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Open Elective

Course Title: Water Resource Management

(As per choice based credit system (CBCS) scheme)

Semester-IV

Subject Code		15CV661			
IA Marks	20	External Mark	80	Total Marks	100

Module - 1

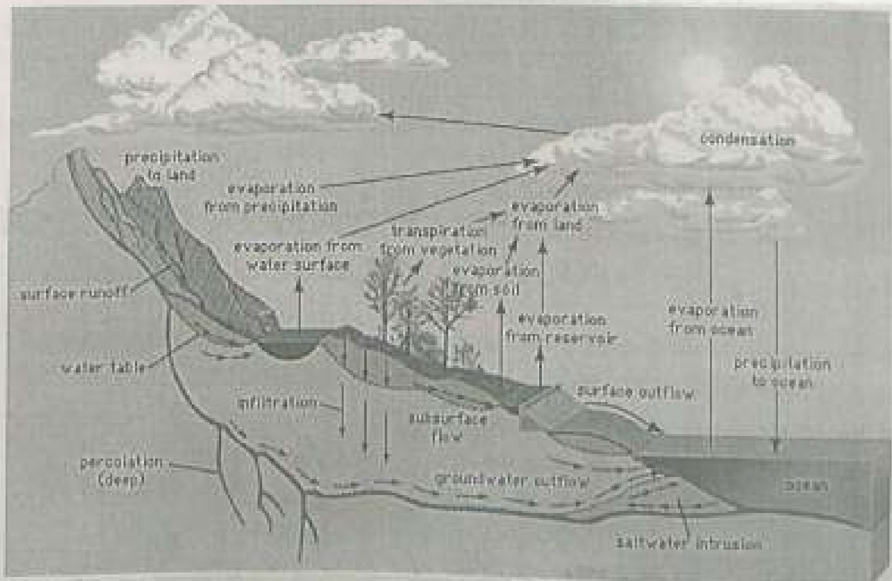
Surface and Ground water Resources

Syllabus:- Hydrological cycle, Global water resources and Indian water resources, Surface water resources, water balance, Available Renewable water resources, Water scarcity, The water balance as a result of Human Interference Groundwater Resources, Types of aquifer, Groundwater as a storage medium.

Hydrological cycle

Definition: The chain of various process through water from one form has to pass in order to return back to the same form is called hydrological cycle.

Most of the earths water reservoirs such as rivers, lakes, oceans and underground sources get their supply from rain. Water from these sources gets evaporated into the atmosphere and precipitates back in the form rain water, snow, hail, sleet etc. This process of evaporation and precipitation continuous for ever and thus a balance is maintained between the two. The process is called as hydrological cycle which can be graphically represented as shown below.



Process : The three important phases of the hydrological cycle are

1. Evaporation and Evapotranspiration
2. Precipitation and
3. Runoff

Other Main components of hydrological cycle are (Detailed process in hydrological cycle)

1) Evaporation
2) Transpiration
3) condensation
4) precipitation
5) Infiltration
6) Runoff

1) Evaporation

- Water is transferred from the surface to the atmosphere through evaporation, the process by which water changes from a liquid to a gas. The sun's heat provides energy to evaporate water from the earth's surface. Land, lakes rivers and oceans send up a steady stream of water vapour and plants also lose water to the air (transpiration)
- Approximately 80% of all evaporation is from the oceans, with the remaining 20% coming from inland water and vegetation.

2) Transpiration

Transpiration is the process of water loss from plants. Transpiration takes place when the vapour pressure in the air is less than that in the leaf cells, i.e. transpiration is nil when the relative humidity of the air is 100%.

3) Condensation

The codensation is the process by which water vapor changes in to water. Water vapor condenses to form dew, fog or clouds. condensation takes place due to cooling of air.

As water rises higher in the atmosphere, it starts to cool and become a liquid again. when a large amount of water vapor condenses, it results in the formation of clouds.

4) Precipitation

when the water in the clouds gets too heavy, the water falls back to the earth. This is called precipitation precipitated water may fall into water bodies or on land. It can then go to streams or penetrate in to the soil

Types of Precipitation

- Drizzle
- Rain
- Freezing rain
- Sleet.
- Snow
- Hail

5) Infiltration

Some precipitation seeps into the groundwater and is stored in layers of rock below the surface of the earth.

This process of precipitation seeping into the groundwater is called infiltration. This water stays there for varying amounts of time. Some water may evaporate in to the hydrological cycle within days, while other water will stay in the ground for centuries or more.

6) Run-off

Most of the water which returns to land flows downhill as run-off. Some of its penetrates and charges groundwater while the rest becomes river flow. As the amount of groundwater increases or decreases, the water table rises or falls accordingly when the entire below the ground is saturated, flooding occurs because all subsequent precipitation is forced to remain on the surface.

Flooding is very common during winter and early spring because frozen ground has no permeability, causing most rainwater and meltwater to become run-off.

Global Water Resources and Indian Water Resources

For proper control and use of water it is essential to have an idea of availability of water resources of the world. World oceans cover about three fourth of earth's surface. The world's total water resources are estimated at 1.36×10^8 M ha-m. which is enough to cover the earth with a layer of 3000 meters depth. of these global water resources, about 97.3% is in oceans as saline water and only 2.7% is available as fresh water at any time on the planet earth. About 77.2% of freshwater lies frozen in polar regions and another 22.4 per cent is present as ground water and soil moisture. The rest is available in lakes, rivers, atmosphere and vegetation.

Distribution of water on Earth

Saline water (oceans & sea) – 97.3%
Fresh water – 2.7%

Freshwater Resources

Polar Ice caps – 77.2%
Groundwater & Soil Moisture – 22.4%
Lakes, swamp & Reservoirs – 0.35%
Atmosphere – 0.04%
Rivers & streams – 0.01%

The crisis about water is not available for use and secondly it is characterized by its highly uneven spatial distribution.

Detailed world wide distribution

Sl.No	Type of water	volume in $10^6 m^3$	% of the Total water
1	World of ocean	1,370,323	94.2
2	Ground water	60,000	4.1
3	Glacier	24,000	1.65
4	Lake & Reservoir	280	0.019
5	Soil Moisture	85	0.006
6	Atmospheric water	14	0.001
7	River Water	1.2	0.001 APP
Total	Total	14547003	99.976

World Wide Distribution of fresh Water.

S.No	Type	Vol. 10^6 m^3	%
1	Glaciers	24000	85
2	Groundwater	4000	14
3	Lakes & Reservoir	155	0.6
4	Soil moisture	83	0.3
5	Atmospheric water	14	0.5
6	River	1.2	0.004
	Total	28253.2	100%

Water Resources of India

India, with a geographical area of 329 million hectares is blessed with large river basins which have been divided into 12 major and 48 medium river basins comprising 252.8 Mha and 24.9 Mha of total catchment area, respectively. It possesses about 4% of the total average annual runoff of the rivers of the world.

The per capita water availability of natural runoff is only 2200 cubic meter per year which is about one-third of the per capita water avilability in U.S.A and Japan. The per capita water availability in India would further decrease with ever increasing population of the country.

— The annual precipitation in the country is estimated about 4000 cubic km. This amount includes snow precipitation as well.

— As per the assessment of Central water commision (CWC) the average annual runoff of various river basins in the country is about 2333 cubic km treating both surface and groundwaters as one system.

— More than 80 to 90 per cent of annual runoff occurs during monsoon months. Because of this fact and other constraints, it is assessed that the total average annual potential of water available in India is about 1869 cubic km out of which only about 1123 cubic km of water can be put to beneficial use by conventional methods of developement of water resources.

Availability of water per capita Annum In India

Sl. No	Years	per Annum per capita availability of water
1.	1951	6602
2.	1971	4349
3.	1981	2829
4.	2000	2384
5.	2025	1589
6.	2035	N.A.
7.	2045	N.A.

The reduction of forest due to various man made activity, has influenced the average rainfall resulting less and less annual rainfall, average water per capita has reduced considerably. The per capita annum availability of water is shown in above table.

According to the brouchure entitled " water Resources of India" issued by Central water and power commission in April 1988, the acutal utilisable surface and ground water resources estimated are shown in table below.

Surface water in 10^5 hectare Meter	Ground water in 10^5 hectare meter	Total in 10^5 hectare meter	utilised upto 1990		
			Surface water	Ground water	Total
69.03	41.85	110.88.	36.2×10^5	19.0×10^5	55.2×10^5 hect. m.

Surface Water Resources

There are four major sources of surface water. These are rivers, lakes ponds, and tanks. In the country, there are about 10,360 rivers and their tributaries longer than 1.6 km each. The mean annual flow in all the river basins in India is estimated to be 1,869 cubic km. Due to topographical, hydrological and other constraints, only about 690 cubic km (32 %) of the available surface water can be utilized.

Fig illustrates schematically the distribution of global freshwater Resources.

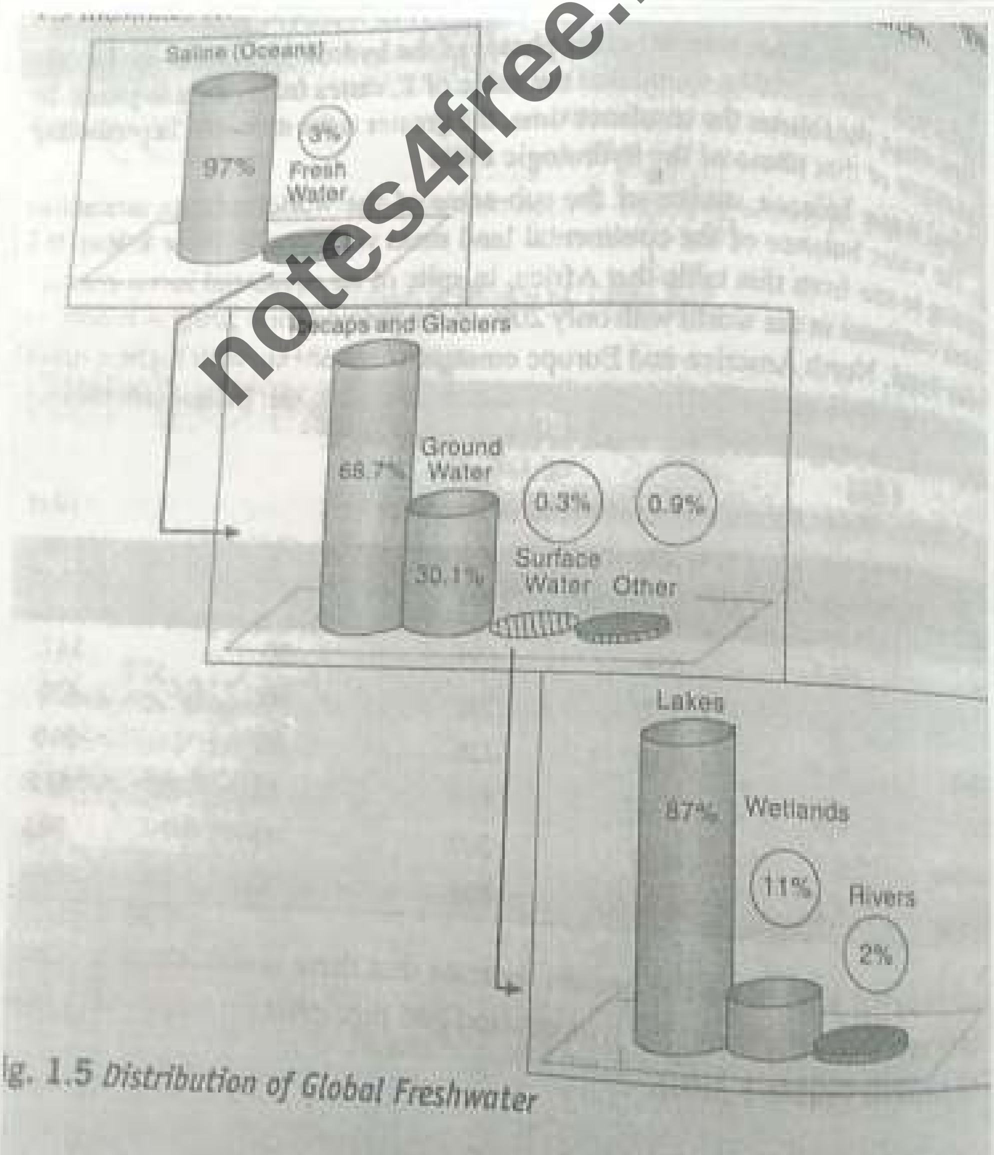


Fig. 1.5 Distribution of Global Freshwater

1. Freshwater lakes

Natural fresh water lakes account for about 0.26% of the freshwater resources. More than 50% of these lakes are found in Canada (World)

2. Wetlands.

A part of freshwater resource (amounting to about 0.04%) is distributed in the globe as wetlands, marshes, lagoons, swamps, bogs and mires. These water bearing bodies play a very important role in maintaining the freshwater ecology as well as in the recharge of groundwater.

3. Rivers

Flowing water in rivers form one of the most important part of freshwater, (surface) water resources sustaining human activity and ecology in the world. Even though this component forms a tiny fraction (0.006%) of freshwater resource, it forms the core of human activity related to natural water use. A substantial part of the subject of engineering hydrology deals with river flow.

4. Reservoirs

Reservoirs are artificial lakes created by by humans through construction of dams across rivers. Most of the water in these reservoirs, estimated to be of the order of 4300 km^3, are used for beneficial purposes such as irrigation, drinking water, hydro-power generation and industrial use.

Groundwater Resources

Groundwater is that part of the subsurface water which occurs within the saturated zone of the earth's crust where all pores are filled with water.

— Groundwater has also been referred to as that part of the subsurface water which can be lifted or which flows naturally to the earth's surface.

The selection of groundwater as a source of water supply, rather than the surface water sources, has following advantages:

1) It is made available within a few hundred meters of the place where it is required for irrigation and where as surface water requires long conveying channel system

2) It is made vailable for areas where surface water is utilised for other uses

3) Yield from wells generally exhibit less fluctuations than surface stream flow in alternating wet and dry periods.

4) Compared to surface water, it is relatively free from the effect of surface pollutants because it results from deep percolation of water infiltrated in to the soil.

