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Module-4

Water Governance and water Policy

What is water governance?

Water governance is related to the range of political,social,economic and administrative systems that are in a place to develop and manage water resources and the delivery of water services at different levels of society.

Or

Water governance is the set of systems that control decision-making with regard to water resource development and mangement.hence,water governance is much more about the way in which decisions are made (i,e how,by whom, and under what conditions decisions are made) than the decisions themselves.

What is water policy?

Water resource policy encompasses the policy-making processes that affect the collection,preparation,use and disposal of water to support human uses and protect environmental quality. A second dimension of issues addresses how policies are created,excuted and amended.

Public → Elected officials → regulatory agencies Water policy → Management staff → Water Management

Legal framework of water

It defines and identifies the legal rights and obligations of public and private water users tied to water use and provides the perspective parameters for resource development and management to promote public interest.

LEGAL FRAMEWORK OF WATER

- The existing legal, institutional and decision making frame work for water law in India, both at the national and state level. The national legislations as applicable to water are:

1.Water prevention and control of pollution Act 1974

2.Air prevention and control of pollution Act 1977

3.Environmental protection Act 1986

4.Forest conservation Act 1980 and amended in 1988

5.Public liability insurance Act 1991

6.Environmental Assessment Development of projects,1994

- the ministry of environmental 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.

1.WATER PREVENTION AND CONTROL OF POLLUTION ACT 1974

- An Act to provide for the prevention and control of water pollution and the maintaining or restoring of wholesomeness of water for the establishment, with a view to carrying out the purpose aforesaid, of boards for the prevention and control of water pollution, for conferring on and assigning to such boards powers and functions relating there to and for matters connected there with.
- The Act was amended on 1988 and finally updated in the year 2003
- The aim of the Act is to deal with a variety of environmental issues, including waste on land, water pollution, abandoned mines, noise pollution and the prevention of atmospheric pollution

2.Air prevention and control of pollution Act 1977

- An Act to provide for the prevention, control and abatement of air pollution, for the establishment, with a view to carrying out the aforesaid purposes of boards powers and functions relating there to and for matters connected there with.
- "Air pollutant" means any solid, liquid or gaseous substance (including noise) present in the atmosphere in such concentration as may be or tend to be injurious to human beings or other living creatures or plants or property or environment
- The act was amended on 1981.

3.Environmental protection Act 1986

- An act to provide for the protection and improvement of environment.
- "environment" includes water ,air and land the inter-relationship which exists among and between water, air and land human beings, other living creatures,plants,micro-organism and property.
- Environmental pollutant means any solid or gaseous substance present in such concentration as may be,or tend to be, injurious to environment.

4.Forest conservation Act 1980 and amended in 1988

- An Act to provide for the conservation of forests
- It extends to the whole of india except the state of Jammu and Kashmir.
- It shall be deemed to have come into force on the 25^{th} day of October 1980.
- Whoever contravenes or abets the contravention of any of the provisions of section 2,shall be punished with simple imprisonment for a period which may extend to 15days.

5.Public liability insurance Act 1991

- An act to provide for public liability insurance for the purpose of providing immediate relief to the persons affected by accident occurring while handling any hazardous substance and for matters connected there with or incidental there to.

6.Environmental Assessment Development of projects,1994

- Enacted in the year 1994
- This assessment concentrates all the environmental consequences of plan policy or program.

Existing legal framework 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 utilization of ground water 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 economics capacity to draw.

Need of legal framework for ground-water rights existing legal frame work for ground water is as follows

- 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 Community rights but who may have 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.

Tank Water Bodies

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

In major irrigation system, Irrigation canals covers only 367 of the agricultural land. Remaining 64% is rain fed ground water 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.

Recommendations

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

Areas where legal sanction is needed

1.Where there is over exploitation of ground water
2.Where there are disputes between two parties regarding the exploitation of water.

3.Where there is environmental degradation due to over exploitation

4.Where there is ground water pollution

National water laws

- Why is a national water law necessary?

Water like air is one of the most basic requirement for life. If a national law is considered necessary on subjects such as the environment, forests, wildlife, biological diversity etc. national law on water is even more necessary. Water is as basic as (if not more basic than)those subjects.

Other key issues

- Lack of awareness :about the laws and policies, frame work is still a major issue (issue in rural India).all participants are completely unaware of the law and policy changes that is happening across the country.
- Lack of participation: In law and policy making process there is a collateral impact due to the lack of awareness. Mostly law and policy making process follow a top down approaches where people are at the receiving end having no role to play in framing of norms and regulations. The idea of participation is 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 making framework related to water and sanitation. Women and lower caste people are often neglected in the process.

National water commissions

Functions of national water commission:

- Incentive the state government to implement the irrigation projects.
- Lead the national aquifer mapping and ground water management program.
- Develop a specific program for rejuvenation of the rivers example:Ganga rejuvenation program etc.

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 frame work 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 can be challenged in a court of law.

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

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 adopted was in September 1987. It was reviewed and updated in 2002 and later in 2012.

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 stale boundaries]

4. In addition, there are challenges of flood and draught, growing population Rising need climate change, miss management 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, and 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 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 consensus on water - sharing principles and on the arrangements for minimizing 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 uses 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 polity. Hence a National water policy is necessary.

Central agencies in water resources sector

- Central water commission (CWC)
- Central ground water board(CGWB)
- National water Development Agency(AWDA)
- Brahmaputra board
- Central water and power research Station(CWPRS)
- Central soil and materials research Station(CSMRS)
- National institute of hydrology (NH)
- Ganga flood control Commission (GFCC)
- Water and power consultancy Services (India) Ltd(
- National Projects Construction corporation ltd(NPCC)

Water user Association (WUA)

- WUA is a organization for water management made up of a small group and large scale water users such as irrigators who pools the financial requirements,technical,material, human resource for operation and maintenance of local water body system such as river or water basins.
- WUA is a non profit structure.
- Members are typically based on contract and agreement between the members and the WUA.
- WUA Plays a key role in integrated approaches of water management that seek to establish a decentralized,participatory,multi-sector,multi-disciplinary government sectors.

Objectives/ scope of WUA

- Conservation of water catchments.
- Sustainable water resource management
- Increase availability of water resource.
- Increase the usage of water for economic and social improvements.
- The core function of WUA is to operate the water works under its responsibility and to monitor the allocations of water among its members.

Key functions of WUA

- Exchange information and ideas on water resource use.
- Monitor water availability and use.
- provide technical assistance in areas such as soil,water,crop management,livelihood,diversification (including climate change) that may affect the water usage.
- Operate and maintain a water service or structure such as (water mill) canal or irrigation
- Management of water distribution system including plans, tariff and collecting fees.
- Resolve conflicts relating to water use
- Representation of stakeholders needs at higher level.

Criteria for becoming a member of the WUA

Most by laws restrict membership to the registered landowners in the hydraulic unit who are engaged on a full-time basis in farming.

- But it in some countries like Nepal extends the right to become a member to both owners and tenants, 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 owner's fisherman.
- In many cases, women appear 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 house hold.
- On occasion 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.

Irrigation management transfer policies and activities

- Irrigation management is a system of physical structures such as dams,canal,gates,pumps and other that capture water from the natural source and distribute it to farmers for watering crops.
- Irrigation management transfer policy is defined as "the transfer of some or all irrigation management responsibility from government agency to one or more private person or organization".
- Management transfer need not be total but could be limited to specific parts of irrigation systems or to specific management functions
- Irrigation management transfer policy has two policies:

  1.Government Agency

  2.Private organization.

For system managed by government agencies include three basic components

1.A basic rule or system for allocating water to farmers.

2.A plan or a set of customary practices for distributing water to outlets.

3.A system for collecting irrigation fees from farmers.

The means by which IMT is to be implemented

The following seven elements as them key dimensions 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 dimensions

State water policy

Similar to national water policy the state have their own water policies:

1.Rajasthan state water policy 1999

2.Uttar Pradesh state water policy 1999

3.Karnataka state water policy,2002

4.Maharashtra state water policy 2003

5.Punjab state water policy,2008

6.Bihar State water policy 2010

7.Other State water policies..

Irrigation management activities and institutions

- Water Distribution: Capturing and distributing water in an irrigation system (also called operations)
- Maintenance: Repairing and maintaining the physical structures of the irrigation system.
- Resource mobilization: Raising the resources needed for operations and maintenance (O&M).
- Conflict Resolution: Resolving conflicts among users and system managers over the above three items above

Water allocation

- What is water allocation?

  A water allocation is an authority to take water, and an entitlement to a share of available water resource in a catchment.

- What is water entitlement?

  A water access entitlement is an ongoing right to an exclusive share of water from a water resource (named a 'consumptive pool') as defined in the relevant water management plan (known as a 'water allocation plan').

Why do we need to allocate water?

- There has always been conflict over water.
- At first there is plenty, then a shortage develops due to:

1. Drought and
2. Incresed use

- A system must be developed that allows users to share the resources

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.

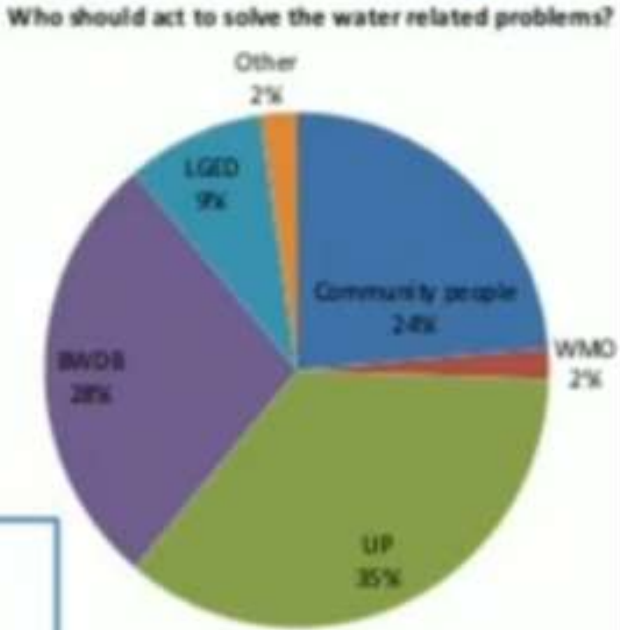
Ten golden rules of basin water Allocation.

- Rule1: 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.

Ten golden rules of basin water Allocation.

- 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 uncertainty 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.

The role of local government institutions in water governance needs to be formally recognized.



- Currently, **no formal role but**:
  - Implication in gate operation,
  - Implication in conflicts resolution,
  - Role in case of urgency, natural calamity.

    → **Trust in elected representatives.**

- **Advantages**
  - Conflict resolution
  - Coordination of all the stakeholders
  - Social safety nets for maintenance of water infrastructures (gate, canal re-excavation, embankments).
  - Not a new institutional layer added
  - Strengthen capacities of local governments

- **Example**

Union Parishad Coordination Committee

Water policy reforms:INDIA

- India: Draft national water policy 2012
- Ministry of water resources, government of India, in January 2012,released a draft national water policy for the consideration and opinion of state government and other stakeholders.
- The need for a holistic national policy has its genesis in the changing patterns of water use across India-both personal and industrial use.
- This includes the imperatives of providing both clean drinking water and adequate resources for irrigation; the move to look at renewable sources of energy like hydropower, and natural disaster management and rehabilitation following devastating floods and drought

Water policy reforms:India

- India has more than 17% of the world's population, but has only 4% of world's renewable water resource with 2.6% of the world's land area.
- Water-which is currently managed by individual states will likely become a topic of national interest after the formulation of the legislation by the central government.
- The policy has been vociferously opposed by farmers in some states, as the proposed water policy intends to impose an official control on the use of ground water something currently unregulated in most states.

