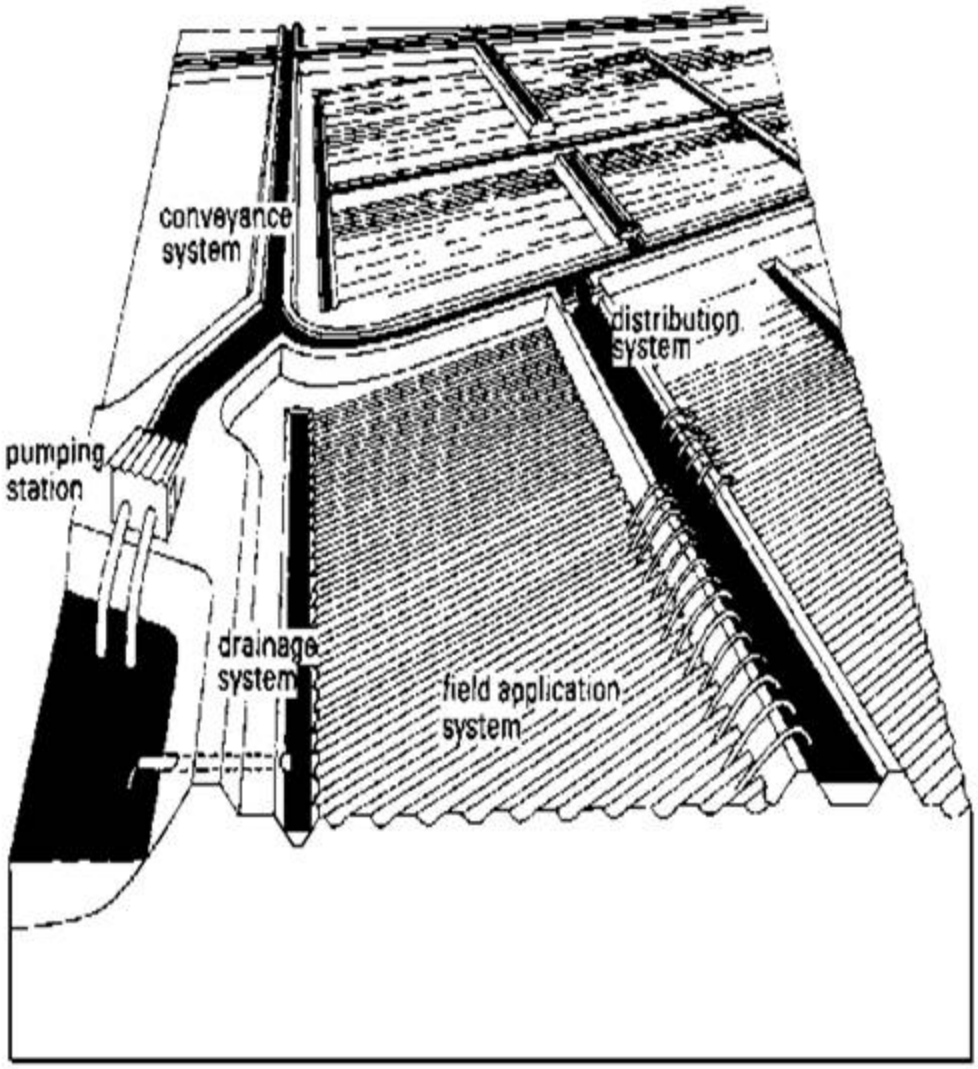
Irrigated Systems – Salinity Control Measures

Presentation Outline

- Irrigated Systems
- Irrigation Methods
- Water Logging
- Salinization
- Symptoms of Salinity
- Irrigation Water Quality
- Salinity Control Measures
- Mapping of Salinity

Irrigated System

- **Irrigation system** consists of:
  - intake structure or pumping station
  - conveyance system
  - distribution network
  - field application system
  - drainage system
- **Intake structure**, or **pumping station** directs water from the source of supply, e.g., reservoir, river, & GW into the irrigation system.
- **Conveyance system** transports water from the intake structure or pumping station to the field ditches.
- **Distribution network** transports water through field ditches to the irrigated fields.
- **Field application system** transports water within the fields.
- **Drainage system** removes excess water from the fields (caused by rainfall and/or irrigation).



Irrigated System

- **Main Intake Structure**
  - The intake structure is built at the entry to the irrigation system.
  - Its purpose is to direct water from the original source of supply (lake, river, reservoir etc.) into the irrigation system.
- **Pumping Station**
  - In some cases, the irrigation water source lies below the level of the irrigated fields. Thus, a pump is required to supply water to the irrigation system.
- **Conveyance System**
  - The conveyance and distribution system consists of canals transporting the water through the whole irrigation system.
  - Canal structures are required for the control and measurement of the water flow.
- **Open Canals**
  - An open canal, channel, or ditch, is an open waterway to carry water from one place to another. Channels & canals supply water to one or more farms. Field ditches convey water from the farm entrance to the irrigated fields.
- **Field Application System (Irrigation Methods)**
  - There are three basic methods of applying water to the field; surface irrigation, sprinkler irrigation & drip irrigation.

Irrigation Methods

- **Surface Irrigation**
  - –Uncontrolled (wild or free) Flooding Method
  - –Border Strip Method
  - –Check Method
  - –Basin Method
  - –Furrow Method
- **Sub-Surface Irrigation**
- **Sprinkler Irrigation**
- **Drip (Trickle) Irrigation**

Surface Irrigation

- In all the surface methods of irrigation, water is either ponded on the soil or allowed to flow continuously over the soil surface for the duration of irrigation.
- Does not result in high levels of performance due to uncertain infiltration rates, cropping pattern, cultivation practices, climate factors, and many other factors.

Uncontrolled Flooding

- When water is applied to the cropland without any preparation of land and **without any levees to guide or restrict the flow of water on the field**, the method is called "uncontrolled", wild or free flooding.
- Uncontrolled flooding generally results in **excess irrigation at the inlet region** of the field and **insufficient irrigation at the outlet end**.
- **Efficiency is reduced** because of either deep percolation or flowing away of water from the field.
- Advantage of this method is the **low initial cost of land preparation**.