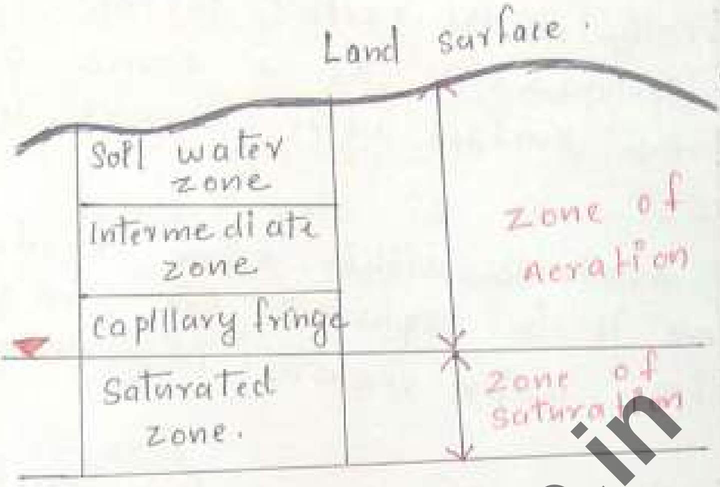
Sources of Groundwater

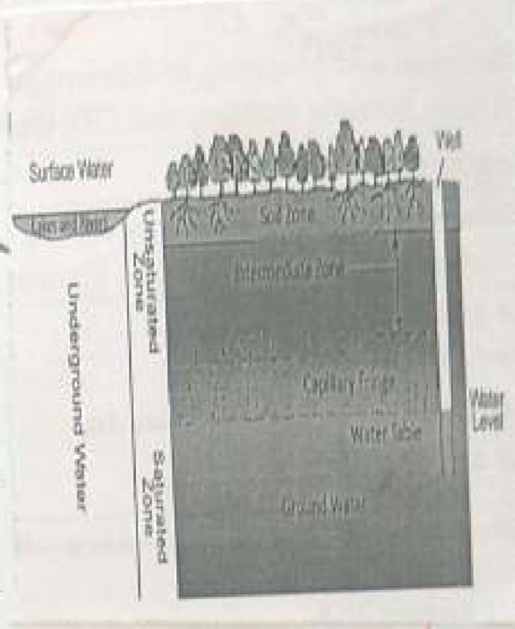
Groundwater is derived from precipitation and recharge from surface water. It is the water that has infiltrated into the earth directly from precipitation recharge from streams, and other natural water bodies and artificial recharge due to action of man. Infiltration and further sorces like rain, melting of snow and ice, rivers and streams, lakes, reservoirs canals and other water resources are the usual main sources that contribute to the groundwater of a region.

Vertical Distribution of Groundwater

Water in the soil mantle (sub-surface) is considered in two zones.

1. Saturated zone
2. Aeration zone.





1. Saturated zone

This zone, also known as groundwater zone, is the space in which all the pores of the soil are filled with water. The water table forms its upper limit and marks a free surface i.e. a surface having atmospheric pressure.

2. Aeration zone

In this zone, the soil pores are only partially filled with water. The space between the land surface and the water table marks the extent of this zone. The zone of aeration has three subzones.

a. Soil water zone

This lies close to the ground surface in the major root band of the vegetation from which the water is transported to the atmosphere by evapotranspiration.

Groundwater Resources (Ground water storage basin)

Groundwater is derived from precipitation and recharge from surface water. It is the water that has infiltrated in to the earth directly from precipitation, recharge from streams and other natural water bodies and artificial recharge due to action of man. Infiltration and further downward percolation from sources like rain, melting of snow and ice, rivers and streams, lakes, reservoirs, canals and other watersources are the usual main sources that contribute to the groundwater of a region.

Forms of Subsurface Water

Water in the soil mantle is called subsurface water and is considered in two zones:-

1. Saturated zone
2. Aeration zone

Diagram

Saturated zone

This zone, also known as groundwater zone, is the space in which all the pores of the soil are filled with water. The watertable forms its upper limit and marks a free surface, i.e. surface having atmospheric pressure.

Zone of Aeration

In this zone, the soil pores only partially filled with water. The space between the land surface and the water table marks the extent of this zone. The zone of aeration has three sub-zones

- Soil water zone: This lies close to ground surface in the major root band of the vegetation from which the water is transported to the atmosphere by evapotranspiration.
- Capillary Fringe: In this subzone, the water is held by capillary action. This subzone extends from the water table upwards to the limit of capillary rise.
- Intermediate zone: This subzone lies between the soil water zone and the capillary fringe. The thickness of the zone of aeration and its constituent subzones depend upon the soil moisture in the zone of aeration is of importance in agricultural practice and irrigation engineering.

Saturated Zone is classified into 4 categories

- Aquifer
- Aquiclude
- Aquifuge
- Aquitard.

- Aquifer

An aquifer is a saturated formation of earth material which not only stores water but yields it in sufficient quantity.

Thus an aquifer transmits water relatively easily due to its high permeability. Unconsolidated deposits of sand and gravel form good aquifers.

Aquitard:

It is a formation through which only seepage is possible and thus the yield is insignificant compared to an aquifer. It is partly permeable. A sandy clay unit is an example of aquitard. Through an aquitard appreciable quantities of water may leak to an aquifer below it.

Aquiclude:

It is a geological formation which is essentially impermeable to the flow of water. It may contain large amounts of water due to its high porosity. clay is an example of an aquiclude.

Aquifuge:

It is a geological formation which is neither porous not permeable. There are no interconnected openings and hence it cannot transmit water.

Massive compact rock without any fractures is an aquifuge.

Types of Aquifer.

Any geological formation that is water - bearing is called as an aquifer. Such rocks may readily transmit water to wells and springs.

Based on the nature and distribution of water bearing zones, aquifers could be classified in to four types.

They are
1. Unconfined
2. Confined

1. Unconfined aquifer

It is also known as water table aquifer. Is one in which a free water surface exists. An unconfined aquifer have water table forms upper surface of the zone of saturation. An aquifer where the water table is the upper surface limit and extends below till the impermeable rock strata is called the unconfined aquifer.

- water table undulates in form of depending upon the recharge and discharge, pumpage of wells and permeability.
- This aquifer is directly accessible to the atmosphere
- A special case of an unconfined aquifer involves perched water body.

Confined aquifer -

When an aquifer is sanwiched between two impermeable layers, it is known as a confined aquifer. It is also known as a pressure aquifer or an artesian aquifer. Confined aquifers are completely filled with water and they do not have a free water table and the aquifer will be under pressure.

- Recharge of this aquifer takes place only in the area where it is exposed at the ground surface.

-

-

- The imaginary surface to which water rises in wells tapping an artesian aquifer is known as piezometric surface.

Figure:-

Water Balance

The water balance equation can be used to describe the flow of water in and out of a system.

- A water balance can be established for any area of earth's surface by calculating the total precipitation input and the total of the various outputs.

- The water balance approach allows an examination of the hydrological cycle for any period of time.

- The purpose of water balance is to describe the various ways in which the water supply is expended.

- The water balance is a method by which we can amount for the hydrologic cycle of a specific area, with emphasis on plants and soil moisture

General water balance equation is

$$P = Q + E + \Delta S$$

where,

P = precipitation

Q = Run off

E = Evapotranspiration

ΔS = change in storage.

or

$$P - R - G - E - T = \Delta S$$

where,

P = Precipitation

R = Surface Runoff

G = Infiltration

E = Evaporation

T = Transpiration

ΔS = change in storage

In its simplest form, this equation reads

Inflow = Outflow + change in storage

- water balance equations can be assessed for any area and for any period of time.

The water balance method has four characteristic features:-

1) A water balance can be expressed for any subsystem of the hydrological cycle, for any size of area, and for any period of time.

2) A water balance can serve to check whether all flow and storage components involved have been considered quantitatively.

3) A water balance can serve to calculate one unknown of the balance equation, provided that the other components are known with sufficient accuracy.

4) A water balance can be regarded as a model of the complete hydrologic process under study, which means it can be used to predict what effect the changes imposed on certain components will have on the other components of the system or subsystem.

Water Scarcity

Water Scarcity is either the lack of enough water (quantity) or lack of access to safe water (Quality).

It currently affects around 2.8 billion people around the world, on all continents, at least one month out of every year and more than 1.2 billion people lack the access to clean drinking water.

World water scarcity

The world's water resources are rapidly running dry creating a global crisis for every living being on the planet. Nearly 1/6 th of world's population - are already facing water shortages on a daily basis.

Survey

- The united Nations "FAO" states that by 2025, 1.9 billion people will be living in countries or regions with absolute water scarcity, and 2/3 of the world population could be under stress conditions.
- 780 million people lack access to clean water
- Inadequate access to safe drinking water for about 884 million people.

Causes

1. Demand and usage.
   - Domestic : 30% of the rural population lack access to drinking water.
   - Agricultural : 90% of total water resources used.
   - Industrial : water is both an important input (polluted & non polluted)

2. Supply

I Surface water ① only 48% of rainfall ends up in India's rivers.

② only 18% can be used.

II Ground water

① 82% goes to Irrigation and agricultural purposes

② Only 18% is divided between domestic and industrial.

3. Climate change

4. population

India needs to keep boosting agricultural production in order to feed its growing population.

5. pollution

The polluted water seeps in to the groundwater can condaminate agricultural products when used for irrigation.

Effects

① 1 out of every 4 deaths under the age of 5 worldwide is due to a water-related disease.

② 80% of the illness cause by unsafe water and sanitation condition in world.

③ Every day in rural communities and poor urban centers, hundreds of millions of people suffer from a lack of access to clean, safe water.

③ womens and girls especially bear the burden of walking miles at a time to gather water from streams and ponds - full of water-borne disease that is making them and their family sick.

- freshwater fish are going to extinct at five times the rate of marine fish species.
- In the last 100 years 50% of the worlds wetlands havea been lost to developement.

Water scarcity can be a result of two mechanisms:-

-> physical water scarcity.

and

-> Economic water scarcity.

Where physical water scarcity is a result of inadequate natural water resources to supply a region's demand, and economic water scarcity is a result of poor management of the sufficient avilable water Resources.

States hit by water scarcity in India:-

1) Rajasthan
2) Gujarat
3) Maharashtra
4) uttar pradesh
5) Madhya pradesh
6) chattisgarh
7) Andra pradesh
8) Tamil Nadu.

Solutions for water scarcity:-

So - Recycle water
- Advance Technology Related to water conservation
- Improve practices related to farming
- Improve Sewage system
- Support clean water Initiatives
- Desalination of sea water can be done

Available Renewable Water Resources

Natural renewable water resources are the total amount of a country's water resources (internal and external resources), both surface and ground water, which is generated through the hydrological cycle

Types of water Resources :-

These are defined as the average manual flow of rivers and recharge of aquifers generated from precipitation. It distinguishes between the natural situation (natural renewable resources), which corresponds to a situation without human influence, and the current or actual situation. The amount is computed on a yearly basis.

Renewable and non-renewable water resources.

In computing water resources on a country basis, a distinction is to be made between renewable and non renewable water resources.

→ Renewable water resources are computed on the basis of the water cycle. In this case they represent the long-term average annual flow of rivers (surface water) and groundwater.

→ Non-renewable water resources are ground water bodies (deep aquifers) that have a negligible rate of recharge on the human time-scale and thus can be considered non-renewable.

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Module - 2

Objectives:- Water Resources planning and Management Necessity, System components, planning scales, Approaches planning and Management aspects, Analysis, Models for Impact prediction and evaluation, post planning and Management issues, Adaptive Integrated policies.

Introduction: (Necessity → system components → Approach → planning scale → Aspects → Analysis → products.)

The main sources of water supply are surface and ground water which have been used for a variety of purposes such as drinking, irrigation, hydroelectric energy, transport, recreation, etc. Often human activities are based on the 'usual or normal' range of river flow conditions. However, flows and storage vary spatially and temporally; and also they are limited in nature i.e., there is a limit to the services that can be expected from these resources. There fore, planning is needed to increase the benefits from the available water resources.

The purpose of water resources planning and management activities is to determine:-

1) How can the renewable yet finite resources best be managed and used?
2) How can this be accomplished in an environment of uncertain supplies and uncertain and increasing demands, and consequently of increasing conflicts among individuals having different interests in the management of a river and its basin?

Need for planning and Management :- Necessity

Planning and management of water resources systems are essential due to following factors:

1) Severity of the adverse consequences of droughts, floods and excessive pollution. These can lead to

i) Too little water due to growing urbanization additional water requirements etc.
ii) Too much water due to increased flood frequencies and also increase in water requirements due to increased economic development on river floodplains
iii) polluted water due to both industrial and household discharges.
iv) Sediment accumulation in the reservoir due to poor water quality.
Considering all these factors, the identification and evaluation of alternative measures that may increase the quantitative and qualitative system performance is the primary goal of planning and management policies.

System components

Water resources management involves the interaction of three interdependent subsystems.

1. Natural river subsystem; in which the physical, chemical and biological processess takes places.
2. Socio - economic subsystem, which includes the human activities related to the use of the natural river system.
3. Administrative and institutional subsystem of administration, legislation, and regulation, where the decision, planning and management process take place

Inadequate attention to one subsystem can reduce the effect of any work done to improve the performance of the others.

Too little water

Issues involving inadequate supplies to meet demands can result from → growing urbanization

→ The developement of additional water supplies.

→ conflicts over private property and public rights regarding water allocations.

This ⇝ may lead in to increased groundwater abstractions to supplyment low surface-water flows and storage volumes. Conjunctive use of ground and surface waters can be sustainable as long as the groundwater aquifers are recharged during conditions of high flow and storage volumes.

Too Much Water

Too much water due to increased flood frequencies and also in water requirements due to damage caused by flood.

→ In many river basins of developed regions the level of annual expected flood damage is increasing over time, in spite of increased expenditures on flood damage reduction measures.

→ This is mainly due to increased economic developement on river floodplains, not to increased frequencies or magnitude of flood.

⇒ Flood damage will decrease only if restrictions are placed on floodplain developement. Analysis carried out during planning can help identify the appropriate level of developement and flood damage protection works, on the basis of both the beneficial and adverse economic environmental and ecological consequences of floodplain developement.

Polluted Water

polluted water due to both Industrial and houshold discharges.

→ Planning and management activities should pay attention to these possible negative consequencies of Industrial development, population growth and the intensive use of pesticides and fertilizers in urban as well as in agricultural areas.

→ Other Issues regarding the environment and water quality Include :-

a) Upstream versus downstream conflicts on meeting water quality standards.

b) Threats from aquatic nuisance species.

c) pollution discharges from sediment erosion

e) Inadequate groundwater protection compacts and concerned institutions.

Degradation of Aquatic and Riparian (Near to river areas) Ecosystems.

→ Aquatic and River bank ecosystems may be subject to a number of threats.

→ The most important include habitat loss due to river expansion and reclamation of flood plains and wetlands for urban and industrial developement.

→ Poor water quality due to discharges of pesticides, fertilizers and waste water.

→ The aquatic nuisance speciees can be major threats to the chemical, physical and biological water quality of a river's aquatic resources, They are difficult to manage and impossible to eliminate.

Environmental and ecological effectiveness as well as economy efficiency should be guiding principal in evaluating alternate solutions to problems caused by aquatic nuisance organisms.