Key Items in the Draft Policy

- Since 2012 draft is, the are 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 financial 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 underpricing 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 a abolition 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.

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MODULE-3

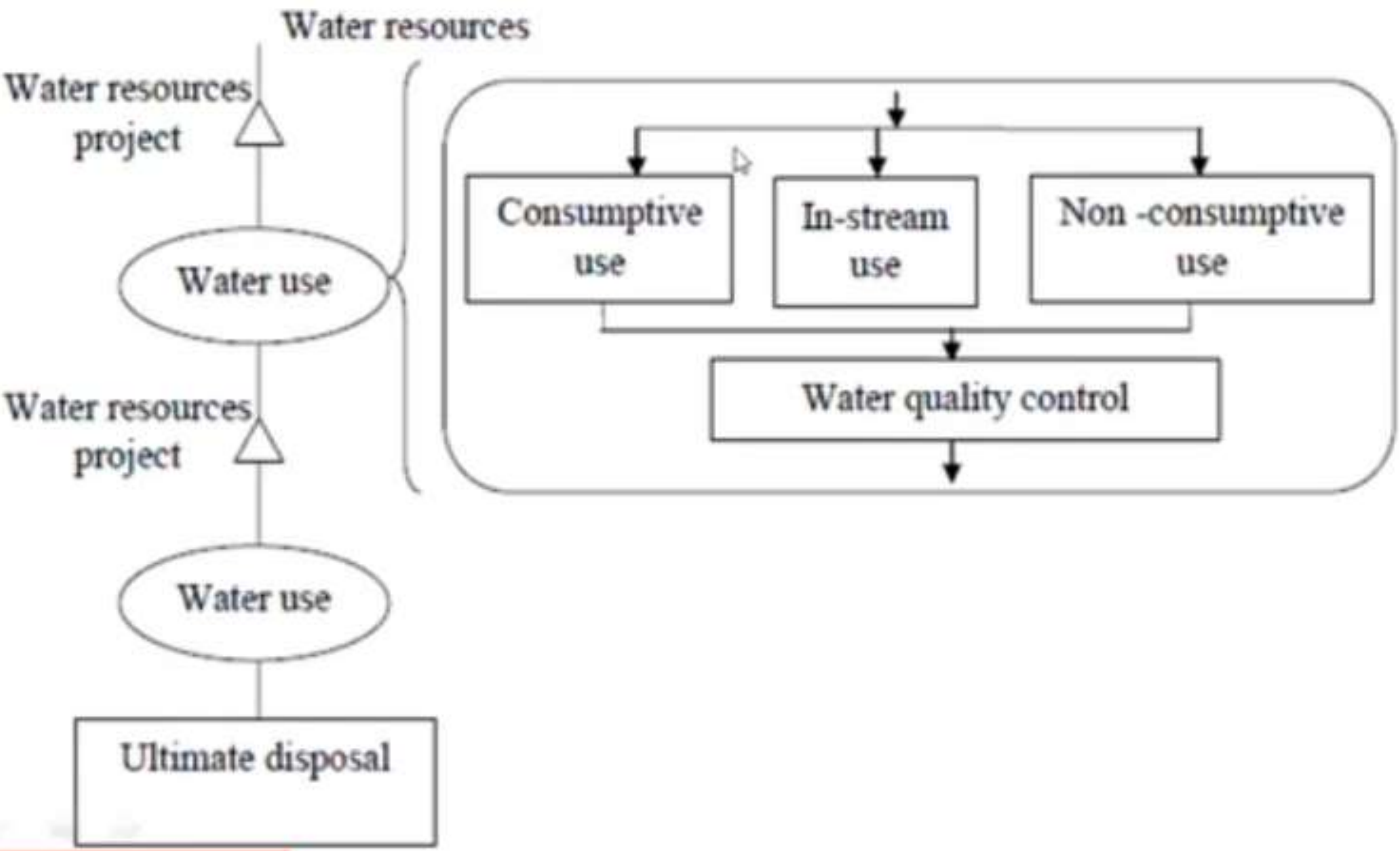
Integrated water Resource Management

Integrated water resources management(IWRM)

A river basin can be divided into three components:

- Source Components(rivers, reservoirs, aquifers and canals)
- Demand components (off-stream such as irrigation fields, industrial plants and cities and in stream such as hydropower, recreation and environment)
- Intermediate components(treatment plants,resuse and recycling facilities).

3.1 Steps in Water Resource Planning



Priorities for water resources planning

1.Domestic consumption

This includes water requirements primarily for drinking,cooking,bathing,washing of clothes and utensils and flushing of toilets.

2.Irrigation

water required for growing crops in a systematic and scientific manner in areas even with deficit rainfall.

3.Hydropower

this is the generation of electricity by harnessing the power of flowing water.

4.Ecology/Environment restoration.

water required for maintaining the environmental health of a region.

Priorities for water resources planning

5.Industries

the industries require water for various purposes and that by thermal power stations is quite high.

6.Navigation

Navigation possibility in rivers may be enhanced by increasing the flow, thereby increasing the depth of water required to allow larger vessels to pass.

7.Other uses

Like entertainment of scenic view.

Definition of IWRM

IWRM is defined by the Global Water Partnership (GWP-2000) as 'A process which promotes the coordinated development and the management of water, land and related resources, in order to maximize 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 financial and water resources.

3.Ecological sustainability: to achieve 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

WRM is based on four principles –the Dublin principles

1.Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.

2. Water development and management should be based on a participatory approach, involving users, planners and policymakers at all levels.

3. Women play a central part in the provision, management and safeguarding of water.

4. Water has an economic value in all its competing uses and should be recognized as an economic good.

1. Fresh water 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. Therefore holistic management has to involve for the demands placed on the resources and the threats to it.
- Creating water sensitive political economy requires co-ordinated policy making at all levels from national ministries to local government or community.
- There is also a need for mechanics which ensure that economic sector decision makers take water costs and sustainability into account when making production and consumption choices.

2. Water development and management should be based on a participatory approach, involving users, planners and policymakers at all levels.

- Water is a subject in which everyone is a stakeholder. Real participation only takes place when stakeholders are part of the decision-making process.
- Participation also occurs if democratically elected or otherwise accountable agencies or spokespersons can represent stakeholder groups.

3. Women play a central part in the provision, 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 that they have a much less influential role than men in management, problem analysis and in the decision-making process related to water resources.
- In developing the full and effective participation of women at all levels of decision-making, consideration has to be given to the way different societies assign particular Social, economic and cultural roles to men and women. There is a need to ensure that the water sector as a whole is gender aware, a process which should begin by the implementation of training programmers for water professionals and community or grass root mobilizers.
- 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.

4. Water has an economic value in all its competing uses and should be recognized as an economic good.

- Within in this principle it is vital to recognize first the basic right of all human beings to have access to clean water and sanitation at an affordable price.
- Managing water as an economic good is an important way of achieving efficient and equitable use and of encouraging conservation and protection of water resources.

Implementation of integrated water resource management

1.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.Role of Institutions: Institutional development is critical to the formation 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.Management instruments: 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.

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

- Political will and commitment
- Capacity development
- Adequate investment, financial 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 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

Legislation frame work

- Enabling Environment –IWRM platform with appropriate policy and legal frame work
- It involves process of making, designing and passing law.
- Principles water sector and achieving political support-hard decision have to be made.
- It plays important role in water management in range of local, National to international forms
- It deals with water body,countries,basins,water reservoir.
- It should be transparent, flexible and capable solving problems.

Characteristics of LFW

- Former Friendly
- Clarifies the rules ,responsibilities users & water provided .
- Clarifies roles of stake holders
- To provide qualitative & quantitative standards foe effluents.

Institutional/organizational frame work

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 frame work and the water use conflicts between stakeholders.
- It is essential to have a basic document on the present water management to start the institutional assessment process; such a document will represent an expert’s opinion and will not necessarily 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 financial 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 and use of the water (quantitative, and qualitative)it Requires information the

a.Climate and meteorology

b.hydrology and hydrogeology

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 private body.

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

- Water users –consumptive and non-consumptive uses
- Water polluters agriculture, industry, domestic etc.
- Water managers organizational 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 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 stake holders will be the obvious operations 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 id formed to identify and select relevant stakeholders from the categories.

- Water policy makers
- Water mangers
- Water service providers
- Water using agencies
- Water using groups
- Water users and other potential interests holders at constitutional, organizational and operation levels.

These stakeholders will be approached for the department 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 questionnaire, which contain questions relating to 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 identification 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
- Financial arrangements
- Human resource development
- Management information systems and decision support systems

Second part of the interview aim to

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, decentralization and other evolution of authority
- Integrated planning
- Participation of stake holders
- 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 between the different stakeholders on the present situations 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.

Step-5: Workshop-1 problem Identification

It is important that all the relevant Stakeholders recognize their problems and those of others hence

1. The first workshop to which all the relevant stakeholders are invited deal with the assessment of the existing water resource management situation and problem identification according to the perception of 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, organizational 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-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-9: Final country basin report

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

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

- Private sector-it means designed to improve the management of public owned Enterprises.
- Government transfers assets into private hands or contract to private sector goods services supplied by private body.
- The private sector plays an important role in financing water resource management through investments in service delivery in water supply and sanitation.

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

Financial: 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 sector

- Full divesture
- Concessions
- Leasing
- Contracting out
- BOOT and BOO
- Joint ventures

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

1.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.

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

3.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

4.BOOT & BOO(Build operate own and tranfer): schemes where contracts for the construction of particular infrastructure project is required and where ownership is handed to a public organization after a specified number of years.in the BOO case ownership remains in the hands of the private sector

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

6.Contracting out: The least controversial form of Private sector involvement. A water understanding sub-contracts certain functions to private forms.

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 regulating framework and ensuring that the poor are served and users are protected from excessive costs.

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Water Resources Management

(18CV653)

MODULE-1

Surface and Ground Water Resources

Hydrological Cycle

- Cycling of water in and out of atmosphere and between all the earth's components.
- The chain of various process through water from one form has to pass in order to return back to same form is called hydrological cycle.
- Most of the earth's 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 called as hydrological cycle which can be graphically represented as shown below.