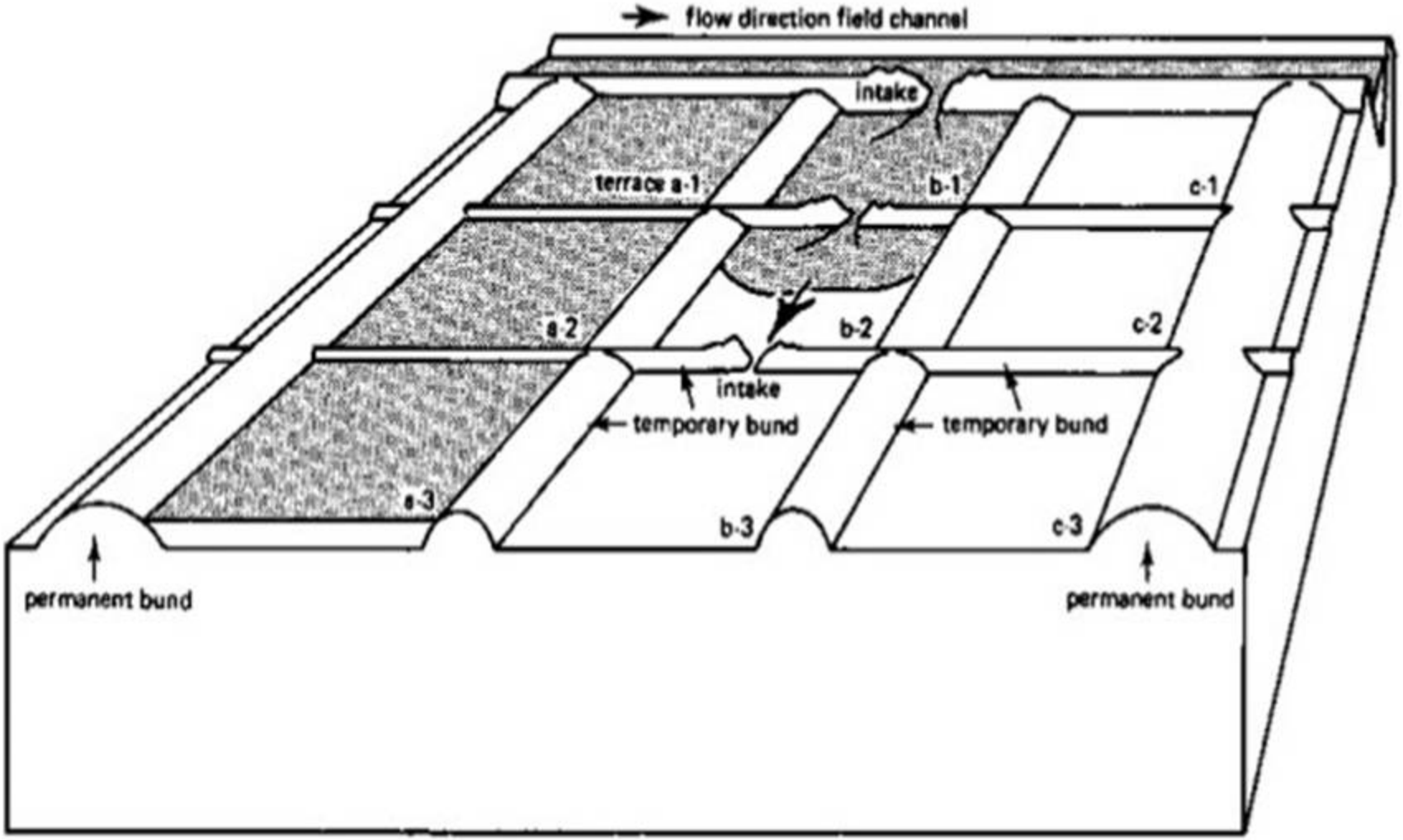
Border Strip Method

- Border (strip) irrigation is a controlled surface flooding method of applying irrigation water. In this method, the farm is divided into a number of strips. These strips are separated by low levees (or borders).
- The border strip method is suited to soils of moderately low to moderately high intake rates and low erodibility.
- This method requires preparation of land involving **high initial cost**.

Check Irrigation Method

- The check method of irrigation is based on **rapid application of irrigation water** to a level (or nearly level) area completely enclosed by dikes.
- In this method, entire field is divided into a number of almost leveled plots surrounded by levees.
- This method is suitable for a wide range of soils ranging from very permeable to heavy soils.
- Loss of water through deep percolation (near the supply ditch) and surface runoff can be minimized and adequate irrigation of the entire farm can be achieved. Thus, **application efficiency of this method is higher**.
- There is some loss of cultivable area which is occupied by the levees.

Check Irrigation Method

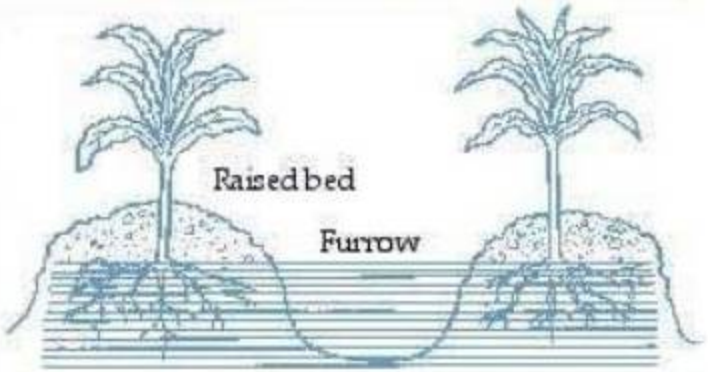


Basin Irrigation Method

Furrow Irrigation Method

- An alternative to flooding the entire land surface is to construct small channels along the primary direction of the movement of water and letting the water flow through these channels which are termed 'furrows', 'creases' or 'corrugation'.
- Furrows necessitate the wetting of only about half to one-fifth of the field surface. This reduces the evaporation loss considerably.
- Furrows provide better on-farm water management capabilities for most of the surface irrigation conditions, and variable and severe topographical conditions.
- Possibility of increased erosion.
- Furrow irrigation requires more labour than any other surface irrigation method.

Furrow Irrigation Method



Sub-Surface Irrigation

Subsurface irrigation (or Sub-Irrigation) is the practice of applying water to soils directly under the surface. Moisture reaches the plant roots through capillary action. The conditions which favour sub-irrigation are as follows:

- Impervious sub-soil at a depth of 2 meters or more,
- A very permeable sub-soil,
- A permeable loam or sandy loam surface soil,
- Uniform topographic conditions, and
- Moderate ground slopes.