Other planning and Management Issues

1) **Navigation**: Industrial and related port development may result in the demand for deeper rivers to allow the operation of cargo vessels in the river. River channel improvement cannot be detached from functions such as water supply and flood control. Narrowing the river for shipping purposes may increase floodwater levels.

2) **River Bank erosion**

Bank erosion can be a serious problem where people are living close to morphologically active rivers.

3) **Reservoir Related Issues**

→ Sediment accumulation in the reservoir due to poor water quality.

→ Dams can be ecological barriers for migrating fish species such as salmon.

→ The sediment accumulation may reduce the useful capacity of the reservoir.

System Components, Planning scales and Sustainability

Water resources management involves influencing and improving the interaction of three interdependent subsystems :

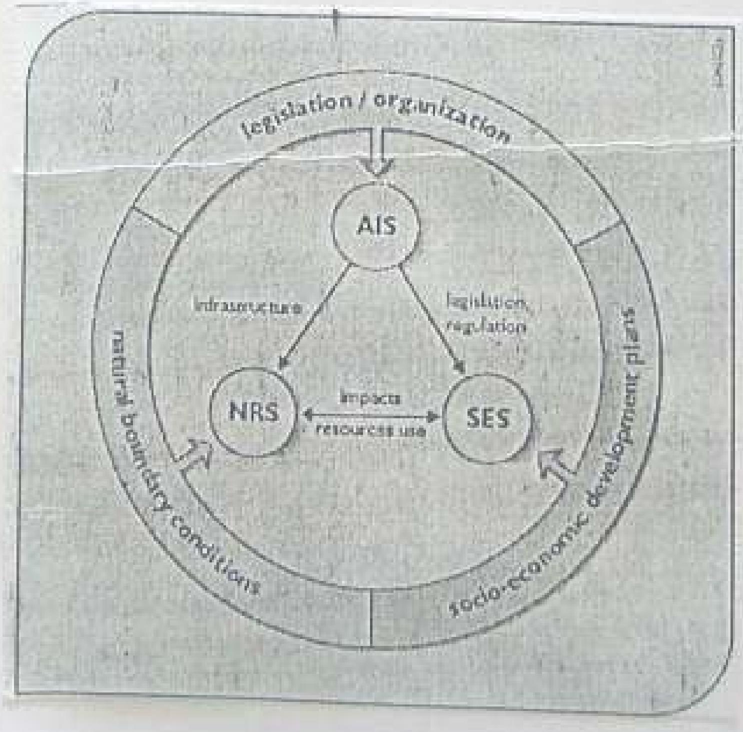
1) **The natural river subsystem** (NRS) in which the physical chemical and biological processes take place

2) **The socio - economic subsystem**, which includes the human activities related to the use of the natural river system. (SES)

3) **The administrative and Institutional sybsystems** (AIS) of administration, legislation and regulation, where the decision and planning and management processes take place.

Figure down ↓ illustrates the interaction between ~~these~~ subsystems, all three of which should be included in any analysis performed for water resources systems planning and management. Inadequate attention to one can destroy the value of any work done to improve the performance of the others.

Figure



planning scales

(a) Spatial scales for planning and Management

[How land and water are managed]

Watersheds or river basins are usually considered logical regions for water resoures planning and management.

→ How land and water are managed in one part of a river can affect the land and water in other parts of the basin.

For example, The discharge of pollutants or the clearing of forests in the upstream portion of the basin may degrade the quality and increase the variability of the flows and sedimentation downstream.

→ To maximize the economic and social benefits obtained from the entire basin, and to ensure that these benefits and accompanying costs are well distributed, planning and management is often undertaken on a basin scale.

Disadvantages / limitations

→ May be inadequate for addressing particular water resources problems that are caused by events taking place outside the basin.

Hence, The administrative boundries should be expanded to include the entire applicable 'problem-shed' area.

(b) Temporal scales for planning and Management

(Time Based)

water resources planning requires looking in to the future. Decisions recommended for the immediate future should take account of their long-term future impacts. This impact may also depend on economic and physical conditions now and on into some distant future

— Decisions that are to be made later can be based on updated forecasts, then current information and planning management objectives.

— Water resources plans need to be periodically updated and adapted to new information, new objectives, and updated forecasts of future supplies, demands, cost and benefits.

Planning and Management Approaches

Two approaches which lead to an integrated plan and management policy are

→ From the top down or the command and control approach

→ From the bottom up or the grass - roots approach.

Top down approach:

water resources professionals prepare integrated multipurpose, 'master' development plans with alternative structural and non structural management options. There is dominance of professionals and little participation of stakeholders. In this approach one or more institutions have the ability and authority to develop and implement the plan. But nowadays public have active participation in planning and management activities, top down approaches are becoming less desirable or acceptable.

Bottom up approach:

In this approach there is active participation of interested stakeholders – those affected by the management of the water and land resources. plans are being created from the bottom up rather than top down. Top down approach plans do not take into consideration the concerns of affected local stakeholders. Bottom up approach ensures cooperation and commitment from stakeholders. The goals and priorities will be common among all stakeholders by taking care of laws and regulations and by identifying multiple alternatives and performance criteria

Planning and Management - Aspects

→ Sources (Technical view)
→ Solution / Development (Technical view)

Technical Aspects

It is first necessary to identify characteristics of resources in the basin, including the land, the rainfall, the run off, the stream and river flows and the ground water. planning involves

→ Predicting changes in landuse / covers
→ Economic activity at watershed and river basin levels.
→ These will influence the amount of runoff, and the concentration of sediment and quality of constituents.

Technical aspects also include the estimation of the costs and benefits of any measures taken to manage the basin's water resources. These measures might include.

→ Engineering structures for making better use of water.
→ Canals and water - lifting devices.
→ Sewerage and industrial wastewater treatment plants, including waste collection and disposal facilities.
→ Diversion structures, ditches, pipes, checks, and other engineering facilities necessary for the effective operation of irrigation and drainage systems.

Economic and Finacial Aspects

→ water as an economic good
→ This benefit using for other development

→ water should be treated as an economic commodity to extract the maximum benefits as well as to generate funds to recover the costs of the investments and of the operation and maintenance of the system.

→ Cost Recovery - Revenues are needed to recover construction costs, if any and to maintain, repair and operate any infrastructure designed to manage the basin's water Resources.

→ Finacial component of any planning process is needed to recover construction costs. In management policies, finacial viability is viewed as a constraint, that must be satisfied.

Institutional Aspects → To Control & Regulate

→ The first condition for successful project implementation is to have an enabling environment

→ There must exist national, provincial and local policies, legislation and institutions that make it possible for the right decisions to be taken and implemented correctly. The role of the government is crucial because :-

1) water is a resource beyond property, it cannot be 'owned' by private persons. Water rights can be given to companies, but only to use water not to own it. Conflicts between users automatically turn up at the table of the final owner of the resource - The Government.

2) Many water resources development projects are very expensive which only can be made by government or state-owned companies.

3) only the government can address the issues related with good water management.

An insufficient institutional setting and the lack of a sound economic base are the main causes of water resources developement project failures, not technical inadequacy of design and construction. This is the reason why at present much attention is given to institutional developement sector.

Analysis of Planning and Management

Analysis of water resources planning and Management generally comprise several stages, these stages is referred to as the analytical framework. The models for quantitative analysis will be referred to as the Computational framework.

The purpose of the analysis is to prepare and support planning and management decisions. The decision-making process are factors causing the decision makers to return to earlier steps of the process. Thus part of the process is cyclic.

Two types of cycling steps

Comprehension cycle = which improves the decision-makers understanding of a complex problem by cycling within or between steps.

Feedback cycle - Returning to earlier phases of the process.

These 2 cycling process are needed when:

→ Solutions fails to meet criteria
→ New Insights change the perception of the problem and its solutions [Due to more/ better Information]
→ Situation change (political, international, societal developments)

The three elementary phases of analysis framework are :-

→ Inception
→ Development
→ Selection

~~Inspect~~ **Inception Phase**

→ The first phase of the process is the Inception phase.
→ Here the subject of the analysis i.e, (what is analysed under what conditions)

→ Its objects are specified
(The desired results of the analysis)

→ Based on this initial analysis, during which intensive communication with decision makers is essential, the approach for the policy analysis is specified.

→ The results of the Inception phases are represented in the inception report, which includes the work plan for the other phases of the analysis process.

→ **Developement phase**

→ In the development phase tools are developed for analysing and Identifying possible solutions to the WRM problems.

→ The main block of activities is usually related to data collection and modelling.

→ Various preliminary analysis will be made ensure that the tools developed for the purpose are appropriate for solving the WRM problems.

→ Individual measures developed and screened in this phase, and attempts will be made to combine promising measures into management strategies

→ The development phase is characterized by an Increased understanding of the water Resource system, which starting with limited data sets are simplified tools and ending at the levels of detailed ~~deep~~ deemed necessary in the inception phase.

→ Scanning of possible measures ~~being considered~~ should also ~~start~~ start as soon as possible during this phase.

→ Interactions with decision makers are facilitated through the presentation of interim results in interim reports.

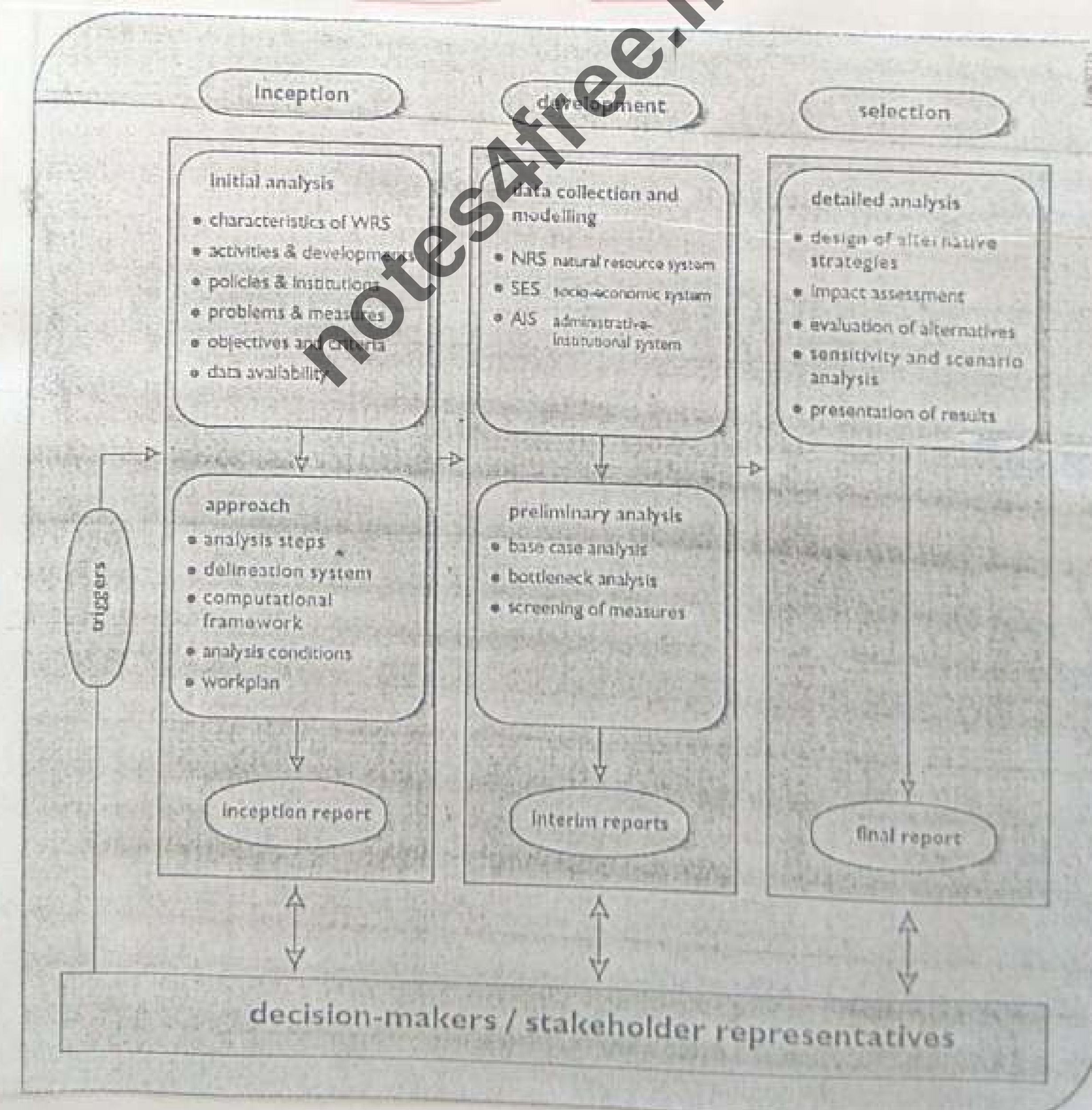
Selection phase

→ The purpose of selection phase is to prepare a limited number of promising strategies based on a detailed analysis and their effects on the evaluation criteria, and to present them to the decision-makers, who will make the final selection.

→ Important activities in this phase are strategy design, evaluation of strategies and presentation.

→ The results of this phase are included in the final report.

Figure:→ Typical analytical framework for water Resources studies



Models for Impact Prediction and Evaluation

→ Models are used to assist in the identification and evaluation of alternate ways of meeting various planning and management objectives.

→ They provide an efficient way of analysing spatial and temporal data in an effort to predict the interaction and impacts, over space and time, of various river basin components under alternative designs and operating policies.

Models can assist planning and Management at different levels

→ Some are used for preliminary screening of alternative plans and policies, and as such do not require major data collection efforts.

→ Screening models can also be used to estimate how significant certain data and assumptions are for the decesions being considered, and hence can help guide additional data collection activities.

→ Much more detailed models can be used for engineering design. These more complex models are more data demanding, and typically require higher levels of expertise for their proper use.

→ Models can assist in this process of reaching a common understanding and agreement among different stakeholders. This has a greater chance of happening if the stakeholders themselves are involved in the modelling and analysis process. It gives them a feeling of ownership.

→ Develop models useful for aiding negotiation processes as well as for understanding the system and issues being negotiated.

→ This models might especially useful in simulations of natural disasters, or for training in educational institutions.

Planning And Management products

Adaptive Integrated policies :-

Water resources planning and management final report should contain:-

→ A discussion of the water resources management issues and options.

→ Another part of the report might include a prioritized list of strategies for addressing existing problems and available developement or management opportunities in the basin.

→ Consideration also need to be given to improving the quality of the water resources planning and management. review process.

→ Models adapted for predicting the economic as well as ecologic interactions and impact due to changes in land and water management and use could be used to address questions such as:-

Eg:-1
— what are the hydrological, ecological and economic consequences of human land uses such as urban and commercial developements and large residential areas?

Eg:2
what are the economic limitations and ecological benefits of having light residential zones between waterways and commercial, urban or agricultural lands?