Components of Earth System

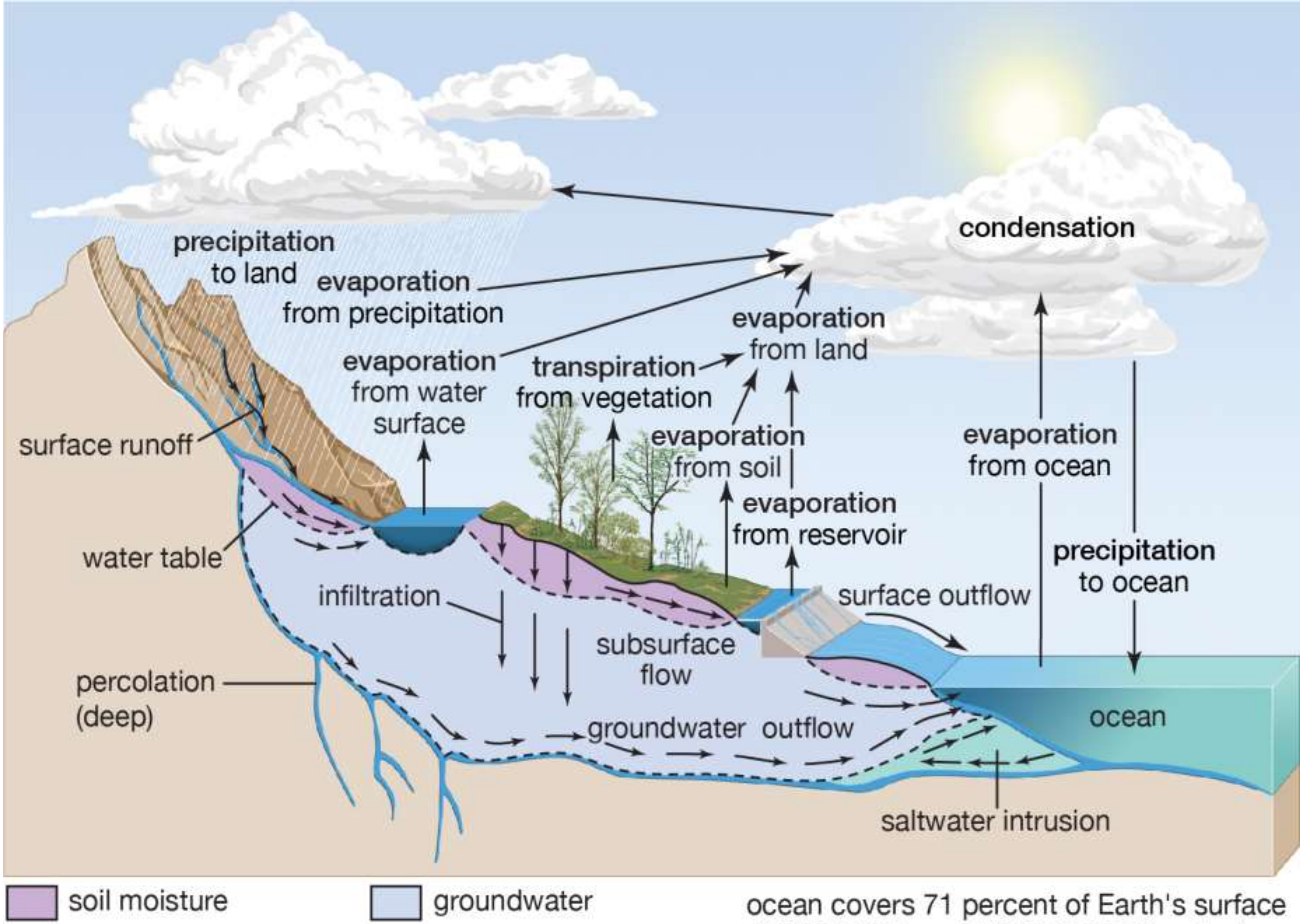
- Lithosphere : The Solid Earth; Land
- Hydrosphere : The Liquid Earth; Water
- Atmosphere : The Gaseous Earth; Air
- Biosphere : Living things (organisms) the part of Lithosphere, Hydrosphere, and atmosphere in which thing live
- Cryosphere : Frozen or solid water such as ice caps, glaciers, snow and permafrost

Water appears in all 3 of its phases at different times during the hydrologic cycle

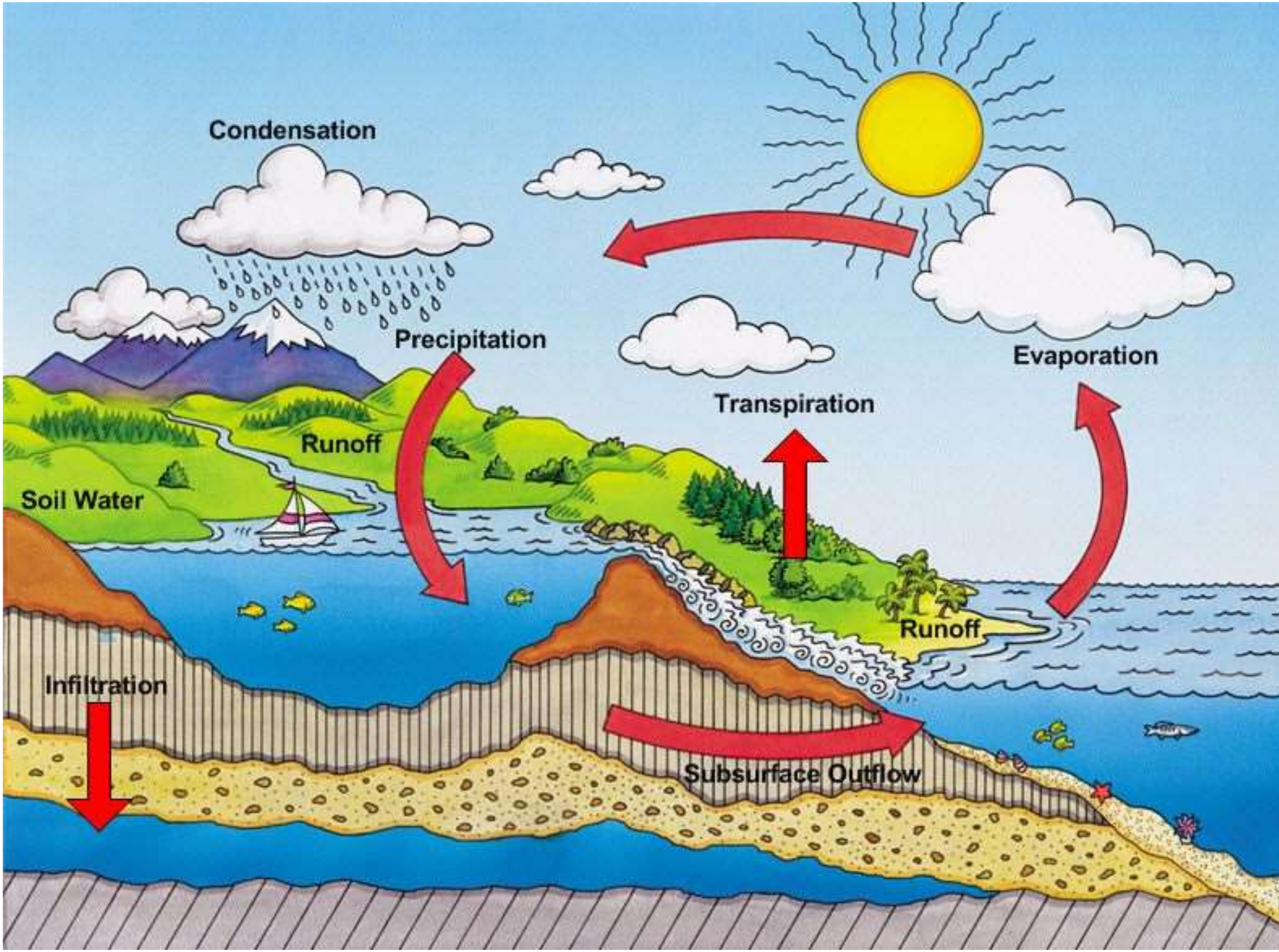
- Solid
- Liquid
- Gas

Five Processes of the Hydrologic Cycle

1. Evapotranspiration: Evaporation+Transpiration
2. Condensation
3. Precipitation
4. Run-off
5. Infiltration(Percolation)



ocean covers 71 percent of Earth's surface
196,950,000 sq mi (510,000,000 sq km)


Condensation
Precipitation
Evaporation
Transpiration
Runoff
Soil Water
Runoff
Infiltration
Subsurface Outflow

Evaporation

- Evaporation occurs when water changes from liquid state to gaseous state.
- 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 land, lakes rivers and oceans send up a steady stream of water vapor and plants also lose water to the air
- Approximately 80% of all Evaporation is from the oceans, with the remaining 20% coming from inland water and vegetation

Cont....

Transpiration

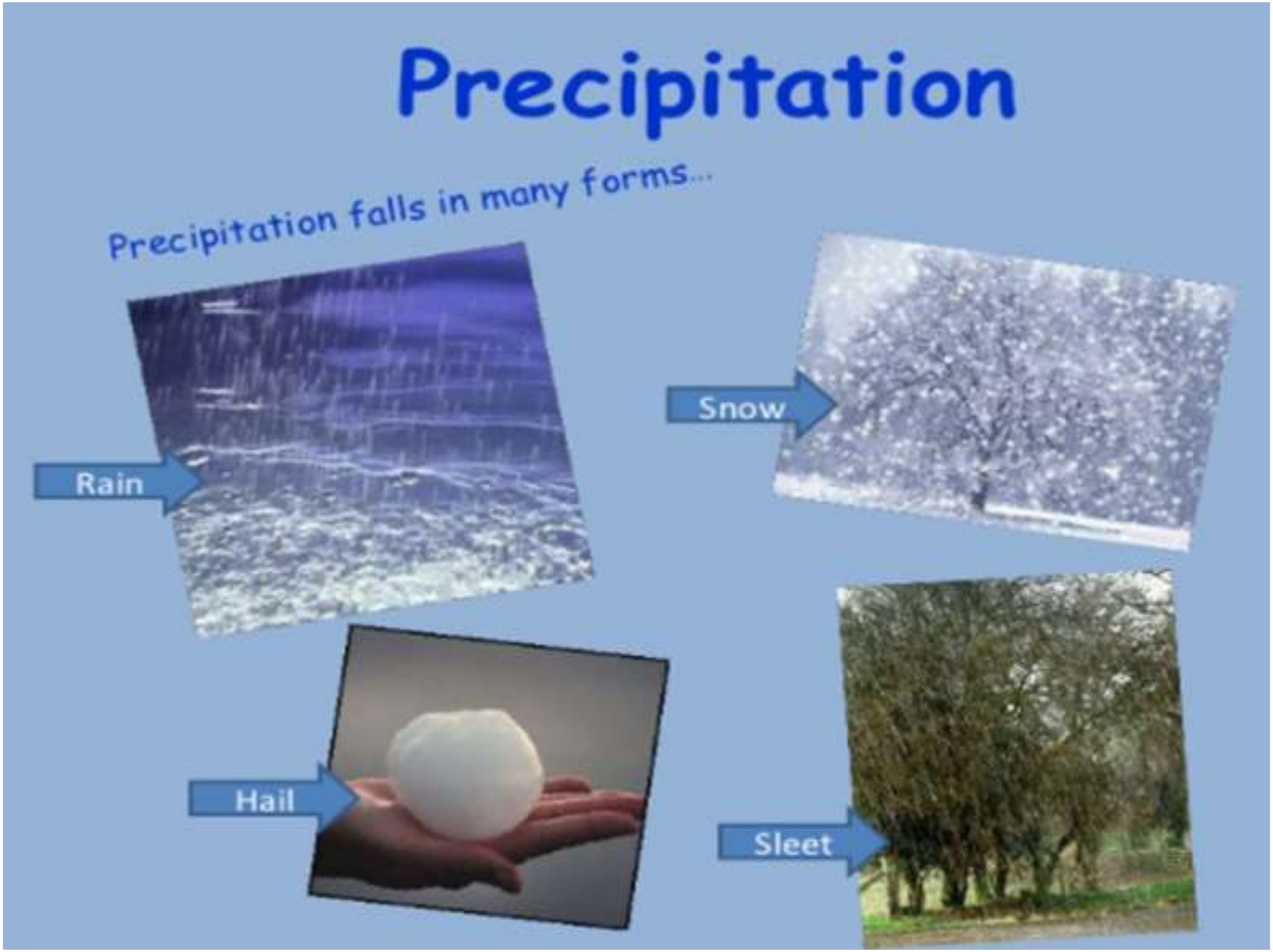
- The release of water vapor from plants into the atmosphere.
- As plants absorb water from the soil, the water moves from the roots through the stems to the leaves, once the water water reaches the leaves, some of it evaporates from the leaves, adding to the amount of water vapor in the air, this process of evaporation through plant leaves is called transpiration.

Condensation

- The opposite of evaporation. Condensation occurs when a gas is changed into a liquid.
- The Condensation is the process by which water vapor changes into water. Water vapour 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 large amount of water vapor condenses ,it results in the formation of clouds.

