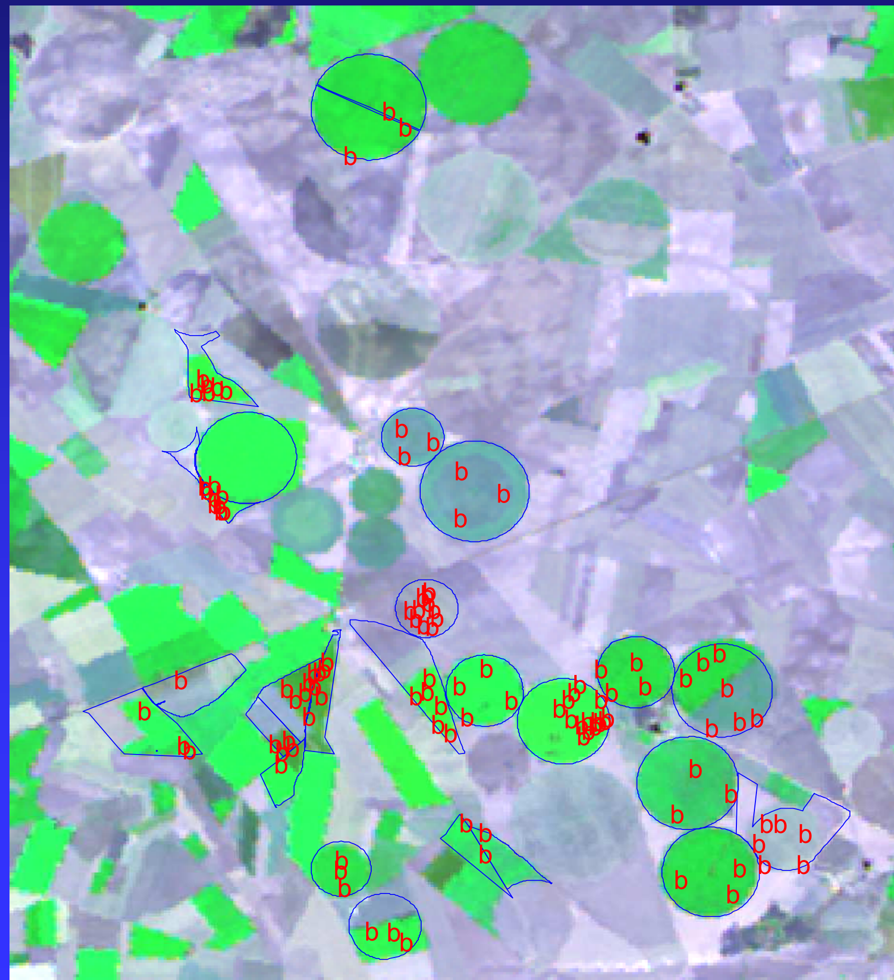
Techniques for water application

SPRINKLER IRRIGATION mobile gun



Techniques for water application

SPRINKLER IRRIGATION pivot systems



Techniques for water application

SPRINKLER IRRIGATION pivot systems

Techniques for water application

SPRINKLER IRRIGATION

TABLE 3.2 - Summary of Sprinkler Irrigation Systems

System			Use
Conventional systems	portable	hand move roll move tow line	Uses small rotary impact sprinklers Widely used on all field and orchard crops Labour intensive
	semi permanent	sprinkler hop pipe grid hose pull	Similar to portable. Lower labour input but higher capital cost
Mobile gun systems	hose pull hose drag		Large gun sprinklers but can be replaced by boom. Good for supplementary irrigation
Mobile lateral systems	centre pivot linear move		Large automatic systems. Ideal for large farms with low labour availability
Spray lines	stationary oscillating rotating		Fixed spray nozzles. Suitable for small gardens and orchards

Techniques for water application

TRICKLE IRRIGATION

Techniques for water application

TRICKLE IRRIGATION

Techniques for water application

TABLE 3.3 - Technical Factors Affecting Selection of Irrigation Method

Irrigation Method	Crops	Soils	Labour (h/ha/irrigat.)	Energy Demand	Potential Efficiency (%)	Capital Cost
Surface					60	low
• Basin	all crops	clay, loam	0.5 - 1.5	low		
• Border	all crops except rice	clay, loam	1.0 - 3.0	low		
• Furrow	all crops except rice and sown/drilled	clay, loam	2.0 - 4.0	low		
Sprinkle	all crops except rice	loam, sand	1.5 - 3.0	high	75	medium
Trickle	row crops, orchards	all soils	0.2 - 0.5	medium	90	high

Techniques for water application

TABLE 3.4 - Scheme Development Factors Affecting Selection of Irrigation Method

Irrigation method	Design	Construction	Operation	Maintenance
Surface	simple	simple	complex	simple
Sprinkle	complex	complex	simple	complex
Trickle	complex	complex	simple	complex

Techniques for water application

OVERALL EFFICIENCY OF DIFFERENT IRRIGATION METHODS

IRRIGATION METHOD	OVERALL EFFICIENCY (%)
BASIN	20-40
FURROW	40-60
SPRINKLER	70-80
DRIP	80-90