Eg:3
what are the associated ecological and economic impacts of the trend in residential, commercial and forests lands replacing agricultural lands?

Post planning and Management Issues

Once a plan or strategy is produced, a common Implementation issues include:-

→ How are the impacts resulting from the Implementation of any decision going to be monitored, assessed and modified as required and desired?

→ who will keep the stakeholders informed?

→ who will keep the plan current?

→ How often should plans and their databases be updated.

→ How can new projects be operated in ways that increase the efficiencies and effectiveness of joint operation of multiple projects in watersheds or river basins - rather than each project being operated independently of the others?

These questions should be asked and answered, at least in general terms, before the water resources planning and management process begins. The questions should be revisited as decisions are made and when answers to them can be much more specific.

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7/3/2018

Module - 3
Integrated Water Resources Management

Overview:- Definition of IWRM, principles, Implementation of IWRM, Legislative and organizational framework, Types and forms of private sector involvement

Definition

The integrated approach is called integrated water resources management and is defined as a "process which promotes the co-ordinated developement and management of water, land and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems."

Introduction to Integrated Approach

→ Issues

- → Resources under pressure
- → population under water pressure
- → Impact of pollution
- → Water governance crisis

→ challenges

- → Securing water for people
- → Securing water for food production
- → protecting vital ecosystems
- → Managing Risks
- → Developing other job creating activities
- → Creating popular awareness and understanding
- → Ensuring collaboration across sectors and boundaries.

Development

The development of IWRM was particularly recommended in the final statement of the ministers at the international conference on water and Environment in 1992 (So called the Dublin principles)

→ This concept aims to promote changes in practices which are considered fundamental to improved water resource management.

The IWRM rests upon three principles that together act as the overall framework.

Integrating the three E's

1. – Social Equity :- Ensuring equal access for all users., Means all people must have access to water of adequate quantity and quality.
   – participation in water management by all stakeholders – Best way to ensure equity.

2. Economic Efficiency:- Efficiency in water use is core principles of IWRM, water must be used with maximum possible efficiency by bringing the greatest benefit to the greatest numbers of users possible with available finacial and water Resources.

3. Ecological Sustainability :- To acheive ecological sustainability, current water use should be managed in such a way that it does not affect future generations.

Note: sustainability meaning :- Ability to maintain

Principles - In Detail
WRM is Based on four principles - The Dublin principles

principles : 1 Freshwater - is a finite and vulnerable resource, essential to sustain life development and the environment.

→ water sustains life in all its forms and is required for many different purposes, functions and services. There fore holistic management has to involve for the demands placed on the resources and the threats to it.

→ Creating a water sensisitive political economy requires co-ordinated policy making at all levels from national ministries to local government or community

→ There is also a need for mechanisms which ensure that economic sector decision makers take water costs and sustainability into account when making production and consumption choices.

principles : 2 Water development and management should be based on a participatory approach involving users, planners and policy - makers at all levels.

→ Water is a subject in which everyone is a stakeholder. Real participation take place when stakeholders are part of the decision making process.

→ participation also occurs if democratically elected agencies or person can represent stakeholders group.

Principle : 4 Water has an economic value in all its competing usess and should be recognised as an economic good.

→ With in this principle, it is vital to recognise first - the basic right of all human beings to have access to clean water and sanitation at an afforable price.

→ Managing water as an economic good is an important way of achieving efficient and equitable use and of encourging conservation and protection of water resouries.

principle: 3 : Women play a central part in the vision, management and safeguarding of water.

→ Women play a key role in the collection and safeguarding of water for domestic and in many cases - agricultural use, but they have a much less influential role than men in management, problem analysis and in the decision making process related to water resources.

→ The women's views, interests and needs shapes the development agenda as much as men's, and that development agenda support progress towards more equal relations between women and men.

Implementation of Integrated water Resource Management.

An IWRM Implementation is focused on three basics and aims at avoiding a fragmented approach of water resources management by considering the following aspects.

→ Enabling Environment: A proper enabling environment is essential to both ensure the rights and assets of all stakeholders (Individuals as well as public and private sector organizations and companies), and also protects public assets such as an intrinsic environmental values.

2. <u>Role of Institutions</u>: Institutional development is critical to the formulation and implementation of IWRM policies and programmes. Failure to match responsibilities authority and capacities for action are all major sources of difficulty with implementing IWRM.

3. <u>Management Instruments</u>: The management instruments for IWRM are the tools and methods that enable and help decision-makers to make rational and informed choices between alternative actions.

<u>Some of the cross-cutting conditions that are also important to consider when implementing IWRM are</u>:-

- → political will and commitment.
- → Capacity development
- → Adequate investment, finacial stability and sustainable cost recovery.
- → Monitoring and Evaluation.

IWRM should be viewed as a process rather than a one-shot approach.

- → There is no correct administrative [illegible] Model.
- → The art of IWRM lies in selecting, adjusting and applying the right mix of these tools for a given situation.
- → IWRM has no fixed beginnings or endings

Development objectives

Elements of an Integrated water legistation frame work.

→ National, provincial and local water and policies determine stakeholders play their respective roles in the development and management of water resources.

→ Basin organizations put up by law have a strong mandate.

→ Laws and water policies spell out rules responsibility and accountability of public and private sectors.

→ water management framework should be a part of an existing national administrative system.

→ Basin and national water policy management plans should be harmonized.

Assessment of the institutional/ organizational framework.

Process and Tools :

Assessment of the institutional framework requires a process, to come from an identified present water resources management situation to a desired integrated water resources management situation.

The steps in this process are

→ Identification of the present situation.
→ Formulation of a desired IWRM situation.
→ Formulation of interventions to arrive at the desired IWRM situation and establishment of a monitoring system to see whether the interventions are being carried out properly and whether they really contribute to the achievement of the IWRM goals.

Step -1

→ The present situation on water resources use and Management should be well known before any intervention directing to IWRM can be made.

→ understanding the water situation is a prerequisite for assessment and analysis of the institutional framework and the water use conflicts between stakeholders.

→ It is essential to have a basic documents on the present water management to strat the institutional assessment process,

Such a document will represent an experts opinion and will not necessarily to be complete...

→ Accurate and representing the opinions, desires and aspirations of all stakeholders.

Important aspects to be dealt with are

- water availability and water use
- stake holders.
- Physical conditions.
- Socio Economic conditions.
- legal framework.
- Institutional framework.
- Policies and the trends and finacial situation.

This report serves as a general background document for the following steps and has to be disseminated accordingly.

Physical Conditions

The assessment of the Physical conditions concentrates on the temporal and spatial availability and use of the water (quantitative, and qualitative). It requires information on the :-

a) Climate and Meteorology.
b) Hydrology and hydro geology.
c) Aquatic Ecosystems.
d) Availability and capacity of storage facilities.

Stakeholders and Interest Groups:

Stake holders are people or groups of people with interest, The stakeholders are considered as a private body.

Assessment of institutional frameworks in IWRM the stakeholders can be classified as follows.

-> water users - Consumptive and non-consumptive uses.
-> water polluters agriculture, Industry, domestic etc
-> water managers organisational and operational level.
-> water policy and low makers - constitutional level.
-> Society - general interests represented by government.
-> Specific interests represented by NGOs

Inventory of water problems.

The water use flow diagram can be most useful to put the registered problems an. In this stage the inventory of water problems limits itself to those generally known and the registered water problems by the main stakeholders.

Step - 2 : Stakeholder Selection.

Stake holders inventory will be made in step one.
-> These stakeholders will be the obvious operators of water services, co-ordination bodies and policy and law makers.
For further process a selection of stakeholders has to be made to avoid duplication.

An independent team is formed to identify and select relevant stakeholders from the catagories

- → water policy makers.
- → water managers.
- → water service providers
- → water using agencies
- → water using groups.
- → water users and other potential interest holders at constitutional, organisational and operation levels.

These stakeholders will be approached for in depth interviews.

step 3: stakeholder interviews

Experts carry out an elaborate procedure of interviewing the selected stakeholders applying the guidelines for interviews. These guidelines are in the format of a quistionnaire, which contain questions relating to the the stakeholders interviewed and their perception of the existing situation and what they consider to be the desired IWRM situation. During this interview

- → Previously overlooked stakeholders can be identified through the identification of parties that negatively influence the implementation of the stakeholder's duties.

A different set of questions under the issues in the matrix is used for all three functional levels. They are:- organized under the headings

- → Stakeholders
- → Awareness
- → policy
- → Legal framework
- → Institutional framework.
- → Finacial arrangements.
- → Human Resource development.
- → management information systems and decision support systems

Second part of the interview aim to:

1) obtain a description of the stakeholder's concept for improvement of the existing water resources situation, towards more Integrated water resource management.

The following aspects and principles should be included.

→ Equitable and socially acceptable water distribution
→ Efficient and economically sustainable water use
→ Delegation, decentralisation and other devolution of authority
→ Integrated planning
→ participation of stakeholders.
→ private sector participation
→ Environmental protection

Step 4: Analysis of stakeholder's opinions

The outcome of all the interviews will be collected and an inventory will be made of agreements b/w the different stakeholders on the present situation the problems and constraints and the steps to be taken to come to a better water management.

→ The results of the interviews are described in a report
→ These stakeholders should also be invited to the workshops that follow in the process.

Workshop-1 problem Identification:

It is important that all the relevant stakeholders recognise their problems and those of others. Hence,

1) The first workshop to which all the relevant stakeholders are invited ~~to~~ deal with the assessment of the existing water resource management situation and problem Identification according to the perception of the stakeholders.

2) The purpose of the first workshop is to obtain common understanding between all different stakeholders of what the real problem and which should be addressed.

3) The analysis report which is formulated in the analysis of step 4 will be used as a reference and will be improved in accordance with the outcome of the workshop.

4) The agreed set of problems by the stakeholders will be then be used as an input for the further stages on formulation of a desired IWRM situation and necessary interventions.

5) End result of this workshop should be a selection of a very fruitful method to arrive at a set of most important problems.

Step-6 : workshop-2

Formulations of desired IWRM situation and interventions.

The second workshop one or three months after the first workshop.

- It will elaborate extensively on the principles of Integrated water resources management and it will further result in the formulation of a desired water resources management situation in that specific river basin and set of inventions that will be needed to achieve that.
- This workshop outcome provides directions for constitutional, organisational and operational interventions.
- The outcome should be seen as an input for national policy and decision makers.

Step 7: Preliminary - Sub basin report.

Based on the foregoing steps the experts will draft a preliminary country document comprising.

- Assessment of existing water management situation.
- complete problem Inventory
- Desired water resources management situation.
- proposed set of general and specific interventions needed to reach the desired situation.

Step - 9 : Final country basin report :

Experts draft a final sub basin / basin report which is offered to the government and finacing agencies for endorsement and inclusion into the strategy in to specific water related projects for the specific country.

Step - 8

The draft country / basin / sub basin report is disseminated and a through procedure for collecting comments from the different stake holders at the different levels is followed.

Step - 10 Monitoring Procedure

A monitoring procedure is developed to see whether the interventions are taking place and whether the envisaged results are achieved.

Types and Forms of private sector Involvement

The private sector is morally bound to do invests in environmental protection as a response to regulation, legislation, and specific incentives

→ The private sector plays an important role in financing water resource management through investiments in service delivery in water supply and sanitation.

The motives for growing involvement of the large and international private sector are:

Finacial : Government passes on the cost and work of raising funds.

Expertise : private companies, if large or international, bring essential know how in some technical and economic fields.

Risk - Sharing : Private companies are typically more willing to take large risks than public authorities

The main types of private involvement in water service provision are found

Full divesture :- Transfer of all public assets through sales, in which case, the private sector obtains full responsibility of the water supply network facilities and operations.

Joint Ventures : Partial transfer of assets through share sales resulting in shared ownership and operating responsibilities between private and public sector

Concessions: Assets remain in public ownership but use of the system to by private sector for the duration of 20-25 years.

— private sector can (collect amount) return fee collection or other form of payment

BOOTs (Build, Operate, Own, and Transfer)/BOO

Build, Operate and own) — Schemes where contracts for the construction of particular infrastructure project is required and where ownership is handed to a public organisation after a specified number of years. In the BOO case ownership remains in the hands of the private sector.

Leasing — The water system remains in public ownership, but it leased to private operators.

Contracting out — The least controversial form of private sector involvement. A water undertaking sub-contracts certain functions to private firms e.g. meter reading.

Even when water services are provided by the private sector

— The government still has a key role in providing a clear regulatory framework and ensuring that the poor are served and users are protected from excessive costs.

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Module - 4

Water Governance And Water Policy

Overview: Legal framework of water, Substance of national water laws - other key issues - changing incentives through regulation, National water policy - National level commissions - Irrigation management, Transfer policies and activities, Legal registation of WUA's. Legal changes in water allocation - Role of local institutions - Community based organizations - water policy Reforms: India.

Water Governance

Water governance refers to the political, social, economical and administrative systems that influence water's use and management.

→ Essentially, who gets, what water, when and how, and who has the right to water and related services, and their benefits.

→ Water governance determines the equity and efficiency in water resource and services allocation and distribution, and balances water use between socio-economic activities and ecosystems.

Governing water Includes:-

1) The formulation of water laws
2) Establishment and implementation of water policies.
3) legislation and institutions
4) clarification of the roles and responsibilities of government.
5) The involvement of private sector & civil society.

Legal framework of water In India

The Existing legal Framework :-

The existing legal, Institutional and decision making frame work for water law In India, both at the national and state level is embodied in the nine major acts at the national and state level.

The national legistations as applicable to water are:

1) water prevention & control of pollution Act 1974.
2) Air prevention and control of pollution Act 19?
3) Environment protection Act 1986.
4) Forest conservation Act 1980 and amended in 1988.
5) public liability Insurance Act 1991.
6) Environment Assessment Development of projects, 1994

→ The ministry of environment and Forest is the nodal agency in the administrative structure of the central government for planning promotion and coordination and overseeing the implementation of environment legislation and programs and regulatory functions like environment clearance.

Existing Legal framework of for water: priority areas and water rights.

Groundwater Law :

"Groundwater governance comprises the promotion of responsible collective action to ensure control, protection and socially - sustainable utilisation of groundwater resources for the benefit of humankind and dependent ecosystems."

But, In India the existing groundwater law is inappropriate, because of, following reasons,

→ Traditionally groundwater has been treated as a land property, where the access is to private land owners alone.

→ Such a property do not relate to hydrological, ecological or equity concerns at all. Hence access to groundwater is highly inequitable,, which depend up on land ownership and economic capacity to draw.

\# Need of legal framework for groundwater rights existing legal framework for ground water is as follows:- (why there should be reframing of groundwater law)

→ The existing groundwater rights are under totally land owners regime

→ There is no limit to the volume of groundwater a landowner may draw

→ In such a legal framework only landowners can own groundwater in India.