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 into the soil.
- When the temperature and atmospheric pressure are right, the small droplets of water in clouds form larger droplets and precipitation occurs. The rain drops fall to Earth


Precipitation
Precipitation falls in many forms...
Rain
Snow
Hail
Sleet

Cont....

Infiltration

- Flow of water from surface into the ground
- Returns to lithosphere by infiltration into the ground becoming soil water or ground water.
- Some precipitation seeps into the ground water 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 into the hydrological cycle within days, while other water will stay in the ground for centuries or more.

Cont....

Run off

- Returns to the hydrosphere by flowing as run-off from the land surface into streams,rivers,lakes and eventually the ocean.
- Most of the water which returns to land flows downhill as run-off. some of its penetrates and charges ground water while the rest becomes river flow .as the amount of ground water increases or decrease, 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 melt water to become run-off.

Global 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 3/4th of Earth surface.
- The worlds total water resources are estimated at 1.36x10^8 M ha-m .
- Which is enough to cover the earth with a layer of 3000meters depth. Of these global water resources, about 97.3% is in oceans as saline water and only 2.75% is available as fresh water at any time on the planet earth. About 77.2% of fresh water lies frozen in polar regions and another 22.4% is present as ground water and soil moisture, the rest is available in lak es,rivers,atmosphere and vegetation.

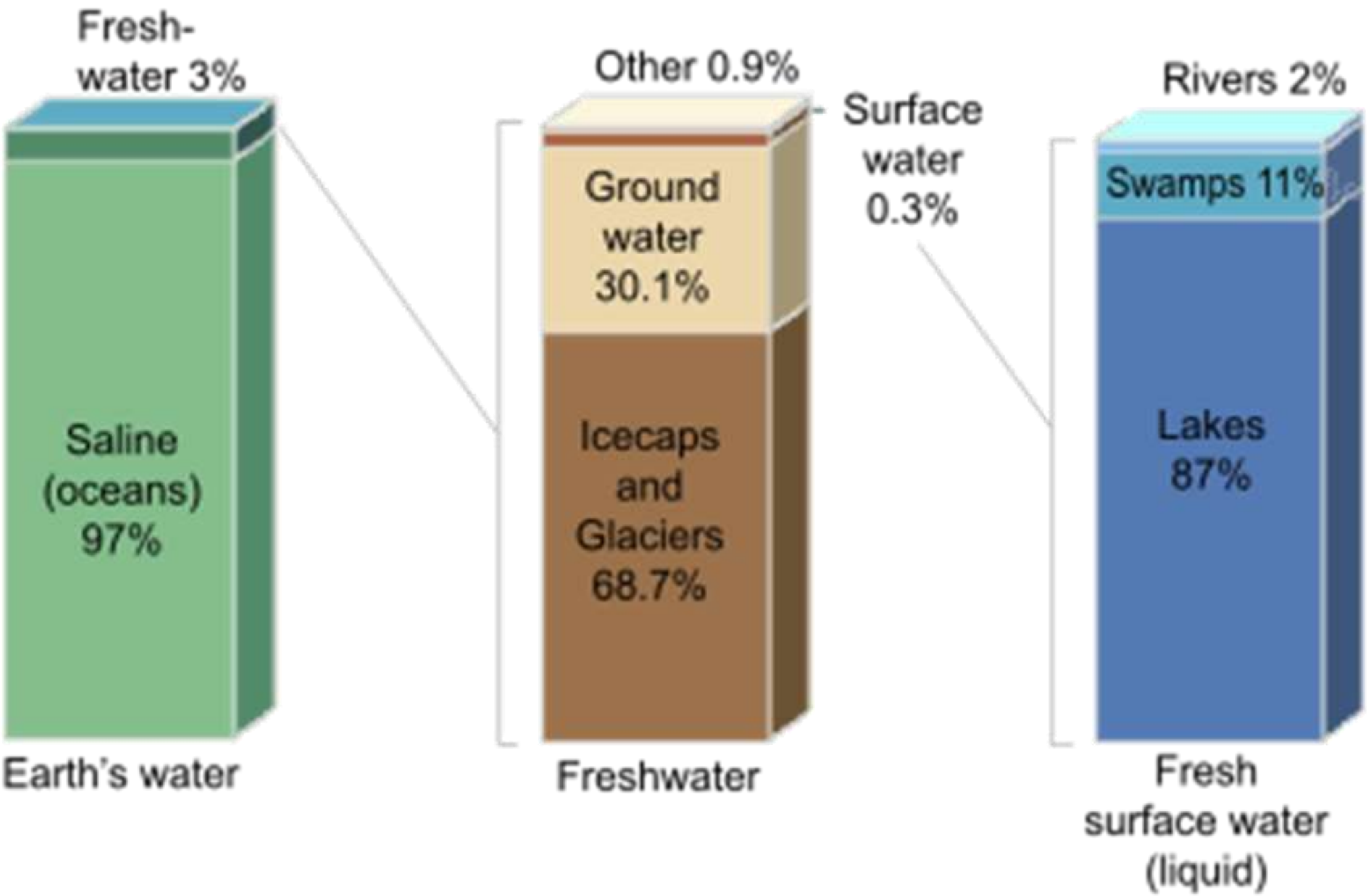
Distribution of water on earth

- Saline water (oceans and sea) - 97%
- Fresh water - 3.0%

Freshwater Resources

- Polar Ice caps - 77.2%
- Ground water and Soil Moisture -22.4%
- Lakes, swamp and Reservoirs -0.35%
- Atmosphere - 0.04%
- Rivers and Streams - 0.01%

Distribution of Earth's Water



World wide Distribution of fresh water

Sl.No.	Type	Vol. 10^6 m^3	Percent
1	Glaciers	24000	85
2	Ground water	4000	14
3	Lakes and Reservoirs	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 252.8Mha and 24.9Mha 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 2200cubic meter per year which is about one third of the per capita water availability in USA and japan. The per capita water availability in India would further decrease with ever increasing population of the country .

Cont....

- 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 commission(CWC) the average annual runoff of various river basins in the country is about 2333 cubic km treating both surface and ground waters as one system.
- More than 80 to 90 percent 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 development of water resources

Availability of water per capita annum in India

SL NO.	Years	Per annum percapita 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

According to the brochure entitled "water resources of India" issued by central water and power commission in April 1988,the actual utilizable 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	Utilized up to 1990		
			Surface water	Ground water	total
69.03	41.85	110.88	36.2x10^5	19x10^5	55.2x10^5 h-m

❑Sources Of Water

Sources of water

Surface water

- Lakes
- Ponds
- Streams
- Rivers
- Storage reservoir

Ground water

- Open wells
- Tube wells
- Artesian wells
- Springs
- Infiltration

Surface water Resources

There are four major sources of surface water .

1) Lake

2) Ponds

3) Streams

4) Rivers

Surface water Resources

- Surface water is any water that collects on the surface of the earth likes oceans,sea,lakes,river or wetlands.
- Out of total precipitation including snowfall of around 4000km^2 in the country. The availability from surface water and ground water is estimated to be 1896 km^3.
- In the country there are about 10360 rivers and their tributaries longer than 1.6km each.

Surface water Resources

- India's average annual surface run- off generated by rainfall and snowmelt is estimated to be about 1869 cubic km. to topographical, hydrological and other constraints ,only about 690 cubic km (32%) of the available surface water can be utilized.
- Many rivers are perennial though few are seasonal.
- Following are the surface basins that flows

1.the Indus system

2.Ganga and Brahmaputra system

3.River of Rajasthan and Gujarat

4.East flowing perennial River.

5.Western flowing perennial River.

6.western coast River


Surface water Resources

1.Fresh water Lakes

Natural fresh water lakes account for about 0.26% of the freshwater Resources more than 50% of these lakes are found in Canada

2.Wetlands

A part of freshwater resources 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 ground water

Surface water Resources

3.Rivers

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

Surface water Resources

4.Reservoirs

- Reservoirs are artificial lakes created 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, hydropower generation and industrial use.

Ground water Resources

- Ground water is the water Present Beneath the earth’s Surface in soil pore spaces and in the fractures of rock formations.
- Ground water 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.
- Ground water 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

1)Open wells

2)Tube wells

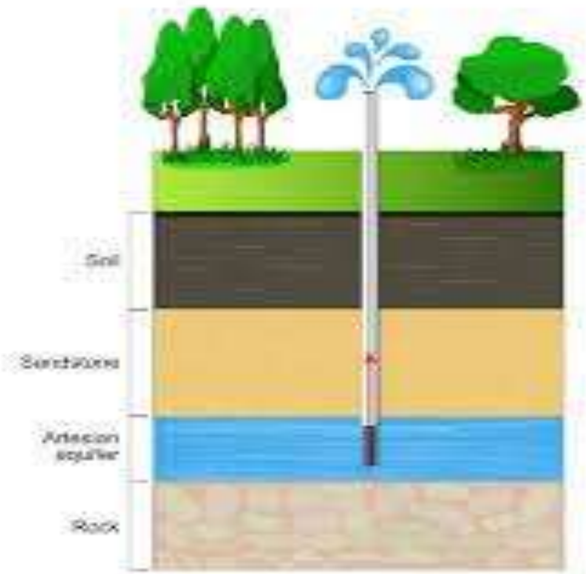
3)Artesian well

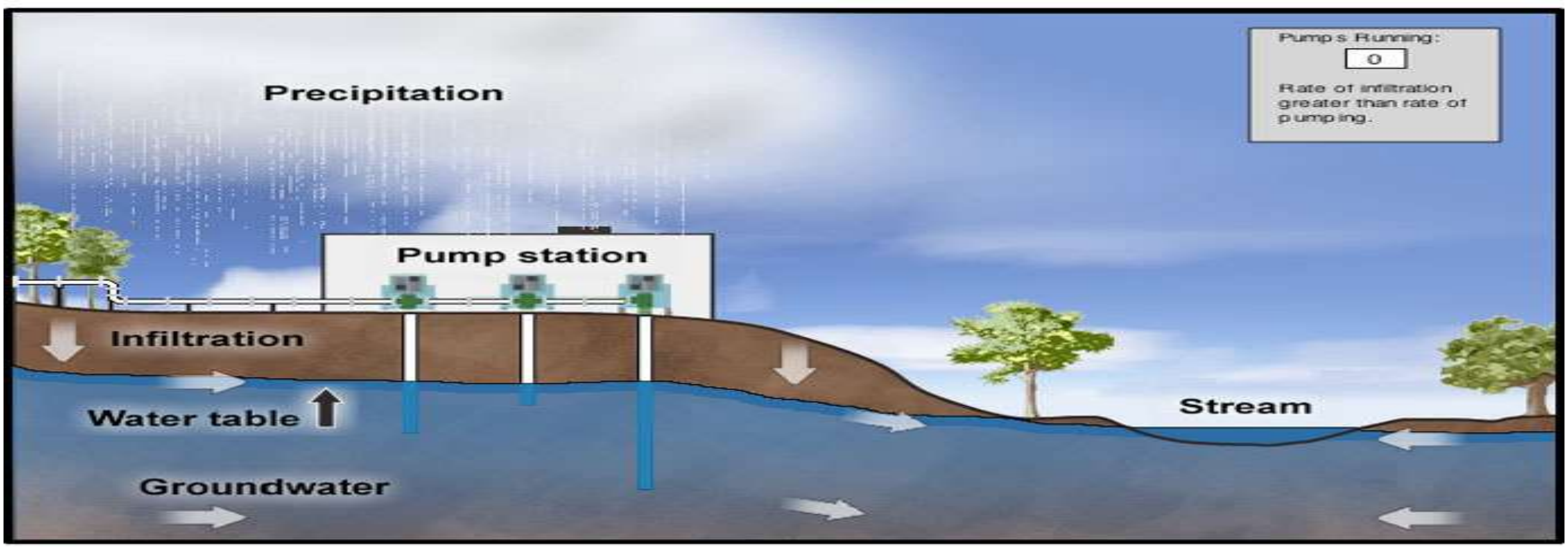
4)Infiltration galleries

Ground water Resources

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

- 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.
- It is made available for areas where surface water is utilized for other uses.
- Yield from wells generally exhibit less fluctuations than surface stream flow in alternating wet and dry periods.
- Compared to surface water, it is relatively free from the effect of surface pollutants because it results from deep percolation of water infiltration in the soil.