Sprinkler Irrigation

- Sprinkler is the method of applying water to the soil surface in the form of a spray which is somewhat similar to rain.
- Rotating sprinkler-head systems are commonly used for sprinkler irrigation.
- Rotating sprinkler-head systems are commonly used for sprinkler irrigation.
- Each rotating sprinkler head applies water to a given area, size of which is governed by the nozzle size and the water pressure. Alternatively, perforated pipe can be used to deliver water through very small holes which are drilled at close intervals along a segment of the circumference of a pipe.

Advantages:

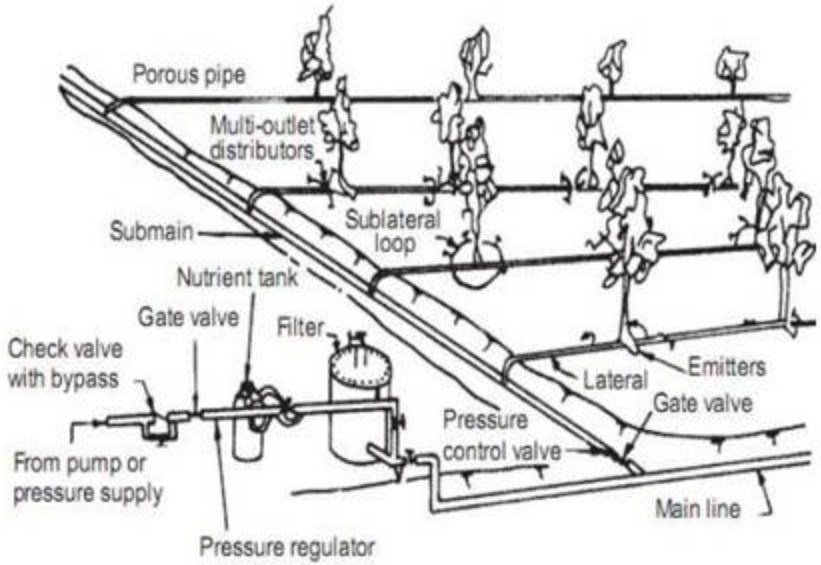
- Low water loss (efficiency up to 80%)
- Saving in fertilizer
- Suitable for any topography
- No soil erosion
- Uniform application of water
- Better seed germination, free aeration of root-zone

Disadvantages:

- High initial cost, cannot adopt by ordinary farmers
- Poor application efficiency in windy weather and high temperature
- High evaporation losses
- Water should be free of debris
- Physical damage to crops by application of high intensity spray

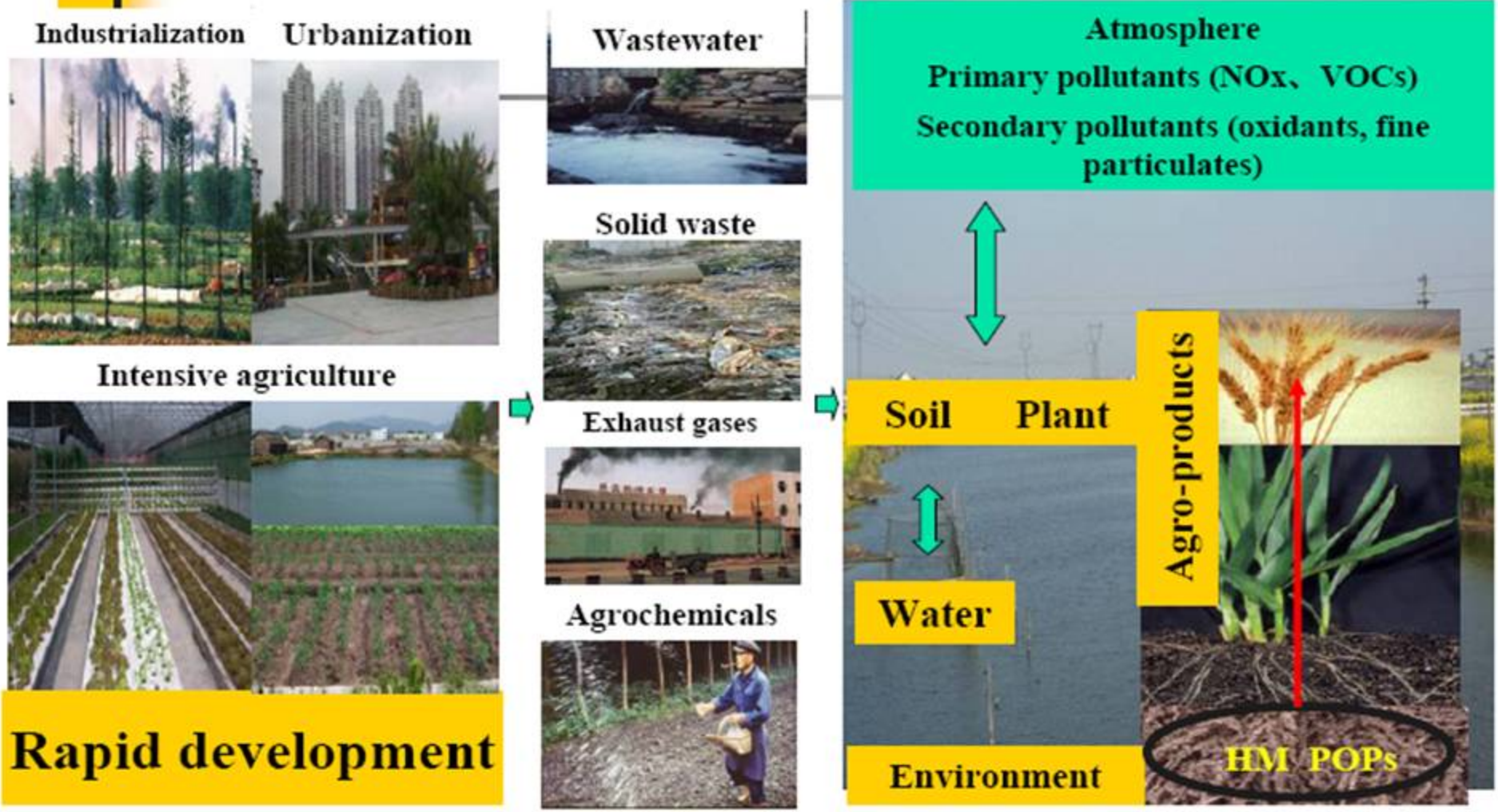
Drip Irrigation

- Drip (Trickle) irrigation system comprises main line, sub-mains, laterals, valves, drippers, pressure gauges, water meters, filters, pumps, fertilizer tanks, vacuum beakers, and pressure regulators.
- The drippers are designed to supply water at the desired rate (1 to 10 LPH) directly to the soil. Low pressure heads at the emitters are considered adequate as the soil capillary forces causes the emitted water to spread laterally and vertically.