→ All landless tribal's, who may have community rights but over land but not private ownership.

→ It also implies that rich land lords can be water lords and indulge in openly selling as much water as they wish.

Recommendations

To ensure proper and equitable distribution of water it is recommended that water rights should be separated from land rights.

Areas where legal sanction is needed

1) where there is over exploitation of groundwater
2) where there is disputes between two parties regarding the expolution of water.
3) where there is environmental degradation due to overexploitation
4) where there is ground water pollution

Tank Water Bodies

In many parts of India, irrigation has traditionally been tank based.

In major irrigation system, Irrigation canals covers only 36% of the agricultural land. Remaining 64% is rain fed, groundwater irrigated and natural or artificial tank irrigated crop lands.

→ Despite this crucial dependence on tanks and wells, India has witnessed the negligence and destructions of thousands of tanks and gross misuse of ground-water.

→ There is a need to reform the appropriate legal structure that will support local controls and provides incentives for sustainable and equitable use of water tanks.

Recommedations

It is proposed to make detailed study of the customary and ~~stly~~ statuatory laws of the concerning use of tank and wetland ~~wasters~~ waters in rural areas.

→ These laws provided various strategies through which common resources could be utilised for common good.

The aim of the study would be to devise appropriate legal strategies for the preservation of tanks, its management and for equitable use of its resources.

→ The negelect of tank and groundwater law is directly related to the emphasis on construction of dams; Since these have been Conceived as the main scientific alternative for irrigation and food production.

→ The appropriate legal framework for Dams will turn the attention to the developement of tank and groundwater laws.

Indian National Water Policy.

National water policy is formulated by the ministry of water resources of the Government of India; to govern the planning and development of water resources and their optimum utilization.

→ The first national water policy was adopted in September, 1987. It was reviewed and updated in 2002 and later in 2012.

② **The Need for a National Water Policy.**

1) → water is a prime natural resource, a basic human need and a precious national asset planning and development resources need to be governed by national perspectives.

2) → India has more than 18% of the world's population, but has only
 → 4% of renewable water resources
 → 2.4% of land area.

3) → There are further limits on utilizable quantities of water owing to uneven distribution over time and space. [water does not respect state boundaries]

4) → In addition, there are challenges of flood and draught, growing population rising need, climate change, Mismanagement wastage, inefficient use and also pollution.

5) Water, like air, is one of the most basic requirements for life. If a national law is considered necessary on subjects such as the environment, forests, wildlife, biological diversity, etc. then a national law on water is even more necessary.

6) Under the Indian constitution water is primarily a state subject, but it is an increasingly important national concern in the context of:

a) The right to water being a part of the fundamental ~~the~~ right to life.

b) The perception of a water crisis because of the mounting pressure on a finite resource

c) The inter use and inter state conflicts that this leads to, and the need for a national concensus on water - sharing principles and on the arrangements for minimising conflicts and settling them quickly without resort to adjudication to the extent possible.

d) The threat to this vital resource by the massive generation of waste by various use of water and the severe pollution and contamination caused by it.

e) The equity implications of the distribution use and control of water, equity as between uses, users, sectors, states, countries and generations.

7) Different state governments tend to adopt different positions on the rights of different states over the waters of a river basin. A national statement of the general legal position and principles that should govern such cases in a desirable way should be required i.e. as nation water policy.

Hence a ~~w~~ National water policy is necessary.

The Nature and scope of a National Water Law.

1.) The proposed national water law is not intended to centralise water management or to change the center-state relations in any-way. It is a framework of law i.e., an umbrella statement of general principles governing the exercise of legislative or executive powers by the center, the states and the local governance institutions.

2) The law is to be justiciable in the sense that the laws passed and the executive actions taken by the central and state governments and the developed functions are exercised in the nation. Any deviations from this law be challenged in a court of law.

3) No administrative machinery or institutional structure is ~~predictable~~ predicting at the center under this framework hence no penal provisions are expected.

Other Key Issues

1. Lack of awareness

1) Lack of awareness about the law and policy framework is still a major issue in rural India

2) lack of participation

1) The lack of public participitation in law and policy making process is a collateral impact of general awareness.

2) Mostly, law and policy making process follow a top-to-bottom approach where people are at the receiving end having no role to play in framing of norms and regulations. This situation is worse in rural areas where people cannot read and write. A lot of efforts needs to be put to make a bottom-to-top approach work in law and policy making process.

3) Hence idea of participation is also important from the angle of implementation of various policies.

Gender and Caste Discrimination

Gender and caste are two important factors to be given adequate attention in the law and policy framework related to water and sanitation.

→ Women and lower caste people are quite often neglected sections. Eventhough women can play crucial and effective role in water resource management and development they are mostly no where in the picture of framing and implementation of various policies and schemes.

→ The emerging legal framework also by implication excludes women, for instance, The participatory irrigation management laws allows only the land owners or occupiers to become members of water user's associations (WUAs), consequently, women are excluded from the key decision making process.

→ Caste is also a crucial determining factor. Even though caste discrimination has been prohibited by law, it is still prevalent in rural areas. Lower caste people usually has to wait till the higher caste people finishes fetching water and they also have to face sometimes abusive language and degrading treatment.

Hence, more actions are needed from the side of the government to eliminate these unique inhuman practices.

~~Irrigation Management Transfer policies and~~ activities

Irrigation Management Activities and Institutions

Definitions

"An Irrigation system is a system of physical structures, such as dams, canals, gates, pumps and others, that capture water from a natural source and distribute it to farmers to use for watering crop plants."

Irrigation Management activities are :-

1) water distribution : Capturing and distributing water in an irrigation system.

Maintenance: Repairing and maintaining the physical features or structures of the irrigation system.

Resource Mobilization (act of movement): Raising the resources needed for operations and maintenance

Conflict Resolution: Resolving conflicts among users and system managers ~~use~~ over the above three items. Irrigation management institutions include the rules and organizations concerned with these four activities.

Irrigation Management Policy.

Government irrigation management policy includes those rules and principles that defines institutions - rules and organizations irrigation management Policies thus define

Water distribution rules: The rules defining the proper distribution of irrigation water to users.

Resource Mobilization rules: The process ~~of~~ for mobilization of resources for operations and maintenance of the system, including requirements for the payment of irrigation fees and for contributing labor.

Conflict Resolution Rules: The rules regarding how conflicts are to be settled.

System Managers: The persons or organizations responsible for operations and maintenance for resource mobilization, and for conflict resolution.

These items are defined in government policy for all government managed irrigation systems.

→ There are more important policy provisions rather than this single document

IRRIGATION MANAGEMENT TRANSFER

Irrigation Management Transfer (IMT) can be defined as the "transfer of some, or all irrigation management responsibilities for an irrigation system from a government agency to one or more private (or local) persons or organizations."

→ Management transfer need not be total but could be limited to specific parts of irrigation systems or to specific management functions.

→ Irrigation management transfer activities are the programes and individual efforts designed to implement IMT policies.

Diemensions for Classifying Irrigation Management Transfer policies and activities.

The definition of IMT includes transfer of responsibilities from a government agency to private persons or organizations.

This suggests that two of the needed traits are:-
↳ pan(characterstics)

→ Definition of the persons or organizations to whom the responsibilities are to be transferred.

→ The responsibilities to be transferred from the government agency to the private person.

Transfer of responsibilities should be to water user associations (WUAs) or some form or other.

The reasoning is that,

a) water users - farmers have the proper set of motivations to handle irrigation management activities efficiently and effectively.

→ The rights and powers, particularly those over water distribution in the board sense, to be transferred.

Since IMT involves two parties the government agency and the private organizations and persons resources should be mobilized for the operation and maintenance for any irrigation system.

other Issues;

1) change in systems and requirements for resource mobilization for the government agency.
2) changes in systems and requirements for resource mobilizations for the private persons and organizations.

The means by which IMT is to be implemented

The following seven elements as the key diemensions for the classification of IMT policies and activities:-

1) Persons or organizations to whom responsibilities are transferred
2.) Responsibilities transferred
3.) Rights and powers transferred
4.) change in agency recourse mobilization
5.) Change in resource mobilization for the private persons or organizations.
6.) changes in conflict resolution institutions.
7.) IMT implementation, in any one of classification it may not be necessary to make use of all of these diemensions

Water User Allocations (WUAS)

WUA - (IS an Association of water users like, Irrigators, farmers etc.)

Origin of WUAs

Two aspects of the origin are particularly relevant to performance
1) The age of the organizations
&.
2) whether the impetus for organising was internal or external.

WUAs originating from internal initiatives are often found in small scale, farmer managed irrigation systems.

Bylaws of the WUAS

Bylaws are normally required before a WUA; can be registered as a legal entity, and before it can be allowed to operate.

The issues that such bylaws address include;

i) Basic facts about, and objectives, of the WUA.
ii) Criteria for becoming a member of WUA
iii) Number of farmers required for the establishment of a WUA.
iv) The WUA as a legal entity
v) Structural organizations and internal arrangement
vi) Operations and maintenance
vii) Water charges.
viii) Rights and obligations of members.
ix) Interpreting and amending the bylaws.
x) liquidation of the WUA and
xi) Establishment of a federation of WUAs

Criteria for becoming a member of the WUA

Most bylaws restrict membership to the registered landowners in the hydrulic unit, who are engaged on a full-time basis in farming.

→ But it in some countries like 'Nepal' extend the right to become a member to both owners and tentants, where membership of WUA is open to 'farmers having lands or tenancy rights.

→ In some cases multiple users of water can become members of the WUA.
Eg: Not only irrigators, but also livestock owners and fisherman.

→ In many cases, women apper to be almost absent from water user's groups or associations. The only women who can potentially participate in water user's groups are either widows or single mothers with no adult male living in the household.

→ On occassion special arrangements are made to provide for the representation of the disadvantaged, such as tail-enders female heads of farms or small famers. i.e., Representatives from the head and tail end of the irrigation system.

Role of water Allocation

→ Water allocation is the process of sharing a limited natural resource between different regions and competing users.

→ It is a process made necessary when the natural distribution and availability of water fails to meet the needs of all water users - In terms of quantity, quality, timing of availability.

→ In simple terms, it is the mechanism for determining who can take water, how much they can take, from which location, when and for what purpose.

Ten golden rules of basin water Allocation.

Rule 1 : In basins where water is becoming stressed, it is important to link allocation planning to broader social, environmental and economic development planning.

Rule 2 : Successful basin allocation processes depend on the existence of adequate institutional capacity.

Rule 3 : The degree of complexity in an allocation plan should reflect the complexity and challenges in the basin.

Rule 4 : Considerable care is required in defining the amount of water available for allocation.

Rule 5 : Environmental water need a foundation on which basin allocation planning should be built.

Rule 6 : The water needs of certain priority purposes should be met before water is allocated among other users.

Rule 7 : In stressed basins, water efficiency assessments and objectives should be developed in or alongside the allocation plan.

Rule 8 : Allocation plans need to have a clear and equitable approach for addressing variability between years.

Rule 9: Allocation plans need to incorporate flexibility in recognition of uncertainity over the medium to long term.

Rule 10: A clear process is required for converting regional water shares into local and individual water entitlements, and for clearly defining annual allocations.

Water Reforms In India

Reform – Make Something better, to improve Something or to remove the faults.

The Mihir shah Committee suggested a reform strategy for the country's water Sector.

→ The report A 21st century Institutional Architecture for India's water Reforms, made several recommendations based on its diagnosis of the ailing sector. (weak)

→ The reform agenda was a proposed restructuring of the Central water Commission (CWC) and Central Ground water board of India (CGWB)

Scope of Reform

India's water Sector faces a challenges. Some of the problem in the water sector identified by the committee are;

1) The efficiency in public irrigation schemes is as low as 35%, there is a huge gap between potential created and potential utilised in the irrigation sector.

2) There is no scope for further development of the surface water in the country, in view of the fact that in India highly developed rivers are facing severe water stress.

3) Managing water today is no longer about only developing new sources through means such as
   - → Construction of Reservoirs.
   - → Digging Wells.
   - → Laying canals and pipelines.

But it is allocating the limited water amongest various competitive uses.

India's Draft National Water Policy 2012

→ Ministry of water resources, Government of India, in Jan 2012, released a draft national water policy for the consideration and opinion of state governments and other stakeholders.

→ **Key Items in the Draft Policy Include**

→ Since 2012 draft is the review of 2002 draft, here priorities are given for water allocation.

-> The center would like water budgeting and auditing to be made mandatory and for each state government to put a regulator for water allocation, water use efficiency, and physical and finacial sustainability of water resources, with a mechanism to establish a water tariff system and fix the criteria for water charges.

-> The draft is made to change the current attitude towards water recharging, both among the government agencies as well as the public, especially the farming communities.

-> Currently heavy under pricing of electricity leads to wasteful use of both electricity and water which this draft also hopes to reverse.

-> The water related services should be transferred to community and/or private sector with appropriate "public private partnership model".

-> The draft Policy calls for the aboliation of all forms of water subsides to the agricultural and domestic sectors, but subsides and incentives should be provided to private industry for recycling and reusing treated effluents.

3/4/2018

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Module - 5

Water Harvesting and Conservation.

Objectives: Water harvesting techniques, Micro catchments - Design of small water Harvesting structures - farm Ponds - Percolation tanks - Yield from a catchment, Rain water Harvesting - various techniques related to Rural and Urban area.

Water Harvesting

→ It is the activity of direct collection of rain water.

→ Water harvesting means capturing rain water where it falls and capture run off from catchment and streams etc.

→ This collected water could be stored for later use and recharged into the ground water again.

Why water Harvesting is Important

→ To conserve & augment the storage of ground water.

→ To reduce water table depletion.

→ To improve the quality of ground water.

→ To arrest sea water intrusion in coastal areas.

→ To avoid flood & water stagnation in urban areas.

→ Water harvesting techniques gather water from an area termed as 'catchment area' and channel it to the cropping area or wherever required.

Techniques of rainwater harvestings

There are two main techniques of rain water harvestings.

→ Storage of rainwater on surface for future use

→ Recharge to groundwater.

Principles of water harvesting & conservation

Water harvesting techniques use to make more efficient use of the available water. It is Important to consider how crops receive or lose water.

- crops receive water through rainfall irrigation and stored soil water.
- They lose it through run off, evaporation and drainage.

Some key principles on effective water management are.

→ Use rainwater effectively

→ Make effective use of soil water reserves.

→ Take measures to avoid run off

→ Avoid wasting water through evaporation

→ Reduce water losses through drainage

→ plan your Irrigation.

- Irrigation should be restricted to the most critical periods

Techniques

1. CONTOUR FARMING

→ Contour farming refers to field activities such as ploughing and furrowing that are carried out along contours rather than up and down the slope.