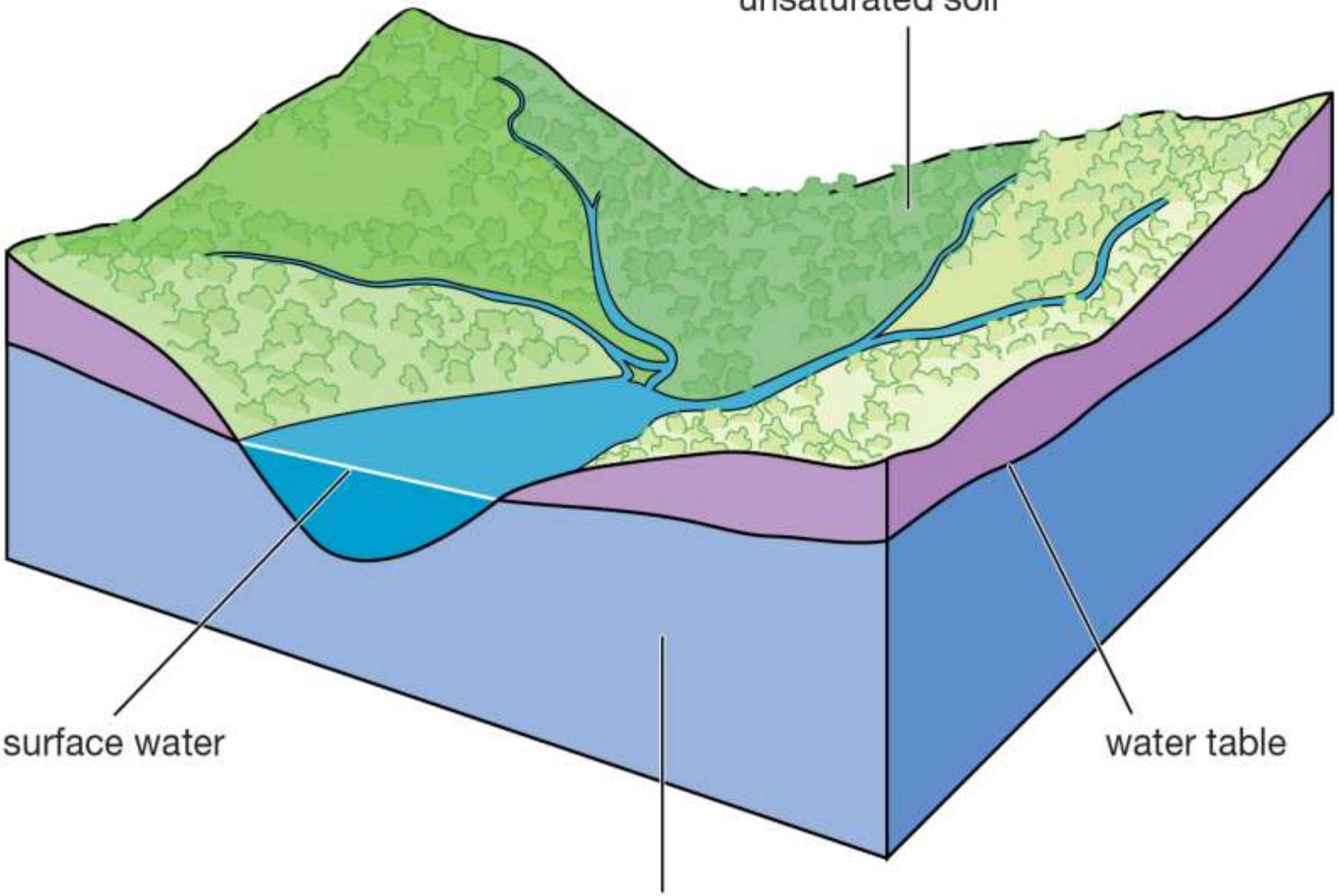

Soil
Sandstone
Artesian aquifer
Rock


Pumps Running:
0
Rate of infiltration greater than rate of pumping.
Precipitation
Pump station
Infiltration
Water table
Groundwater
Stream

Ground water storage basin

- Ground water 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 water sources are the usual main sources that contribute to the ground water of a region.

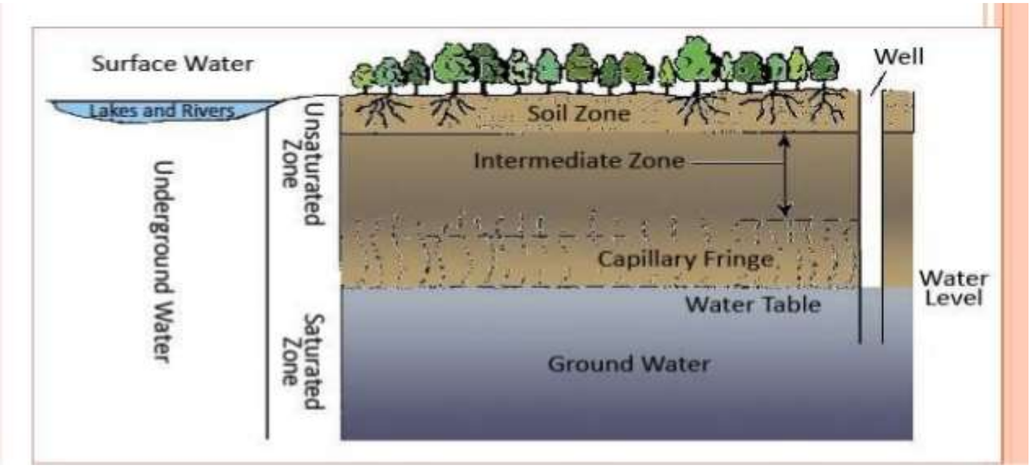
How the water table looks in a cross section of land



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



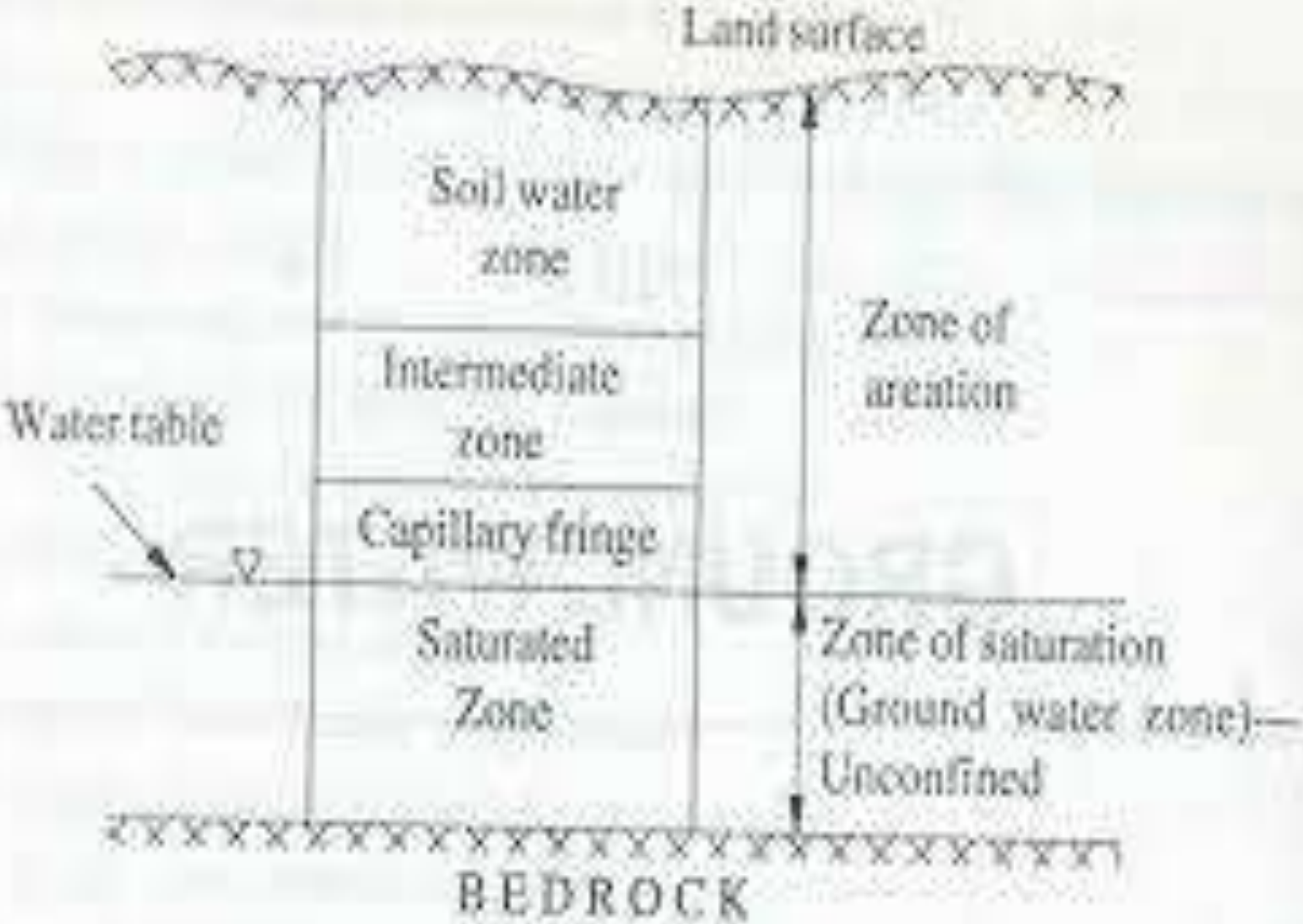


Fig. 9.1 Classification of subsurface water

Forms of subsurface water

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 surface having atmospheric pressure.

Forms of subsurface water

2.Aeration zone

- 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 of aeration has three sub-zones.