Anthropogenic Processes in Natural Environment

Development vs Environment & Health



Canals also lead to problems of water logging due to seepage causing rise in water table, and thus, results in salinization of land.

Effects of Water Logging

- Plant roots require air as well as water and most **plants cannot withstand saturated soil for long periods** (*rice is an exception*).
- If water logging situation lasts for longer time, the plants/crops suffer.
- In very dry areas, there is often accumulation of salts in the soil because of evaporation leaving salts on the ground surface.
- Most crops do not grow well on salty soils.
- One reason is that salt causes a reduction in the rate and amount of water that the plant roots can extract from the soil. Also, some salts are toxic to plants when present in high concentration.
- Measures to control the rise of the GW table & salinity thus become necessary.

Reclamation of Saline & Water Logged Soils through Drainage

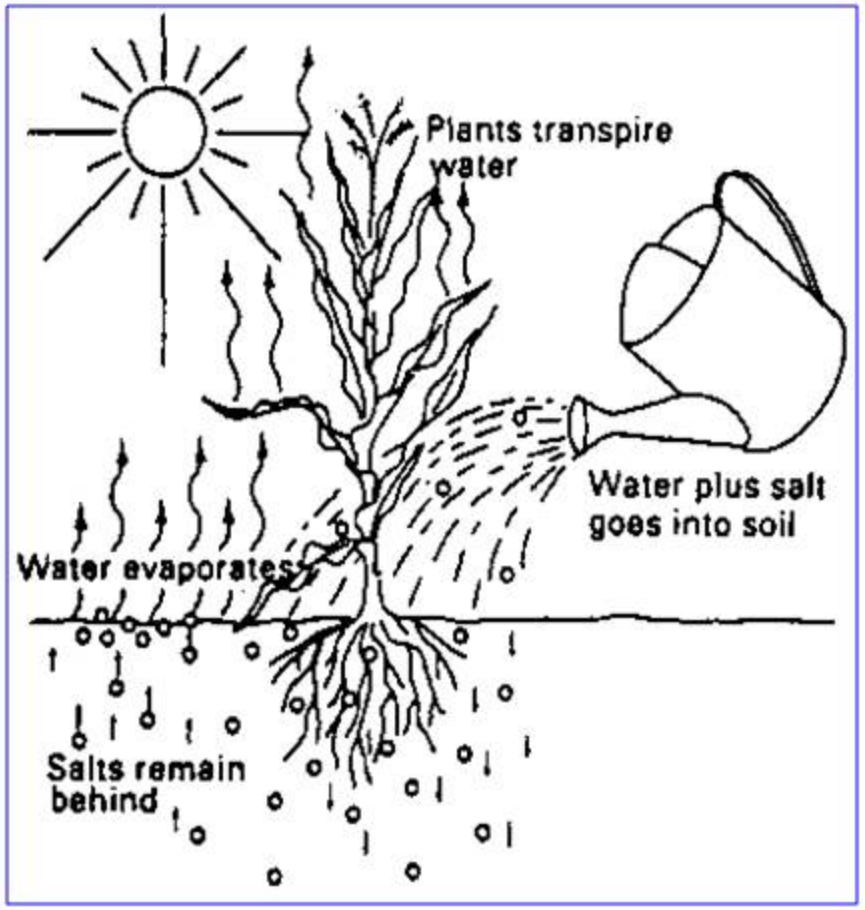
- Drainage is the removal of excess water either from the ground surface or from the root-zone.
- Excess water may be caused by rainfall or by using too much irrigation water, but may also have other sources such as canal seepage, floods, etc.
- Salts can be leached-out by percolating irrigation water through the root-zone of the crops.
- To achieve sufficient percolation, farmers apply more water to the field than the crops need. But the salty percolation water causes the GW table to rise.
- Drainage to control the GW table (water logging), therefore, also serves to control the salinity of the soil.

Salinization

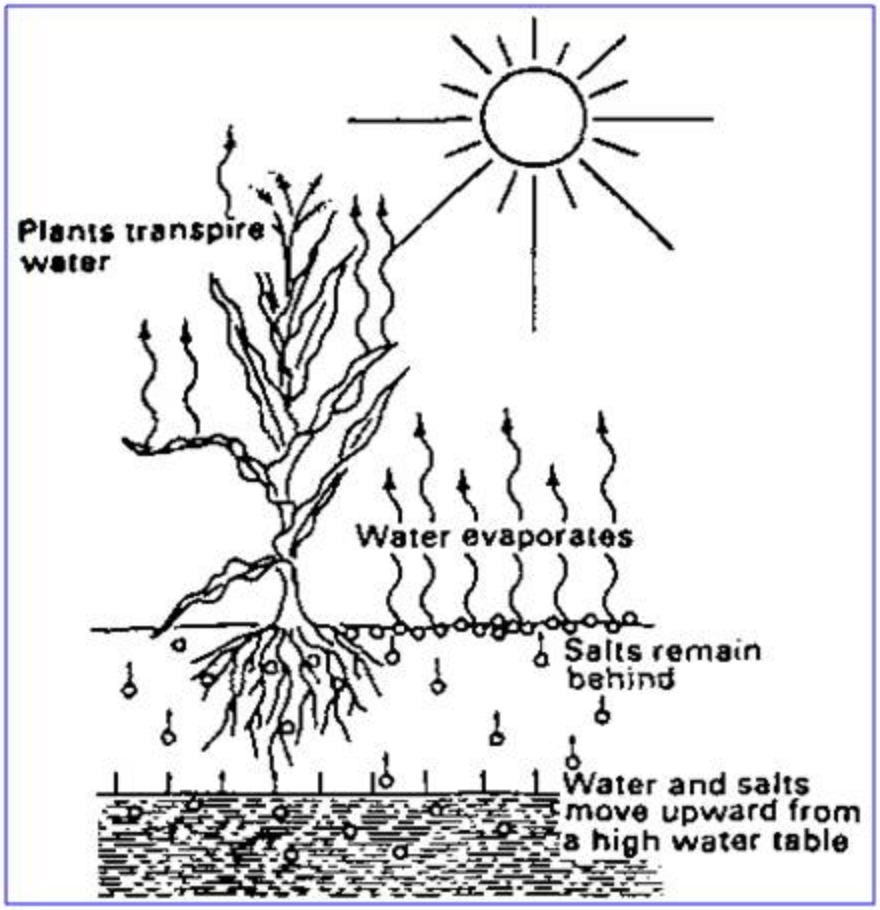
- Build-up of Salts in agricultural areas under intense irrigation.
- Industrial effluents with high dissolved solids.
- Increased use of chemicals in agriculture.
- Geo-chemical composition of the underground formations.
- Quality of the irrigation water.
- Lack of proper drainage in the croplands.
- Heavy fertilization of lands.
- Saline water seepage into the low lying areas (from uplands).
- Inundation of coastal areas by sea water during high tides.