→ They conserve water by reducing surface run off and encouraging infiltration of water in to crop area.

A number of water harvesting techniques are based along contours including

i) Contour ploughing
ii) contour ridges
iii) terraces
iv) Stone lines
v) grass strips

The techniques used depends on the steepness of the slope, Soil type, conditions, crops grown and other factors such as availability of labour.

i) Contour ploughing

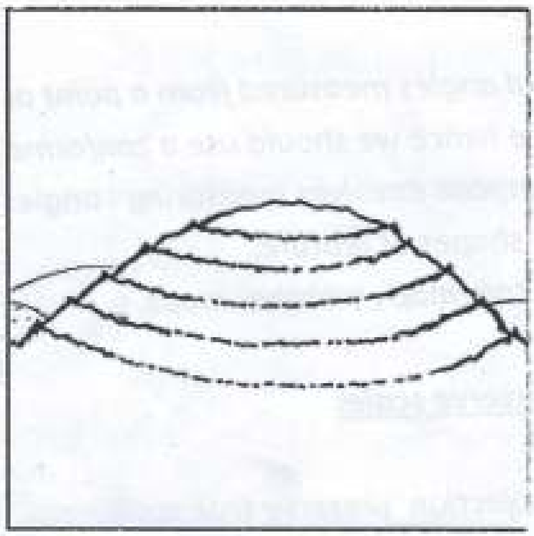
→ Ploughing on a slope should be carried out along the contours rather than up and downs as this reduces run off and soil erosion and increases moisture retention

→ Contour ploughing can be practised on any slope with a gradient less than 10%.

→ steeper slope it should be combined with other measures such as terracing bunds or stripp cropping.

Slope	Medium (up to 10%)
Soil	Not suitable for heavier Soil types
Rain fall	Medium - Not suitable for very low rainfall areas as the catchment area is limited.
Labour	Medium and may require some labour to maintain
crops	[illegible]

Figure

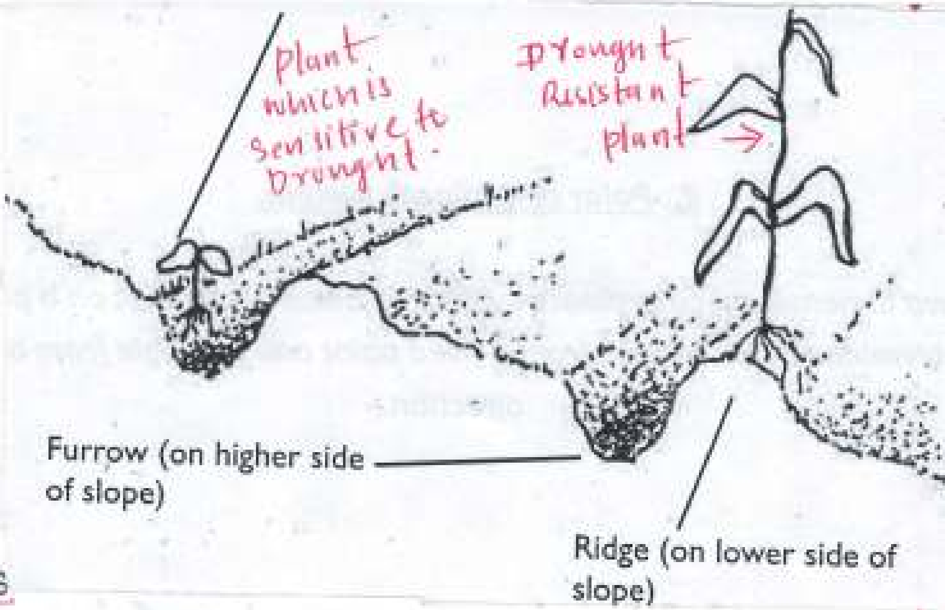


ii) Contour furrows

→ Contour furrows are small earthen banks that run along a contour.
→ A furrow is dug next to each bank on the upper side of the slope.
→ The aim of the contour furrows is to concentrate moisture into the ridge and furrow area where the crops are planted by trapping run off water from the catchment area b/w them. This also reduces the risk of erosion.

Slope :	Gentle 0.5 - 3 %.
Soil :	Not suitable for heavier soil types with low infiltration rates.
Rain fall :	Low rainfall (350 - 700mm). Intense rainfall can cause the ditches to overflow and break.
Labour :	Not too much labour to set up, but furrows need to be maintained and repaired regularly.
Crops :	Cereals, peas and beans.

Figure:-

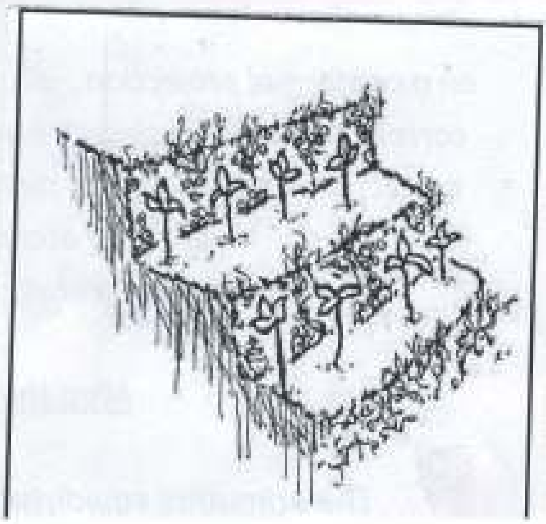


Bench Terraces

→ Terraces are made by creating ridges and furrows along contours on a slope.
→ The ridges hold back water and soil runoff and eventually turn the hillside in to a number of terraces.
→ These can be stabilised by planting grasses or shurbs on them.

Slope	steep (up to 40%) depending on the method
Soil	Needs to be stable
Rainfall	Stone terraces can tolerate high rainfall. Terraces formed by throwing the earth down hill should not be used in areas with intense rainfall
Labour	Extremely high.
Crops	Large range.

Figure:-

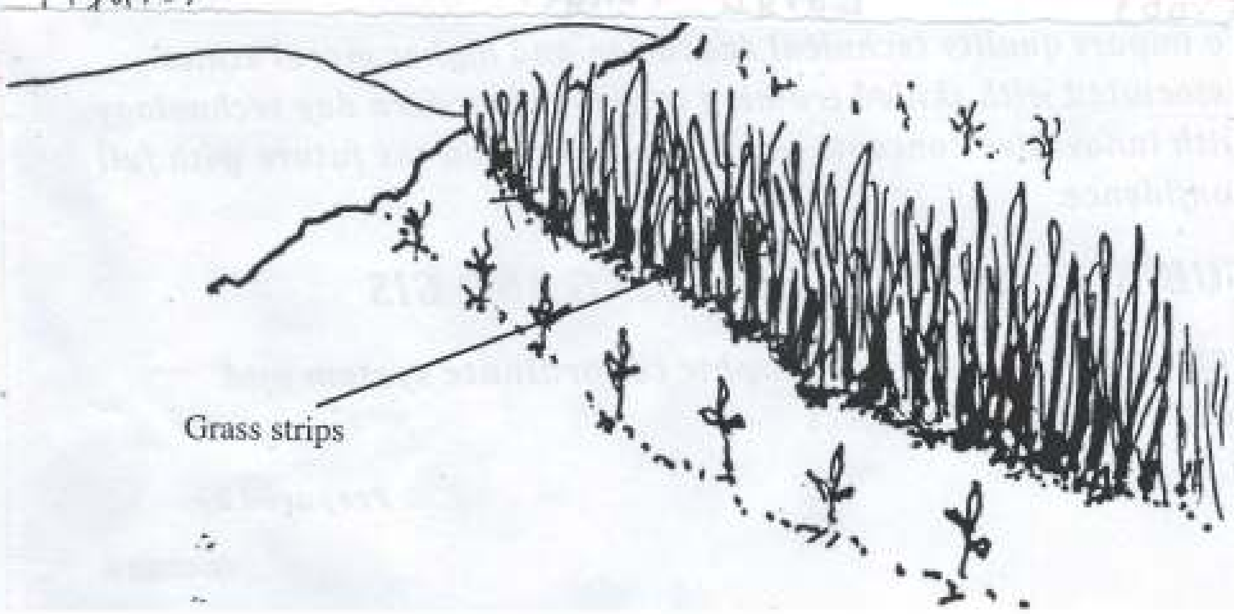


Grass strips

- → Strips of grass (up to 1m wide) planted along a contour can reduce soil erosion and run off.
- → Silts built up in front of the strip and over time benches are formed.
- → On gentle slopes the strips should be widely spaced (20-30m apart), and on steeper slopes narrowly spaced (10-15m apart)
- → The grass needs to be trimmed regularly to prevent it competing with crops.
- → Varities of grass can be used, depending on what is locally available.

Slopes	shallow (< 2%)
Soil	Range of soils – may be problems with competition for water on very light sandy soils.
Rain fall	Not suitable for very dry conditions < 500mm.
Labour	Easy to set up. High labour required for cutting and maintainence
Crops	Range of crops.

Figure:-



Slope	Shallow (< 2%)
Soil	Needs to be relatively free draining and stable.
Rainfall	Arid - Semi arid (500 mm). when heavy rainfall occurs the ditches might overflow and break.
Labour	High labour input to construct and need to be maintained and desilted regularly.
Crops	Can be used for larger ~~movie~~ more water demanding crops such as bananas

Planting pits

→ planting pits are very simple form of freestanding water harvesting structure that are easy to construct.

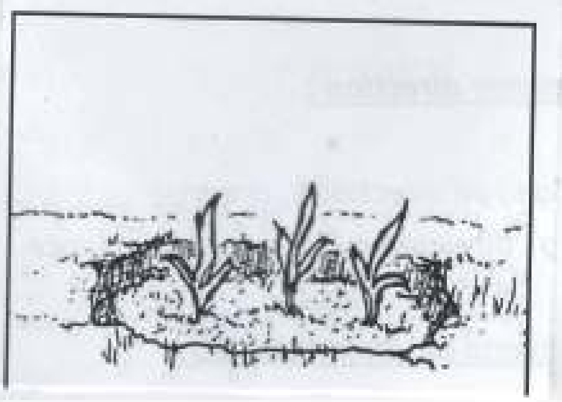
→ They consist of small pits in which small groups or Individual plants are sown.

→ The pits catch run off and concentrate Soil moisture around the roots.

→ The pits are 10 - 30 cm in diameter and 5-15 cm deep and are spaced 1m apart.

→ Successful in areas of low rainfall.

Diagram.



Stone lines

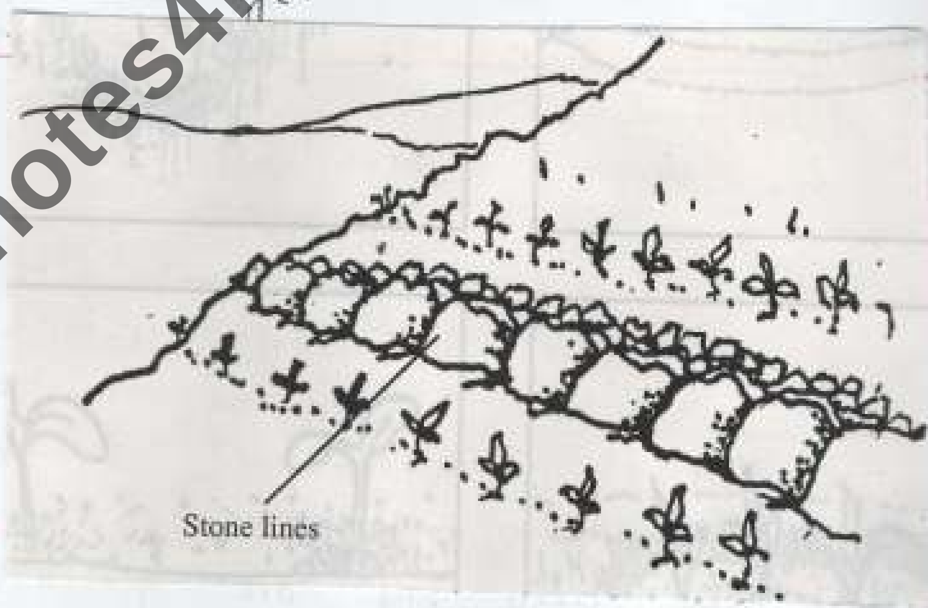
Stones lines running along the contour are of one of the simplest contour techniques to design and construct.

→ The lines of stones form a semi-permeable barrier that slows the speed of run off so that spread of water over the field and infiltration is increased, and soil erosion reduced.

→ The lines are constructed by making a shallow foundation trench along the contour.

Slope	:	Gentle (0.5 to 3 %)
Soil	:	Suitable for wide range of soils.
Rainfall	:	Low 350 - 700 mm
Labour	:	Labour intensive to build.
Crops	:	Wide Range.

Figure:-



Retention Ditches

Similar principle to contour furrows but on a large scale.

→ They are large ditches, designed to catch and retain all incoming run-off and hold it until it infiltrates into the ground, increasing the supply of water to crops planted in the ditch and reducing soil erosion.

Earth Basins

→ Earth basins are designed to collect and hold rainfall and are easy to construct by hand.

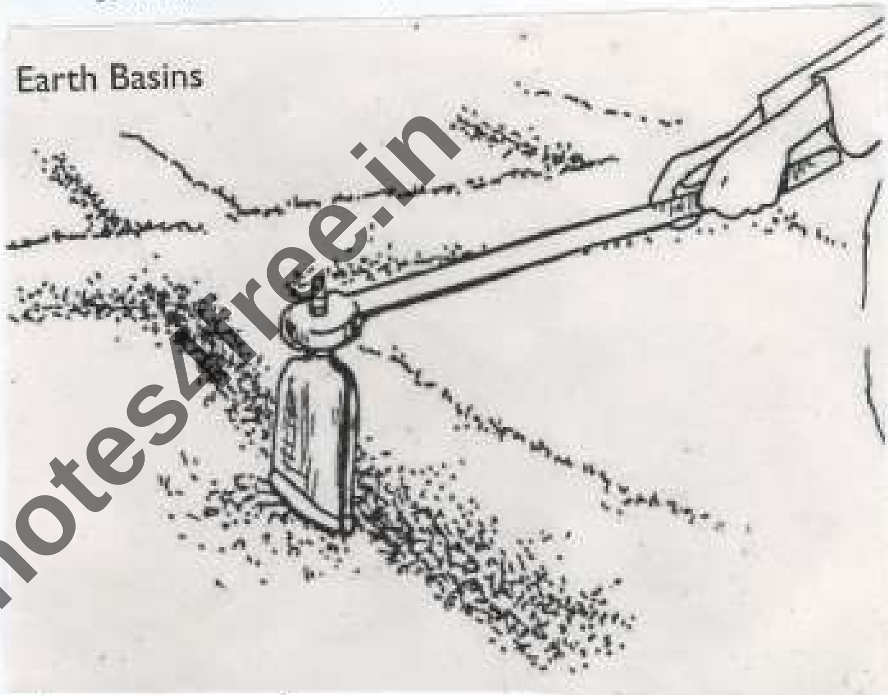
→ They are square or diamond shaped basins with earth ridges on all sides.