Soil water Zone, Capillary fringe and intermediate zone

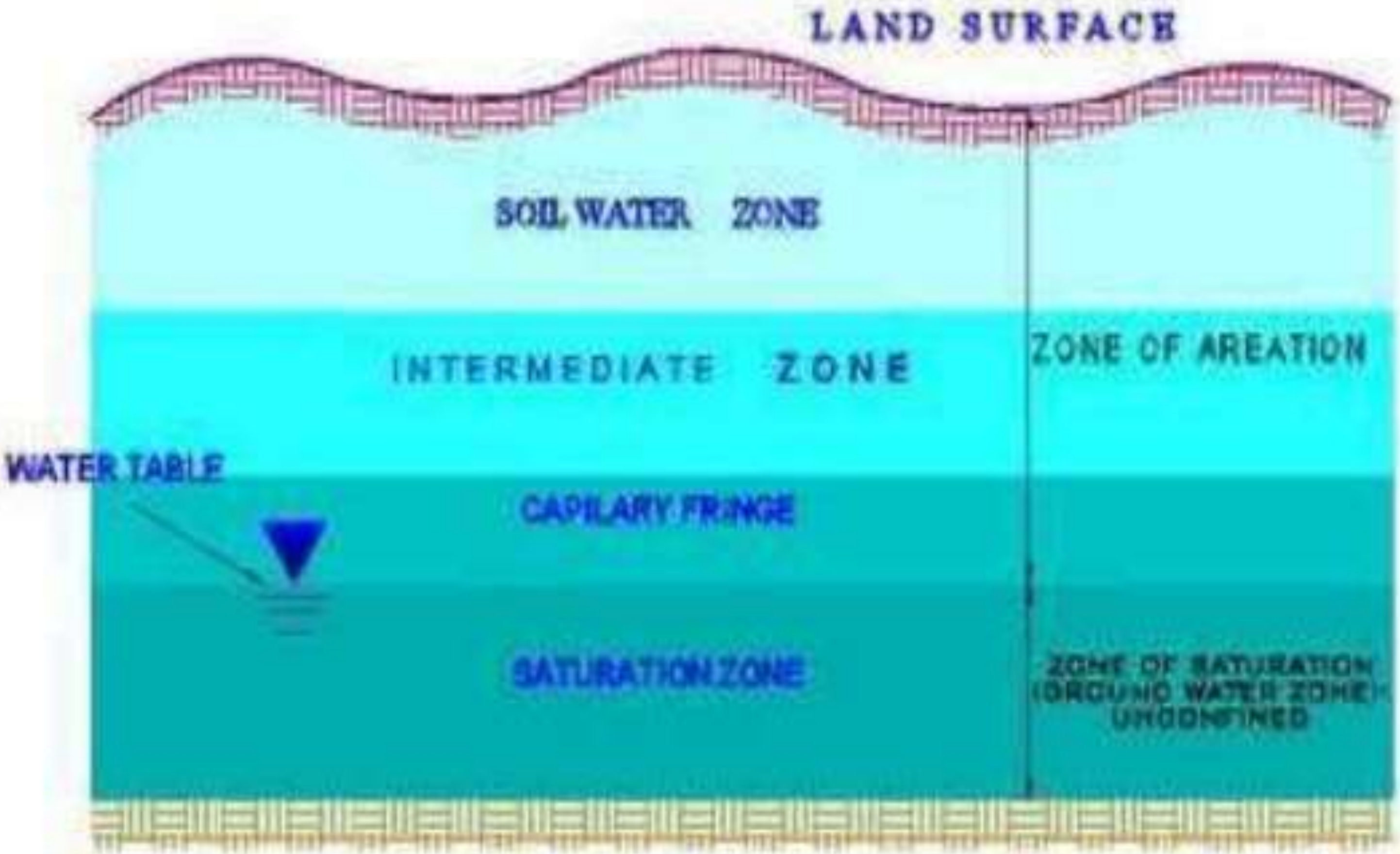


FIG. CLASSIFICATION OF SUBSURFACE WATER

Forms of subsurface water

a.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.

b.capillary fringe

In this sub zone water is held by capillary action, this subzone extends from the water table upwards to the limit of capillary rise.

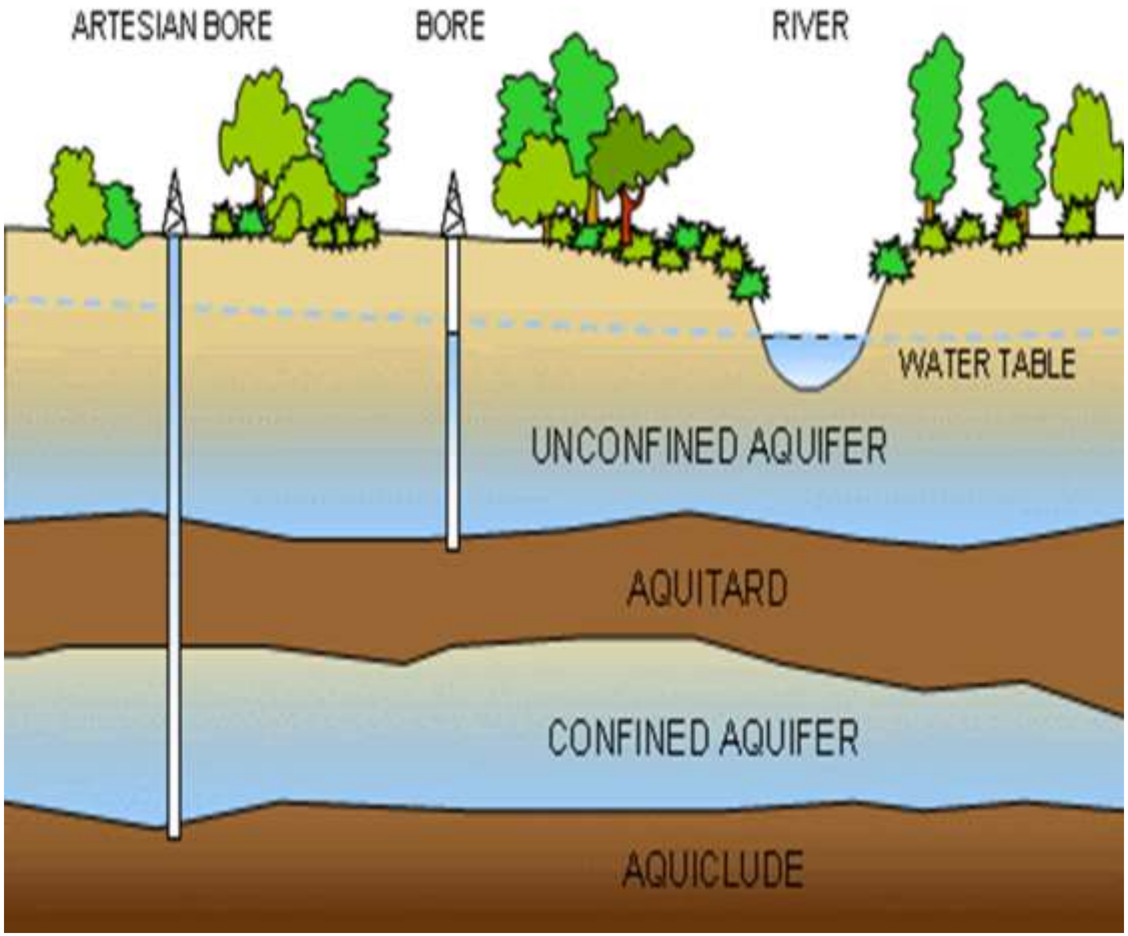
Forms of subsurface water

c.intermediate zone

This sub-zone 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.

Classification of saturated zone

- Aquifer
- Aquiclude
- Aquifuge
- Aquitard



Classification of saturated zone

1.Aquifer

- A 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.

2.Aquitard

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

Classification of saturated zone

3.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.

4.Aquifuge

- It is a geological formation which is neither porous nor 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 two types. They are

  a.Unconfined

  b.confined

Types of Aquifer

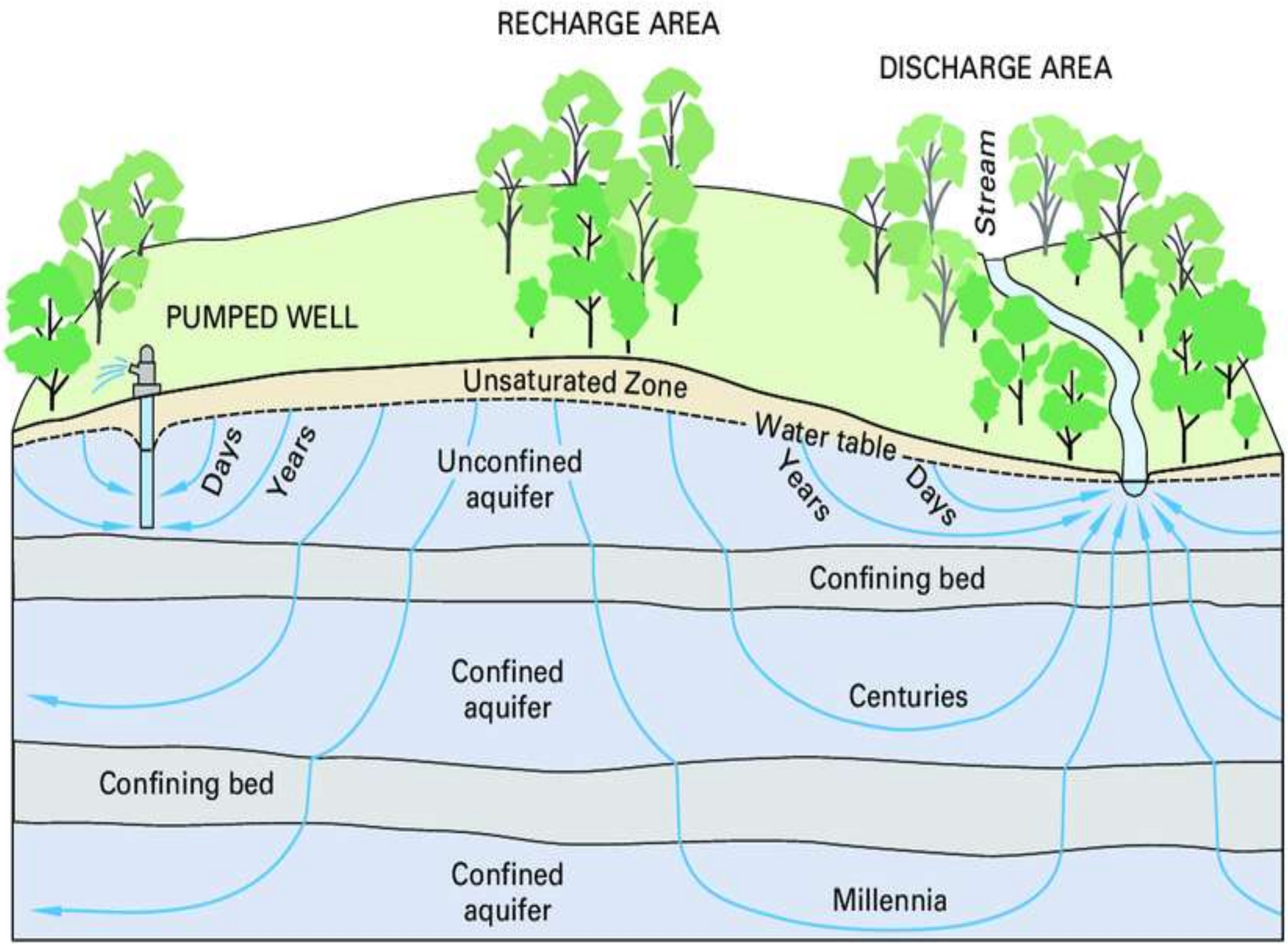
1.Un confined aquifer

- 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.
- This aquifer is directly accessible to the atmosphere.

Types of Aquifer

2.Confined Aquifer

- When an aquifer is sandwiched 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 walls tapping an artesian aquifer is known as piezometric surface.


RECHARGE AREA
DISCHARGE AREA
Stream
PUMPED WELL
Unsaturated Zone
Water table
Days
Years
Unconfined
aquifer
Years
Days
Confining bed
Confined
aquifer
Centuries
Confining bed
Confined
aquifer
Millennia

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

Water balance

- 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.

Water balance

- Heneral water balance equation is

$P=Q+E+\Delta S$, $P-R-G-E-T=\Delta S$

Where, where,

P=Precipitation P=Precipitation

Q=Runoff R=surface Runoff

E=Evapotranspiration G=Infiltration

ΔS=Change in storage E=Evaporation

T=Transpiration

ΔS=Change in storage

In its simplest form, this equation reads

Inflow=out flow+change in storage

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 is life because plants and animals cannot live without water.
- Water is needed to ensure food security, feed livestock, take up industrial production and to conserve the biodiversity and environment.
- Although, India is not a water poor country, due to growing human population, severe neglect and over-exploitation of this resource, water is becoming a scarce commodity.
- While this is a growing concern all over the world, India is most vulnerable because of the growing demand and in-disciplined lifestyle.
- This calls for immediate attention by the stakeholders to make sustainable use of the available water resources to ensure better quality of lives.