Salinization

- A soil may be rich in salts because the parent rock from which it was formed contains salts. Sea water is another source of salts in low-lying areas along the coast. A very common source of salts in irrigated soils is the irrigation water itself. Most irrigation waters contain some salts.
- After irrigation, the water added to the soil is used by the crop or evaporates directly from the moist soil. The salts present in water is left behind in the soil. If not removed, it accumulates in the soil; this process is called salinization. Very salty soils are sometimes recognizable by a white layer of dry salt on the soil surface.
- Salty groundwater also contribute to salinization. When the water table rises (e.g. following irrigation in the absence of proper drainage), the salty groundwater reaches the upper soil layers and supply salts to the root-zone.
- Soils that contain harmful amount of salt are often referred to as salty or saline soils. Soil, or water, that has a high content of salt is said to have a high salinity.



Salinization caused by salty irrigation water.



Salinization caused by high water table.

Salt affected soils occur extensively in different agro-ecological and soil zones of India, particularly arid, semi-arid and sub-humid regions and are widely spread over:

- **Black soil region**
- **Arid areas of Rajasthan & Gujarat**
- **Indo-Gangetic plains**
- **Coastal areas**

Salt Affected Soils are locally known by following names:

Local name		States
• Kallar, Thur	-	Punjab & Haryana
• Ussar, Reh	-	Uttar Pradesh
• Luni	-	Rajasthan
• Khar, Kshar	-	Gujarat & Maharashtra
• Chouddu, Uppu	-	Andhra Pradesh
• Choppan	-	Karnataka

General Salt Removal Practices

Salt removal is expensive & time-consuming process.

1. Control:

- Keeping ground WT sufficiently low.
- Irrigating occasionally with excessive amounts of irrigation to prevent salt accumulation.
- Mulching soil surface to minimize evaporation and salt accumulation (if adequate drainage cannot be provided).
- Growing salt tolerant crops.

2. Eradication:

- Scraping of salts.
- Providing adequate drainage facilities.
- Leaching of salts out of root zone by application of excess irrigation water.

3. Conversion:

- Neutralization of salts.

Inland Saline Soils

Widespread along the canal command areas of Andhra Pradesh, Gujarat, Haryana, Karnataka, Uttar Pradesh, etc.

- EC > 4000 µS/cm at 25 °C
- pH < 8.5
- ESP < 15
- SAR < 13-15

Reclamation:

¶ Providing adequate drainage.

¶ Ponding and leaching of soils.

¶ Growing salt resistant crops, like Palm, Barley, Mustard, Sugarcane, Sugarbeet, etc.

Coastal Saline Soil's Reclamation

Form because of ingress and flooding of tidal waters.

Reclamation:

- Embankment free board of 1m above the high tide level.
- Controlling sea water ingress during high tide with one way sluice gate on embankment.
- Cropping even in summer for desalination.
- Soil mulching with organic matter & residue for growing crops like rice, chilli, cotton & barley.
- Nitrogen application by green manuring, compost dosage.
- Avoiding application of K & P fertilizers.
- Flooding of coastal saline soils.
- Draining till the soils are reclaimed.

Sea Water Intrusion Control Structures in Coastal Areas

Reclamation of Alkali Soils

- EC < 4000 µS/cm at 25 °C
- pH > 8.5
- ESP > 15
- SAR >13-15

- Removal of alkalis by scraping the incrustation & flooding & draining off.
- Conversion of salts to less injurious forms by applying gypsum & growing alkali resistant green manures.
- Growing alkali tolerant crops like Rice, Ragi and Tomatoes.
- Controlling further accumulation of alkalis by proper soil management.
- Application of gypsum.
- Molasses of gur also neutralize the alkalis.

Acidic Soils' Reclamation

Occur in high rainfall areas (Humid Regions) due to leaching of base.

Characteristic of Humid regions.

- EC < 4000 µS/cm
- pH < 7.0 (obviously)
- SAR < 13-15

Low in fertility

- Clay & Organic soils have high potential of being acidic.
- Acid forming fertilizers should not be applied.
- Can be reclaimed by addition of **lime** (calcium carbonate) to neutralize the acidity.

Salinity Control Measures

Reclamation of Saline Lands through Drainage

- The **removal of excess water** either from the ground surface or from the root zone is called drainage.
- Drainage promotes increased **leaching of salts** and prevents their accumulation in soil.

Types of Drainage:

- Surface drainage
- Subsurface drainage

Drainage can be either natural or artificial.