→ Runoff water is channelled to the lowest point and stored in an infiltration pit.

→ They are 1-2 m long up to 30 m are depth

→ Suitable for semi- arid areas with annual rainfall amounts of 150 mm and above.

Fig:-



Semi- Circular Bunds

— Semi - Circular bunds are earth bunds formed in U - shaped on a slope.

→ The uppermost tips of the 'U' lie on a contour so that run off is collected in the lowest section of the U.

→ A shallow pit is sometimes also dug in this section to help moisture.

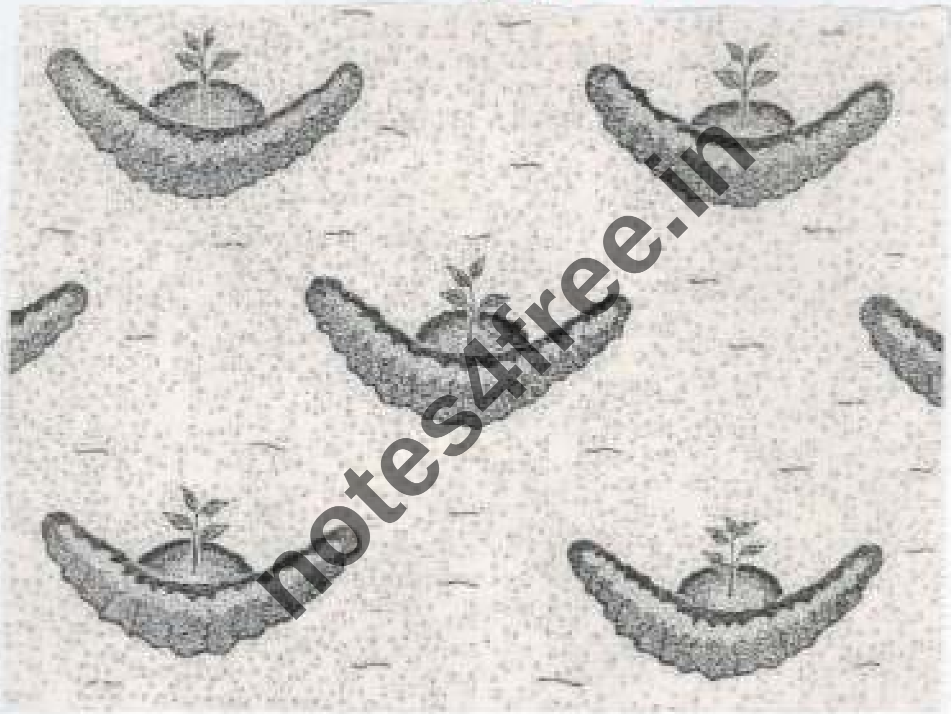
→ Suitable for gentle slopes and uneven terrain with annual rainfall of 350 - 700mm.

Other Methods.

→ Cover crops
→ Mulching
→ Drip Irrigation
→ Conservation Tillage

Figures

↓ Semi circular Bunds



Rain Water Harvesting

Definition :

Rainwater harvesting is the accumulating and storing of rainwater by artificial methods for future utilization.

→ The principle of collecting and using precipitat[ion] from a catchment surface.

→ Mostly done by rooftop harvesting and used for domestic and agricultural purposes

Requirement (Necessity)

→ Surface water is inadequate to meet our deman[d] and we have to depend on groundwater.

→ Environmental changes.
→ To beneficiate water quality aquifers.
→ To reduce soil erosion.
→ To conserve surface water run off during monsoon
→ Due to rapid urbanization, infiltration of rain water in to the sub soil ~~is~~ has decreased drastically and recharging of ground water has diminished etc.

→ To reduce groundwater Pollution.
→ To avoid the flooding of Roads.
→ Supplement domestic water needs.
→ To raise the underground water table.

Methods of Rainwater Harvesting

Broadly there are two ways of harvesting rainwater.

i) Surface runoff harvesting
ii) Roof top rainwater harvesting

i) Surface Runoff Harvesting

In urban area rainwater flows away as surface runoff. This runoff could be cought and used for recharging aquifers by adopting appropriate methods.

2) Roof top Rainwater Harvesting

It is a system of catching rainwater where it falls In rooftop harvesting, the roof becomes the catchments, and the rainwater is collected from the roof of the house/building. It can either be stored in a tank or diverted to artificial recharge system

→ This method is less expensive and very effecti and if implemented properly helps in augmenting the ground water level of the area.

Components of the roof to rainwater harvesting

The illustrate design of the basic components of roof top rainwater harvesting system is given in typical schematic diagram.

The system mainly constitutes of following sub components.

-> Catchment
-> Transportation
-> First flush
-> Filter
-> storage Tank.

-> Catchment

-> The surface that receives rainfall directly is the catchment of rainwater harvesting system. It may be terrace, courtyard, or paved or unpaved open ground.

-> The terrace may be flat RCC/stone roof or sloping roof.

-> Therefore the catchment is the area, which actually contributes rainwater, ~~which actually~~ to the harvesting system. ~~contributes rainwater~~

Transportation

-> Rainwater from rooftop should be carried through down take water pipes or drains to storage / harvesting system.

-> water pipes should be UV resistant (pvc pi[pes]) of required capacity.

-> water from sloping roofs could be caught through gutters and down take pipes.

-> At terraces, mouth of the each drain should have wire mesh to restrict floatin[g] material.

First Flush

First flush is a device used to flush off the to avoid contaminating storable / rechargable water by the probable contaminants of the atmosphere and the catchment roof.

-> It will also help in cleaning of silt and other material deposited on roof during dry seasons provisions of first rain separator should be made at outlet of each drainpipe

Filter

There is always some remote possibility of rain water contaminate groundwater, if proper filter mechanism is not provided.

- Filters are used for treatment of water effectively remove turbidity, color & micro organisms.

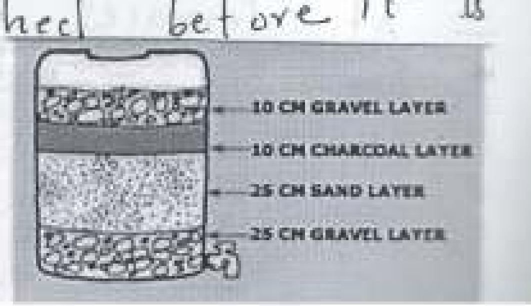
-> After first flushing of rainfall, water should pass through filters.

-> A gravel, sand and 'nelton' mesh filter is designed and placed on top of the storage tank. This filter is very important on keeping the rainwater in the storage tank clean.

-> The filter media should be cleaned daily after every rainfall event.

-> The sand or gravel media should be taken out and watershed before it is replaced in the filter.

Filter unit ->



Storage Tank

There are various options available for the construction of these tanks with respect to the shape, size, material of construction and the position of tank.

-> **Shape:** Cylindrical, square and rectangular.

-> **Material of construction:** Reinforced cement concrete (RCC), masontry, Ferrocement etc.

-> **position of tank:** Depending on land space availability these tanks could be constructed above ground, partly underground or fully underground.

-> Some maintenance measures like disinfection and cleaning are required to ensure the quality of water stored in the container.

If harvested water is decided to recharge the underground aquifer, then some of the below structures mentioned below are used

-> Dug wells, Bore wells, recharge pits and recharge trenches.

2) Suitable for Irrigation

→ Rainwater is free from many chemicals found in groundwater, making it suitable for Irrigation and watering gardens.

→ Storing large reservoirs of harvested water is a great Idea for areas where forest ~~fib~~ fires and bush fires are common during Summer months.

3) Reduces Demands on Groundwater

→ Increase in population is the reason for the Increasing the demand for water continiously. This has lead to depletion of groundwater which has gone to significant low level in some areas where there is huge water scarlity.

4) Reduces Floods and Soil Erosion

→ During rainy season, rainwater is collected in large storage tanks which also helps in reducing flood in some low lying areas.

→ A part from this it also helps in reducing Soil erosion and contamination of ~~Surface~~ water with pesticides and fertilizers from rainwater run-off which results in cleaner lakes & ponds.

5) Reducing Water bills

→ Water collected in the rainwater harvesting system can be put to use for several ondrinking functions as well. For many families and small business, this leads to a large reduction in their utilities bill.

→ Rainwater harvesting can provide the needed amount of water for many operations to take place smoothly without having to deplete the nearby water sources.

c) Can be used to Several Non-Drinking purposes

→ Rainwater when collected can be used for several non drinking functions including flushing toilets, washing clothes, watering the garden, washing cars etc.

→ It is unnecessary to use pure drinking water if all we need to use it for some other purpose rather than drinking.

Disadvantages of Rainwater Harvesting

Unpredictable Rainfall

→ Rainfall is hard to predict and sometimes little or no rainfall can limit the supply of rainwater

→ It is not advisable to depend on rainwater alone for all your water needs in areas where there is limited rainfall.

→ Rainwater harvesting is suitable in those areas that receive plenty of rainfall.

Initial High Cost

→ Depending on the system's size and technology level, a rainwater harvesting system may cost anywhere between $ 2000 to $ 2000 and benefit from it cannot be derived until it is ready

3) Regular Maintenance

→ Rainwater harvesting systems require regular maintenance as they may get prone to rodents, mosquitoes, algae growth, insects and lizards.

→ They can become as breeding grounds for many animals, If they are not properly maintained

4) Certain Roof Types may Seep chemicals or Animal Droppings

→ Certain types of roofs may seep chemicals, insects, dirt or animals droppings that can harm plants If it is used for watering the plants.

5) Storage Limits

→ The collection and storage facilities may also impose some kind of restrictions as to how much rainwater you use.

→ During the heavy rainfall, the collection systems may not be able to hold all rainwater.

Rainwater Harvesting in Bangalore city

- At the city level rainwater is collected in more lakes and allowed to infiltrate and recharge the groundwater.
- At individual buildings, rainwater is harvested either by storing in sump tanks or by recharging through small wells.

Models of RWH

There are two main models of rainwater harvesting done in India.

- Rural Model
- Urban Model

Rural Model of RWH

- Rural areas generally use traditional methods of rainwater harvesting

- Main motive of rainwater harvesting in these areas is to facilitate irrigation for agriculture and use of water for domestic and drinking purposes.

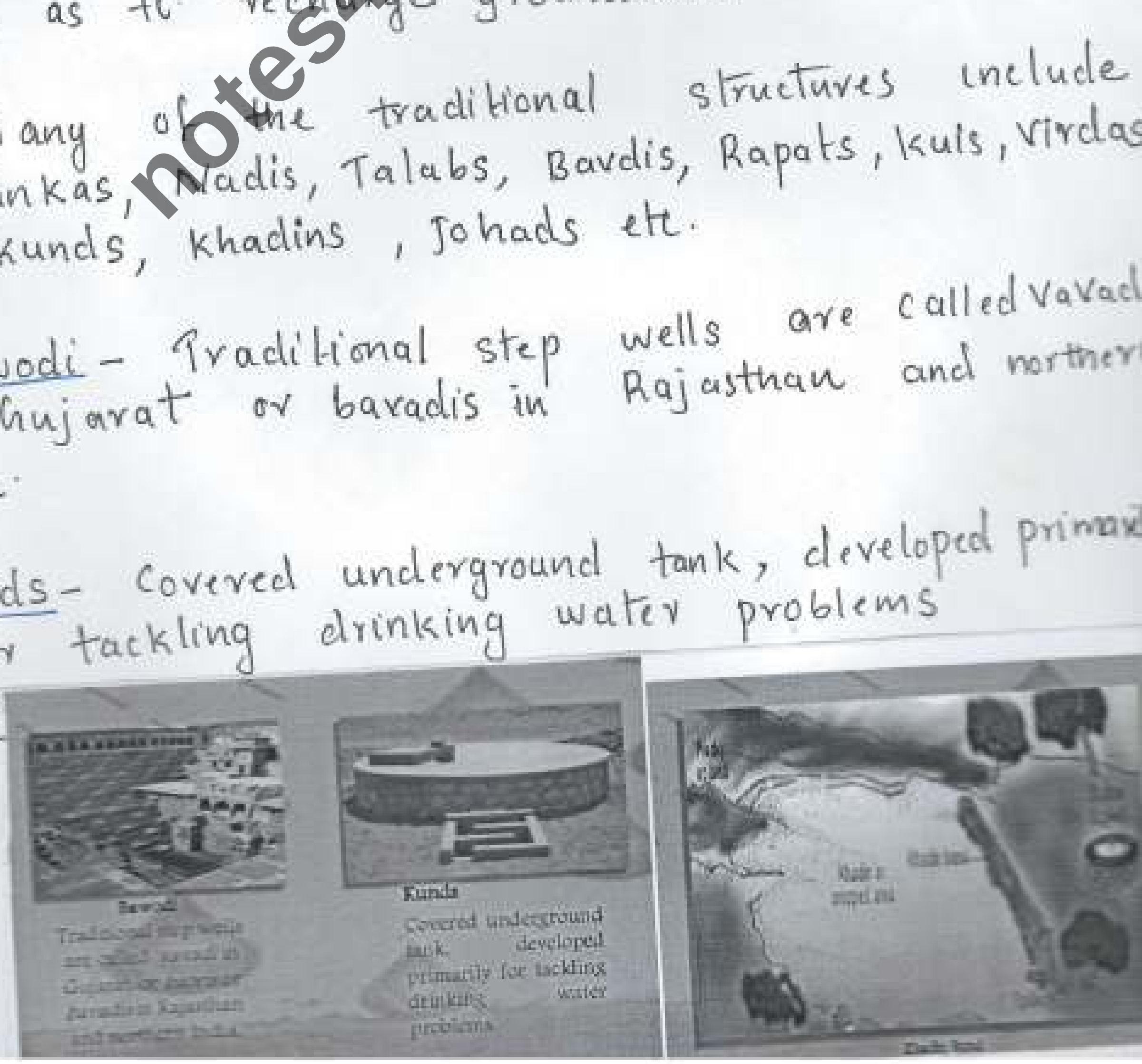
- Now a days practices are also been followed to as to recharge groundwater levels.

- Many of the traditional structures include Tankas, Nadis, Talabs, Bavdis, Rapats, kuls, virdas, kunds, khadins, Johads etc.

Bawodi – Traditional step wells are called vavad in Gujarat or baradis in Rajasthan and northern India.