Water scarcity

- Water scarcity is the lack of sufficient available water resources to meet the demands of water usage within a region. It already affects every continent and around 2.8 billion people around the world at least one month out of every year.
- More than 1.2 billion people lack access to clean drinking water.
- Water scarcity involves water stress, water shortage or deficits, and water crisis.

Water scarcity

- While the concept of water stress is relatively new, it is the difficulty of obtaining sources of fresh water for use during a period of time and may result in further depletion and deterioration of available water resources. Water shortages may be caused by climate change, such as altered weather patterns including droughts or floods, increased pollution, and increased human demand and overuse of water.
- A water crisis is a situation where the available potable, unpolluted water within a region is less than that region's demand.

World water scarcity

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

Water scarcity in India.

- The world's oldest civilization grew around the Indus and the Ganges and is still thriving. But not for long.
- Post-independence, due importance was given to harnessing the power of water by way of controlling and storing of water through large Dams.
- That was the need of the hour. However, our cities and towns have subsequently grown without planning for water need vs water availability.
- In 1951, the per capita water availability was about 5177 m3. This has now reduced to about 1545 m3 in 2011

Reasons behind water scarcity in India

The water scarcity is mostly man made due to excess population growth and mismanagement of water resources. Some of the major reasons for water scarcity are:

- Inefficient use of water for agriculture. India is among the top growers of agricultural produce in the world and therefore the consumption of water for irrigation is amongst the highest.
- Traditional techniques of irrigation causes maximum water loss due to evaporation, drainage, percolation, water conveyance, and excess use of groundwater. As more areas come under traditional irrigation techniques, the stress for water available for other purposes will continue. The solution lies in extensive use of micro-irrigation techniques such as drip and sprinkler irrigation.
- Reduction in traditional water recharging areas. Rapid construction is ignoring traditional water bodies that have also acted as ground water recharging mechanism. We need to urgently revive traditional aquifers while implementing new ones.

Reasons behind water scarcity in India

- Release of chemicals and effluents into rivers, streams and ponds. Strict monitoring and implementation of laws by the government, NGOs and social activists is required.
- Lack of on-time de-silting operations in large water bodies that can enhance water storage capacity during monsoon. It is surprising that the governments at state levels has not taken this up on priority as an annual practice. This act alone can significantly add to the water storage levels.
- Lack of efficient water management and distribution of water between urban consumers, the agriculture sector and industry. The government needs to enhance its investment in technology and include all stakeholders at the planning level to ensure optimization of existing resources.

Survey

- The united nation's "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

- Surface water :a)only 48% of rainfall ends up in indias rivers b)only 18% can be used
- Ground water: a)82% goes to irrigation and agricultural purposes b)only 18% is divided between domestic and industrial.

Causes

3.Climate change

- Climate change is exacerbating the depleting supply of water.

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 ground water can contaminates agricultural products when used for irrigation

Effects

- 1 out of every 4 deaths under the age of 5 worldwide is due to a water related disease.
- 80% of the illness cause by unsafe water and sanitation condition in world.
- Every day in rural communities and poor urban centres .hundreds of millions of people suffer from a lack of access to clean, safe water.
- Women's 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.

Water scarcity can be a result of two mechanisms

- Physical water scarcity
- Economic water Scarcity

- Where physical water scarcity is a result of inadequate natural water resources to supply a regions demand.
- Economic water scarcity is a result of poor management of the sufficient available water resources.

States hit by water scarcity in India

1. Rajasthan
2. Gujarat
3. Maharashtra
4. Uttar Pradesh
5. Madhya Pradesh
6. Chhattisgarh
7. Andra Pradesh
8. Tamil Nadu

Solutions to overcome water scarcity problems

- The amount of water that is wasted during dish washing at home is significant. We need to change our dish washing methods and minimize the habit of keeping the water running. A small step here can make a significant saving in water consumption.
- Every independent home/flat and group housing colony must have rain water harvesting facility. If efficiently designed and properly managed, this alone can reduce the water demand significantly.

Solutions to overcome water scarcity problems

- Waste water treatment and recycling for non-drinking purposes. Several low cost technologies are available that can be implemented in group housing areas.
- Very often, we see water leaking in our homes, in public areas and colonies. A small steady water leak can cause a loss of 226,800 liters of water per year! Unless we are aware and conscious of water wastage we will not be able to avail the basic quantity of water that we need to carry on with our normal lives.

Available renewable 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, Natural renewable water resources are the total amount of a country's water resources (internal and external resources), both surface water and groundwater, which is generated through the hydrological cycle. The amount is computed on a yearly basis. Renewable water resources are computed on the basis of the water cycle. They represent the long-term average annual flow of rivers (surface water) and groundwater.

Available renewable water resources

- Non- on the human time-scale and thus can be considered non-renewable. The computation of the actual renewable water resources of a renewable water resources are groundwater bodies (deep aquifers) that have a negligible rate of recharge country takes account of possible reductions in flow resulting from the abstraction of water in upstream countries
- Actual renewable water resources. These are defined as the sum of internal renewable resources (IRWR) and external renewable resources (ERWR), taking into consideration the quantity of flow reserved to upstream and downstream countries through formal or informal agreements or treaties and possible reduction of external flow due to upstream water abstraction. Unlike natural renewable water resources, actual renewable water resources vary with time and consumption patterns and, therefore, must be associated to a specific year.

The Water Balance as a Result of Human Interference

- Human activity has the potential to indirectly and directly affect water quantity and the natural flow regime of a river system.
- Indirect impacts to the hydrologic cycle can result from land-use changes. Direct impacts can result from water diversions, withdrawals and discharges, and from dams (flow regulation and water storage).

Human interferences

Man influences the hydrological cycle in several ways, either to protect himself against the Water, or to try to make use of the water. The next main activities can be distinguished:

- Flood protection,
- Irrigation,
- Drainage,
- Groundwater withdrawal,
- Water supply,
- Sanitation,
- Flow regulation,
- Power generation,
- Navigation.

Human interferences

Unfortunately there are also a number of unproductive interferences of man, such as:

- Discharge of wastes,
- Discharge of polluted water,
- Pollution of aquifers,
- Discharge of cooling water from industrial and thermal plants.
- Man tries to control the water resource system through hydraulic structures. These structures are designed taking into consideration the risk of failure acceptable for the Specific case.

The objectives of the water management framework

- Provide a high level of protection for the aquatic ecosystem over the long-term;
- Provide incentive to develop cooperative management options for water in the Athabasca River;
- Provide incentive for achieving more efficient water use;
- Provide a reliable supply of good quality water; and
- Ensure water use restrictions are realistic and the framework is straightforward to administer.

THINK,
You Can’t
do anything
without
WATER.

Save it.

Best RO Water Purifier.in


THANK YOU

||Jai Sri Gurudev||

Adichunchanagiri University

BGS Institute of Technology

Civil Engineering Department

MODULE-2

Water Resources planning and Management

INTRODUCTION

- 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 Partially and Temporarily and also they are finite (limited) in nature i.e., there is a limit to the services that can be expected from these resources.
- Rare or "extreme" flows or water quality conditions outside the normal ranges will result in losses to river-dependent, human activities. Therefore, planning is needed to increase the benefits from the available water sources.

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

a. Too little water due to growing urbanization, additional water requirements, in stream flow requirements etc. Measures should be taken to reduce the demand during scarcity times

b. Too much water due to increased flood frequencies and also increase in water requirements due to increased economic development on river floodplains

c. Polluted water due to both industrial and household discharges

Cont..

(2) Degradation of aquatic and riparian systems due to river training and reclamation of floodplains for urban and industrial development, poor water quality due to discharges of pesticides, fertilizers and wastewater effluents etc.

(3) While port development requires deeper rivers, narrowing the river for shipping purposes will increase the flood level

(4) River bank erosion and degradation of river bed upstream of the reservoirs may increase the flooding risks

(5) 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.

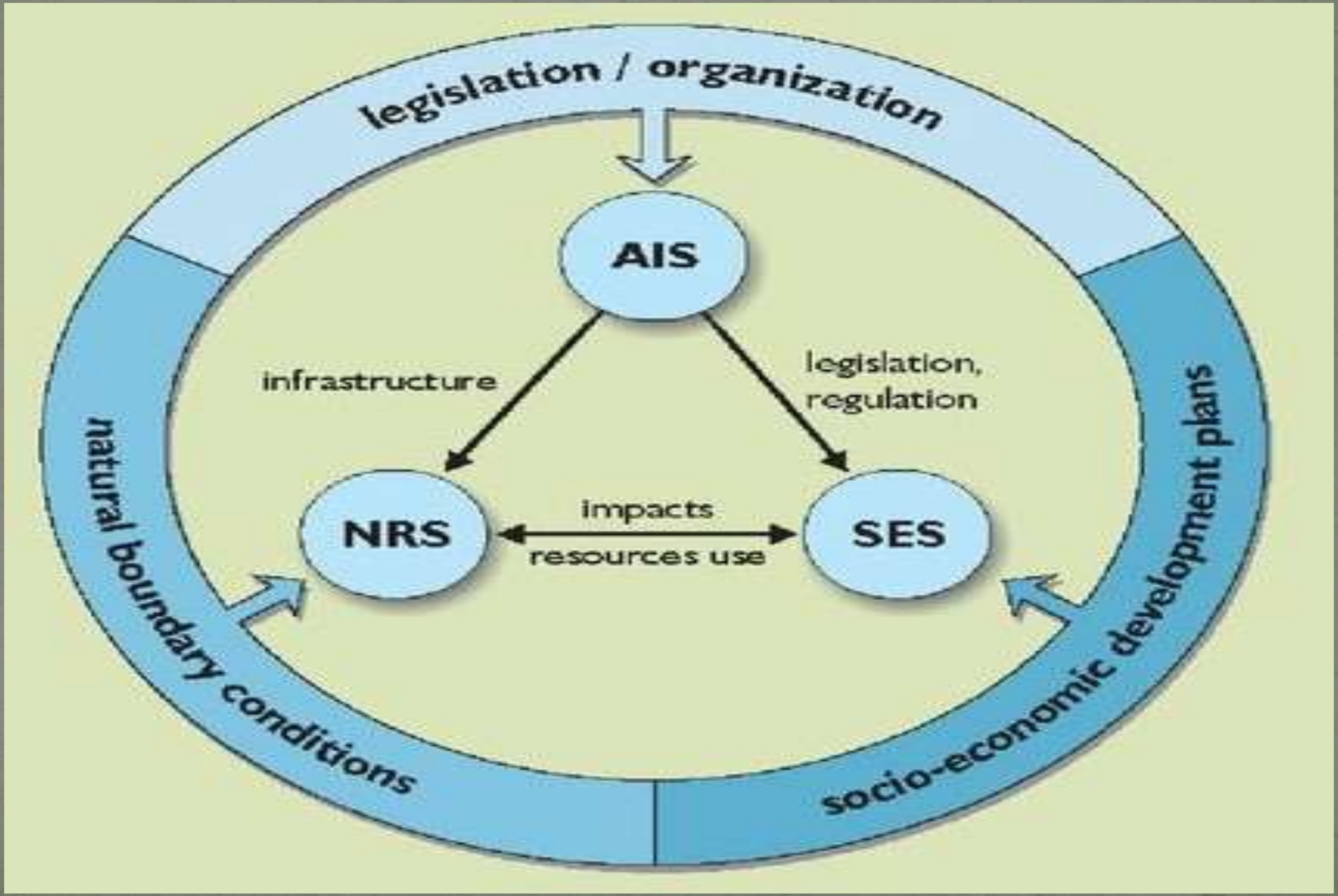
System Components in WRM

1. Natural river subsystem in which the physical, chemical and biological processes takes place

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 processes take place

System components in WRM



System planning Scales

1. Spatial Scales for Planning and Management

- Watersheds or river basins are usually considered logical regions for water resources planning and arrangement. if the impacts of decisions regarding water resources management are contained within the watershed or basin.
- How land and water are managed in one part of a river basin can affect the land and water in other parts of the basin.
- The construction of a dam or weir in the downstream part of a river may prevent vessels and fish from travelling upstream.
- basin boundaries make sense from a hydrological point of view

System planning Scales

2. Temporal Scales for Planning and Management

- Decisions recommended for the immediate future should take account of their long-term future impacts.
- The question of just how far into the future one need look, and try to forecast is important
- Planning is a continuing sequential process
- Irrigation planning and summer season water recreation planning may require a greater number of within-year periods
- Assessing the impacts of alternatives for conjunctive surface and groundwater management or for water quantity and quality management, require attention to processes that take place on different spatial and temporal scales.