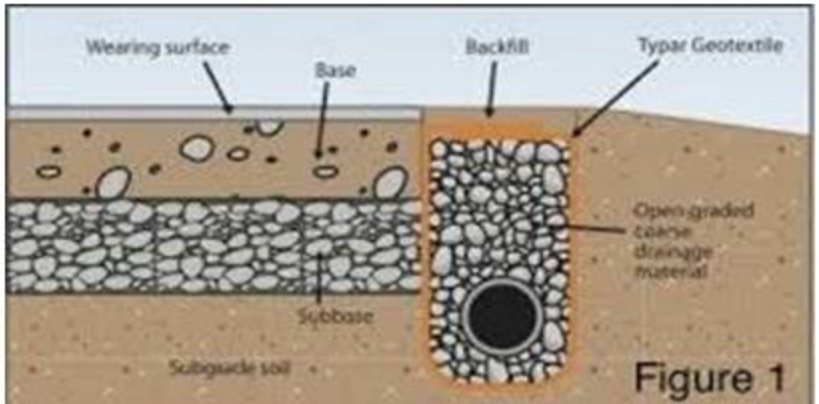
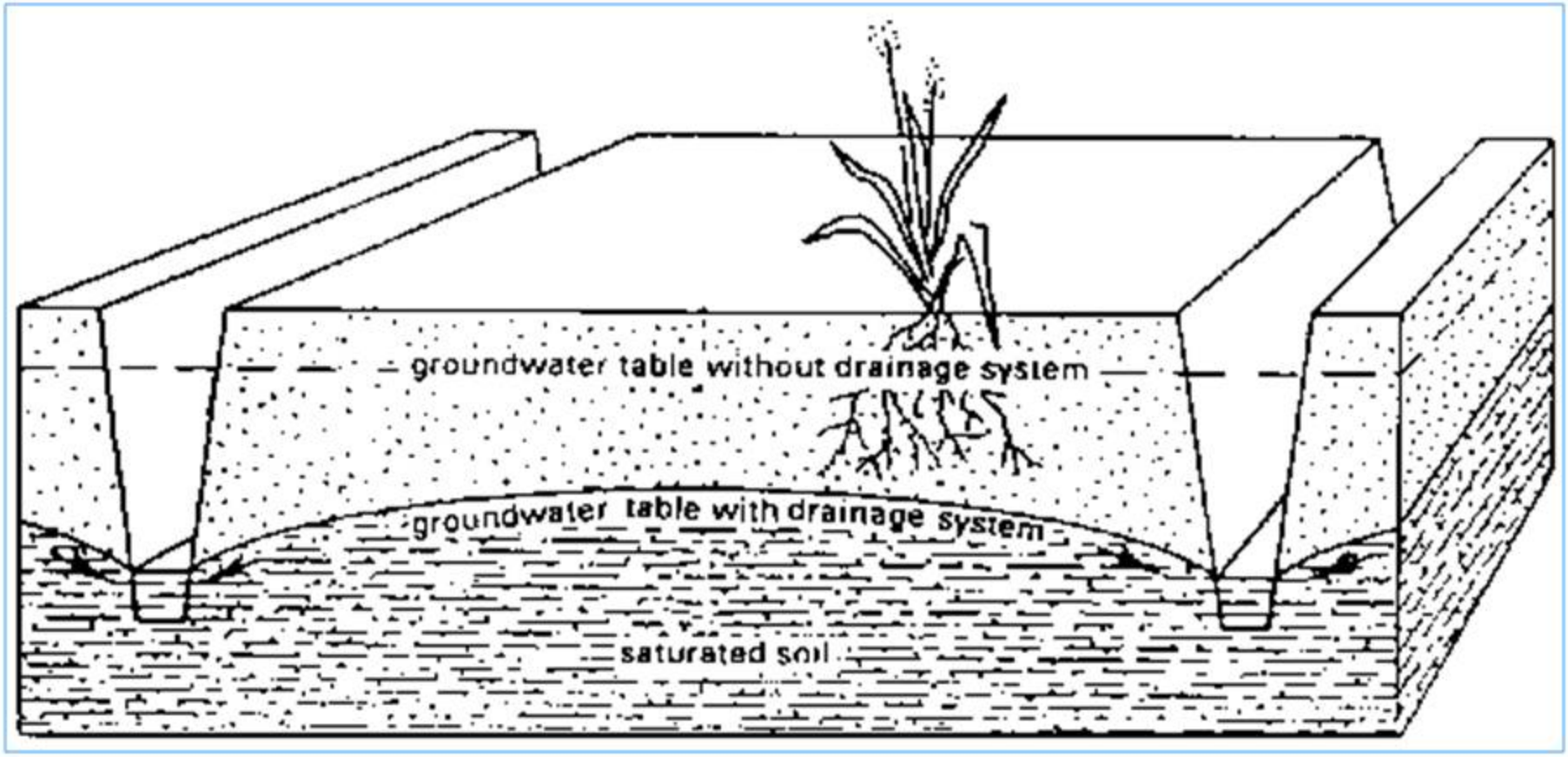