Kunds – Covered underground tank, developed primarily for tackling drinking water problems

Figure



Urban Model of RWH

- More modernized system of rainwater harvest
- The main components of the urban mode are:-
  - Roof catchment
  - Gutters
  - Down pipe
  - First flush pipe
  - Filter unit
  - Storage tank
  - collection pit

Figures:-

Design of small water Harvesting structures

Farm Ponds

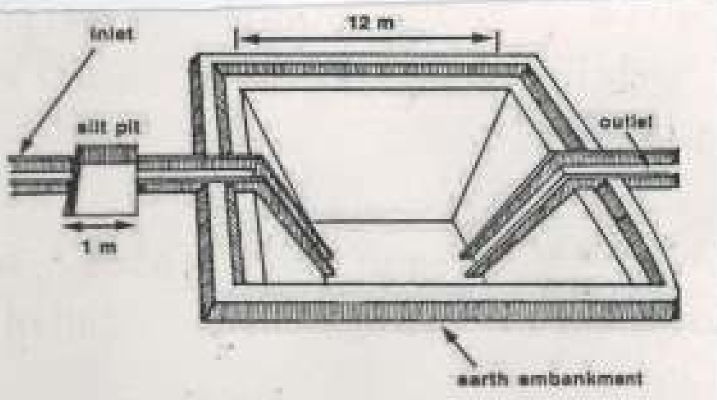
A farm pond is a large hole dug out in the earth. Usually square or rectangular in shape, which harvests rainwater and stores it for future use.

→ It has an inlet to regulate inflow and an outlet to discharge excess water. The pond is surrounded by a small bund, which prevents erosion on the banks of the pond.

→ The size and depth depend on the amount of land available, the type of the soil, the farmer's water requirements, the cost of excavation, and the possible use of the excavated earth.

→ Water from the farm pond is conveyed to the fields manually, by pumping, or by both methods.

Diagram



Dimensions

Bottom width:	6m x 6m	Silt pit depth:	0.8
Top width:	12m x 12m	Inlet width:	2
Depth:	3m	Capacity:	250
Side slope:	1:1	Catchment:	[illegible]

-> The stored water must be used for irrigation only
-> Can be used for ground water recharge also.
-> A farm pond must be located with in a farm drawing the maximum runoff possible in a given rainfall event.

-> A percolation pond can be dug out in any area where the land is not utilize for agriculture.

Site selection

– Think Economically
-> choose an area where a limited amount of excavation will be required to contain or hold back, a large volume of water.

Eg: A ~~narrow~~ valley were a dam can be constructed at a narrow pass is a good example.

Overland Drainage

-> This is surface runoff from precipitation, melting snow, or a spring flowing overland.

-> Drainage area and annual precipitation rates will determine if the water supply will be adequate.

Ground Water

-> ponds which ~~aq~~ acquire water mostly from ground water are often called water table ponds.
-> They are built by excavating below the water table at the location.

Impounding Flowing Waters

-> This can be plentiful water resource for a pond.

-> But impounding flowing water can have adverse effects

-> It can block fish passage

-> warm the water downstream

-> cause sediment from upstream to fill the pond.

-> This type required occasional removal of silt.

-> Hence not recommened to built the pond in this way.

Other Sources

If water cannot be obtained from the natural sources other options are available such as

(1) Diversion ditches can be constructed to catch water from overland drainage that may bypass the pond.

(2) Roof runoff can be collected and sent to the pond or a sump pump drain can be directed to the pond.

(3) Winter snow will recharge the pond when it melts in the spring.

Construction of farm pond

After the site selection and pond diemensions decided the pond site should be ~~site should be~~ cleared of all stones and woody vegetation.

→ Before construction of farm pond, proper layout should be made for proper construct

Earth moving machinery for excavation

→ The selected site should be free from vegetation, bushes and other obstacles, and it should be leveled so that demarcation line of the pond area can be drawn.

→ The design diemensions of proposed pond can be drawn with the help of rope and lines. For demarcation lime powder can be used.

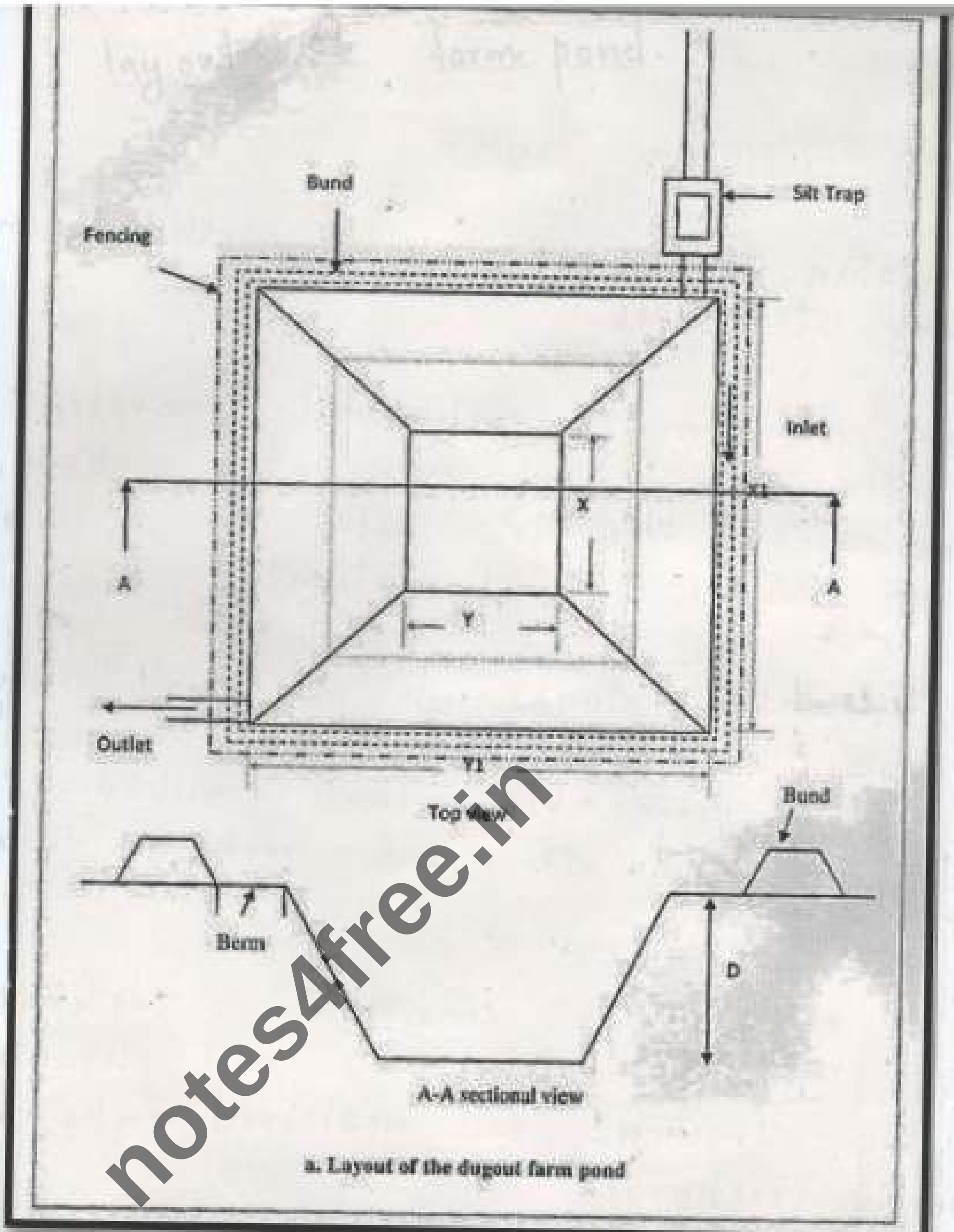
Diemensions of farm pond

→ The size of a pond should be relative to the size of the catchment area contributing surface runoff to the site.

→ ponds with too much watershed require expensive water control structures and are difficult to manage.

Advantages of farm ponds

1) They provide water to start growing crops, with out waiting for rain to fall.
2) They reduce the soil erosion and minimize siltation of waterways and reservoirs.
3) They recharge the groundwater.
4) They improve drainage.



a. Layout of the dugout farm pond

Figure: Layout of farm pond

Typical Average depth of pond.

Climatic conditions	Average depth, m
Wet	2.00 m
Humid	2.40 - 2.80 m
Moist sub humid	2.80 - 3.15 m
Dry sub humid	3.15 - 4.00 m
Semi-arid	4.00 -4.8000 m
Arid	4.80 - 5.50 m

Percolation Tanks

Percolation tanks are mostly earthen dams with masonry structures.

These are most ~~prelevalent~~ prevalent structures in India as a measure of recharge the groundwater reservoir both in alluvial as well as hard rock formations.

→ Percolation tanks is an artificially created surface water body. Since it will be in a highly permeable land, surface runoff made to percolate and recharge the ground water storage.

→ It should be constructed preferably on second to third order streams, located on highly fractured and weathered rocks, for speedy recharge.

→ The size of the percolation tank should be governed by the percolation capacity of the strata in the tank bed rather than yield of the catchment.

→ Detailed analysis of following parameters are necessary to demarcate suitable percolation tank sites.

- → Rainfall pattern
- → Number of rainy ~~season~~ days.
- → dry spells
- → Evaporation rate
- → Detailed hydrological studies

Design of percolation Tank

Capacity of the percolation tank has to be calculated on the basis of the rainfall and catchment area of the tank. The procedure of design is as follows.

1. Select the site for the percolation tank.
2. From the toposheet, find out the correct catchment area of the watershed at that location.
3. Compute catchment yield from rainfall and runoff coefficient.

Good catchment : Hills or plains with little cultivation and moderately absorbant soil.

Average catchment : Flat partly cultivated stiff gravely/ sandy absorbent soil.

Bad catchment : Flat and cultivated sandy soils.

4. Make suitable assumptions: Such as number of fillings per year, utilization of yield per filling etc. Hence compute the capacity of percolation tank

5) Development of storage capacity curve/ table: Draw the contour lines at every 50cm intervel between the bed level and the highest ground level at the site. From these contour lines, the capacity of the tank at 0.5m, 1.0m 1.5m, 2.0m --- height above the bed level is calculated.

6) Compute full tank level (FTL) from stage

8) Compute top width of embankment.

$$W = H/5 + 1.5$$

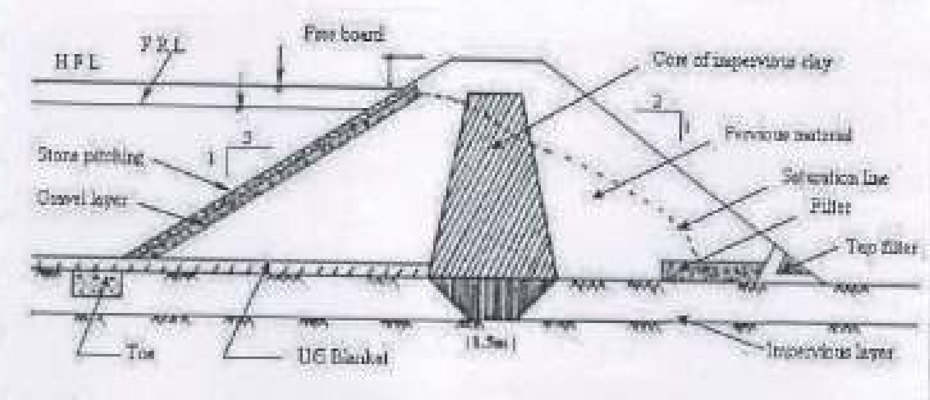
W : top width of embankment (m)
H : total height of embankment (m).

9) Compute length of embankment

Length of the embankment is the distance between the points where the height intersects the contour having same elevation.

10) Based-upon the type of material, assign suitable side slopes for embankments.
11) compute peak discharge.
Compute length of spillway.
12) Compute width of horizontal floor.
13) Check the stability of the structure by
14) locating the saturation line on the base

Diagram



Microcatchment Systems

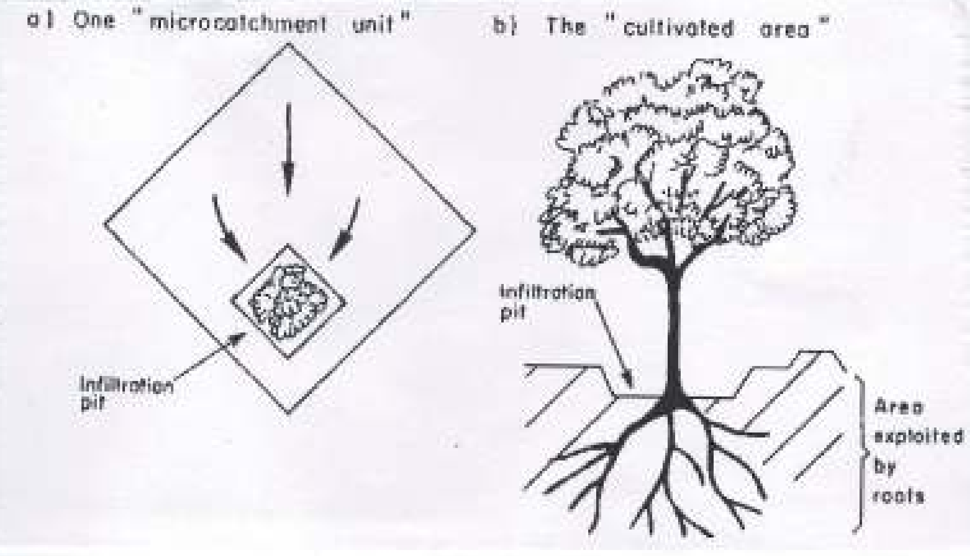
Microcatchment water harvesting is a method for collecting surface runoff from a small catchment area and storing it in the root zone of an adjacent infiltration basin.

- → This infiltration basin may be planted with a single tree, bush or with annual crops.
- → The use of microcatchment as a water harvesting method greatly increases crop productivity, and have been used for thousands of years.

Technical characteristics

- → Overland flow harvested from short catchment length
- → catchment length usually between 1 & 30 meters
- → Runoff is stored in soil profile.
- → Ratio of catchment area to cultivated area is usually 1:1 to 3:1
- → There is no provision for overflow.

Figure :-



Benefits:

1) Increase in crop yield and reliability
2) Allow plants to grow in otherwise unsustainable conditions.
3) Cheaper than installing expensive irrigation system.
4) Erosion control function.
5) Can be constructed on almost any slope, includi[ng] level plains.
6) Simple design and cheap to install and adaptabl[e]

Limitations

(1) Requires deep soil (at least 1.5 to 2m) in cultivated area to store water between rainfall require at least 80mm of precipitation per rainy season ② If the season occurs during the cold season, and requir[es] more than 80mm ③ If rains occur during the summer due to greater evaporation Soils in the catchment area must be crust forming or impermeable Soils in the cultivated area need to have a high wate[r] capacity.