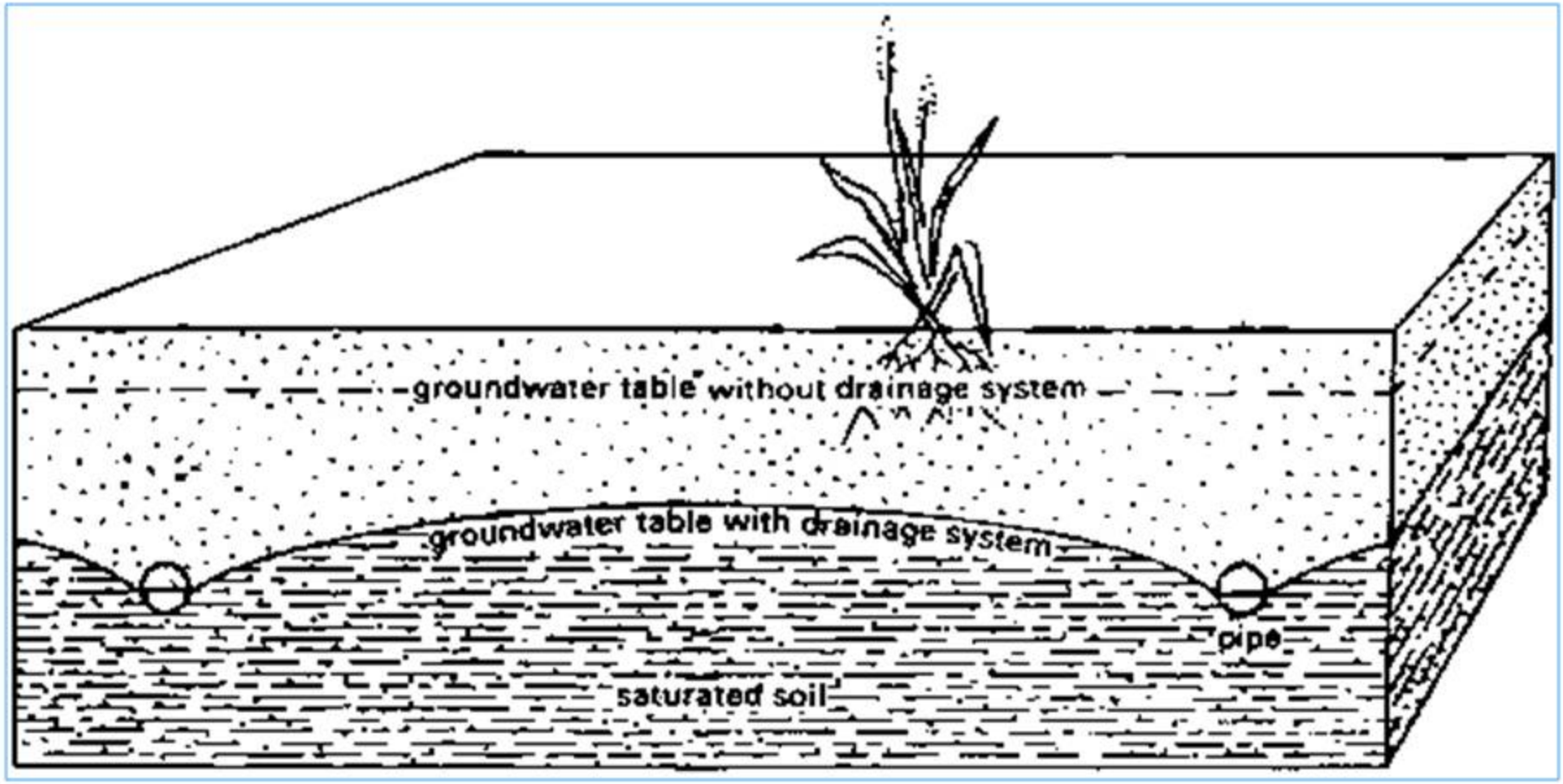
Figure 1

Surface drainage is the removal of excess water from the surface of the land. This is normally accomplished by shallow ditches, also called open drains.



Control of the groundwater table by means of deep open drains

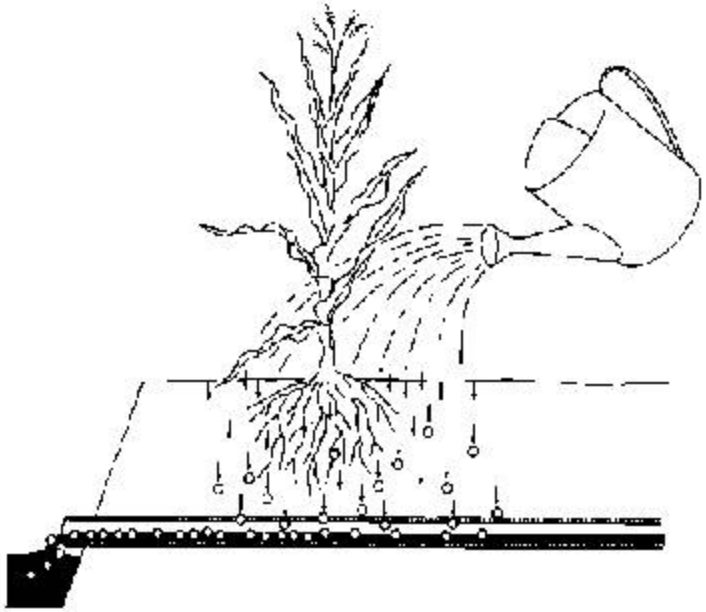
Subsurface drainage is the removal of water from the root zone. It is accomplished by deep open drains or buried pipe drains.



Control of the groundwater table by means of buried pipes

Improvement of Saline Soils

- Improvement of saline soil means reduction of salt concentration in the soil to a level that is not harmful to crops.
- Generally, more water is applied to the field than is required for the crop growth. This additional water infiltrates into the soil and percolates through the root-zone. During percolation, the water washes the salts out of the root-zone. This washing process is called **leaching**.
- The additional water required for leaching must be removed from the root-zone by means of a subsurface drainage system. If not removed, it could cause a rise of the GW table which would bring the salts back into the root-zone. Thus, improvement of saline soils includes, essentially, **leaching** and **sub-surface drainage**.



Prevention of Salinization

- Soils become salty if salts are allowed to accumulate. Proper irrigation management and adequate drainage are not only important measures for the improvement of **salty soils**, they are also essential for the prevention of **salinization**.

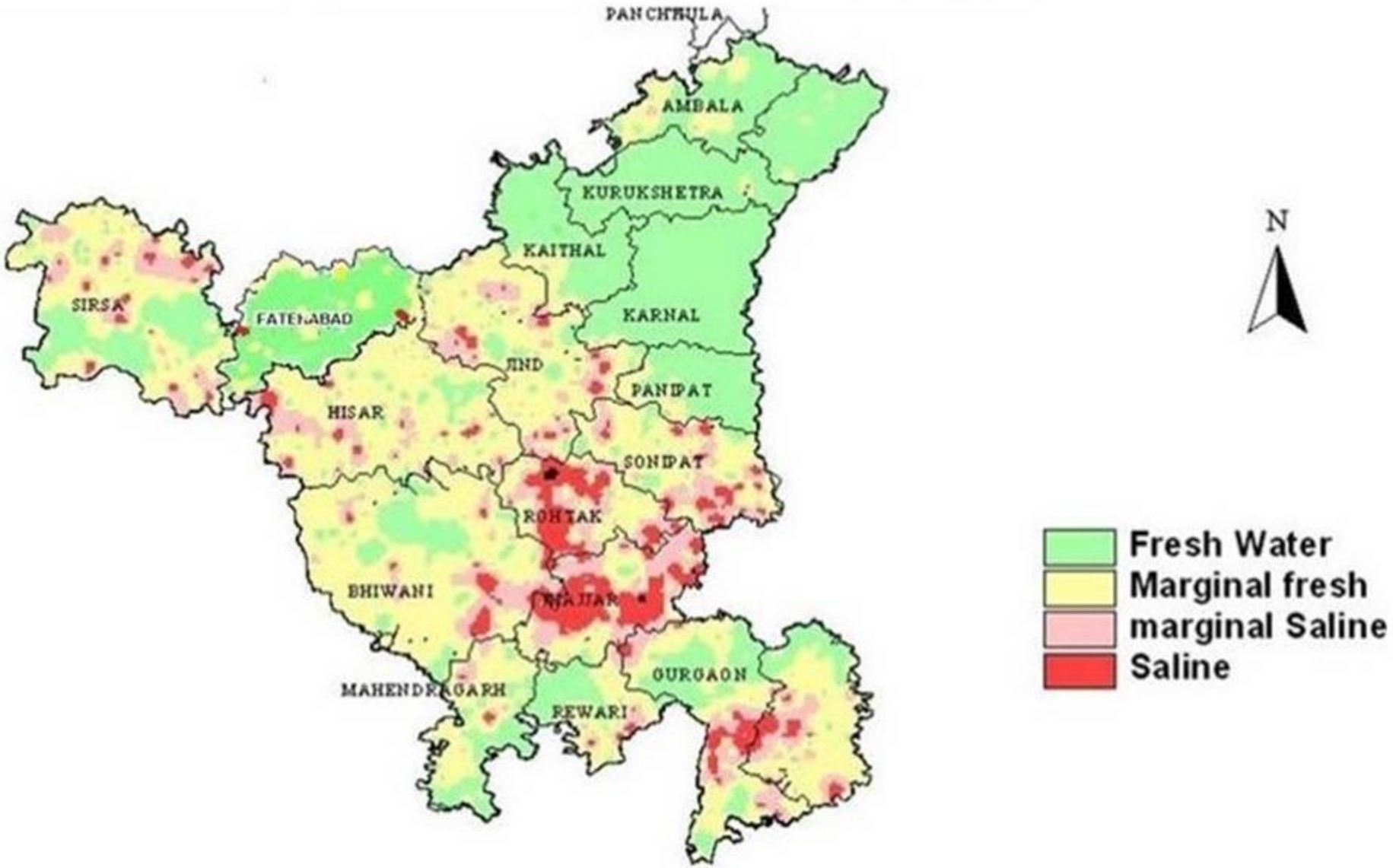
Irrigation Water Quality

- The *suitability of water for irrigation* depends on the amount and the type of salts present in the irrigation water. Higher the salt concentration of the irrigation water, greater the risk of salinization.

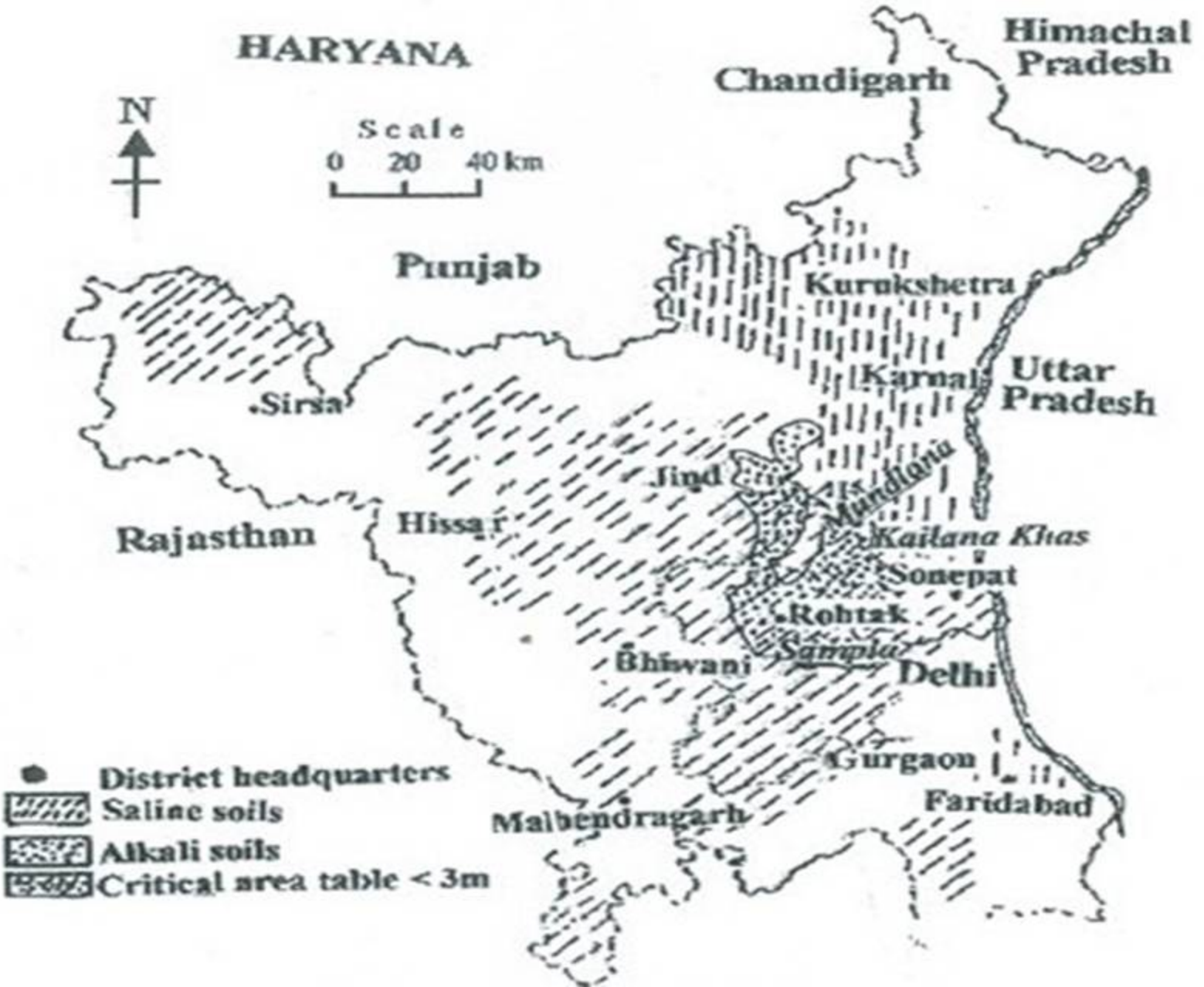
Irrigation Management and Drainage

- Irrigation systems are never fully efficient. Some water is always lost in canals and on the farmers' fields. Part of this seeps into the soil. While this will help in leaching out salts from the root-zone, it will also contribute to a rise of the GW table. A high water table is risky because it may cause the salts to return to the root-zone & also water logging.
- Therefore, both the water losses and the GW table must be strictly controlled. This requires careful management of the irrigation system and a good subsurface drainage system.

Mapping of Saline Zones through RS & GIS



Critical Areas – Vulnerable to Salinity



THANK YOU