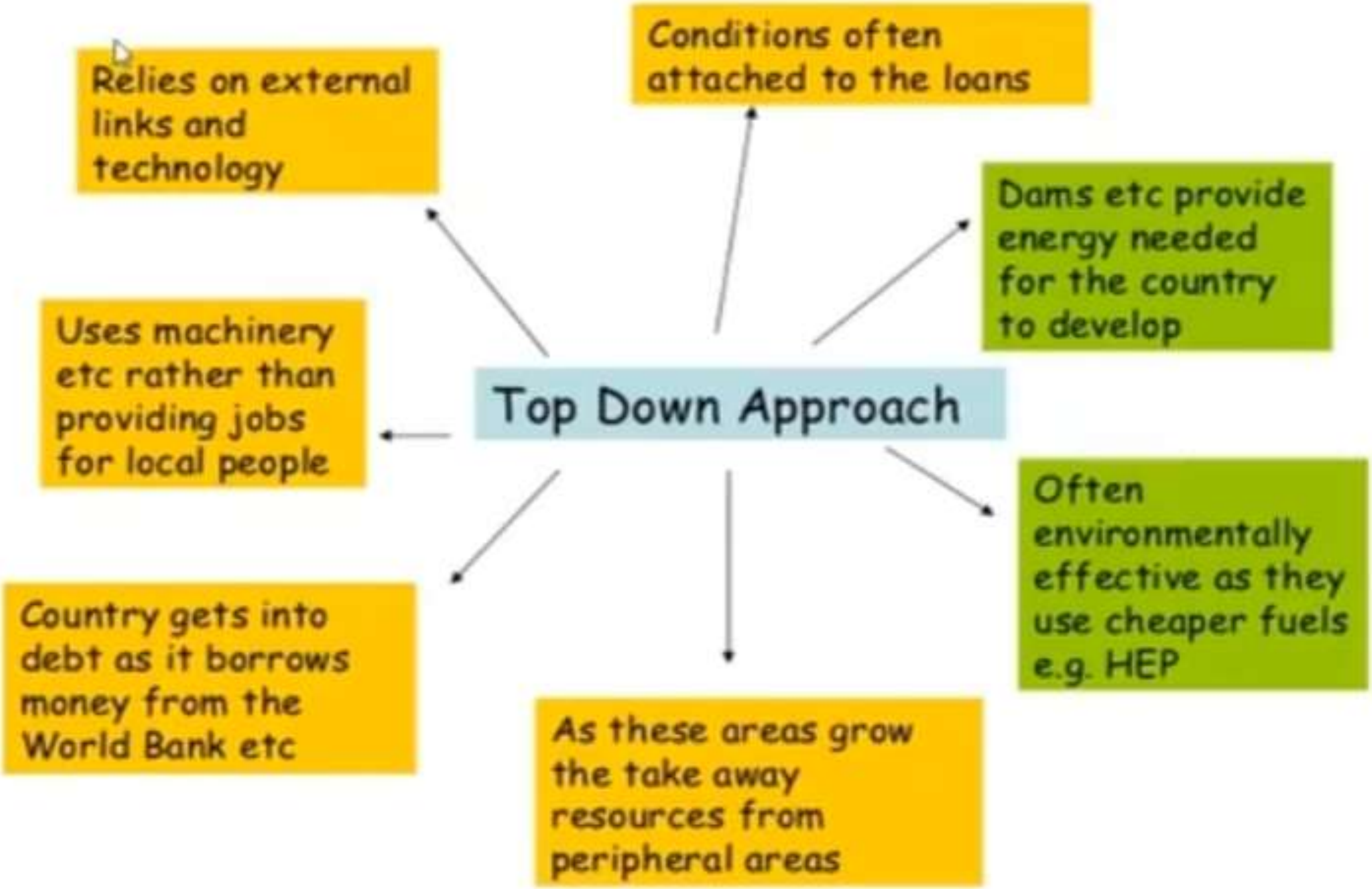
PLANNING AND MANAGEMENT – APPROACHES

Two approaches of planning and management

- From the top down or the command and control approach
- From the bottom up or the grass-roots approach

1.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.
- However, nowadays, since public have active participation in planning and management activities, top-down approaches are becoming less desirable or acceptable.


Top Down Approach
Relies on external links and technology
Conditions often attached to the loans
Dams etc provide energy needed for the country to develop
Uses machinery etc rather than providing jobs for local people
Often environmentally effective as they use cheaper fuels e.g. HEP
Country gets into debt as it borrows money from the World Bank etc
As these areas grow the take away resources from peripheral areas

2.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


Involve the local people
Appropriate technology to the local skill level
Bottom up Approach
Low cost
Very limited impact of national poverty levels

Planning and management Aspects

1. Technical aspects
2. Economic and financial aspects
3. Institutional aspects

1.Technical aspects

- Predicting changes in land use/covers and economic activities at watershed and river basin levels
- Estimation of the costs and benefits of any measures being and to be taken to manage the basin's water resource including engineering structures, canals, diversion structures etc.
- Identification and evaluation of alternative management strategies and also alternative time schedules for implementing those measures

2.Economic and Financial aspects

- Water should be treated as an economic commodity to extract the maximum benefits
- Revenues recovered are far below the capital cost incurred.
- Financial component of any planning process is needed to recover construction costs, maintenance, and repair and operation costs.
- In management policies, financial viability is viewed as a constraint that must be satisfied

3.Institutional aspects

- Water is a resource beyond property rights : it cannot be 'owned' by private persons.
- Water is a resource that often requires large investment to develop.
- Water is a medium that can easily transfer external effects.
- The use of water by one person often has negative effects on others.

Analysis for Planning and Management

- Analysis for water resources planning and management generally comprise several stages. The explicit description of these stages is referred to as the analytical (or conceptual) framework. Within this framework, a set of coherent models for the quantitative analysis of measures and strategies is used. This set of models and related databases will be referred to as the computational framework.

Analysis for Planning and Management

- The purpose of the analyses is to prepare and support planning and management decisions.
- A distinction is made between comprehension cycles and feedback cycles.
- A comprehension cycle improves the 'decision-makers' understanding of a complex problem by cycling within or between steps.
- A Feedback cycles imply returning to earlier phases of the process.

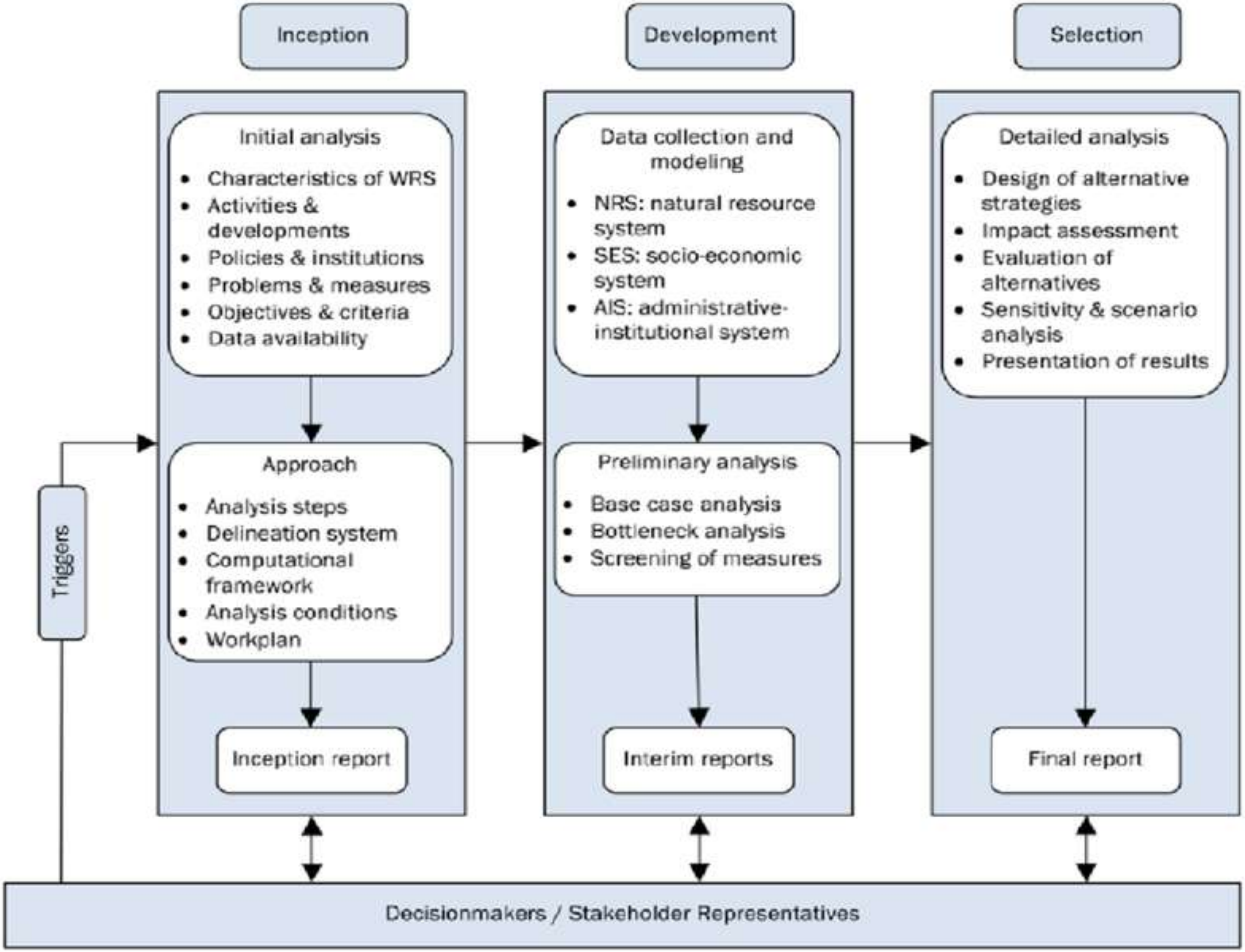
Analysis for Planning and Management

Feedback cycling process are needed when

- Solutions fail to meet criteria.
- New insights change the perception of the problem and its solutions (e.g., due to more/better information).
- Essential system links have been overlooked.
- Situations change (political, international, societal developments).

Elementary phases of analysis of framework

- Inception
- Development
- Selection


Inception
Development
Selection
Initial analysis
Characteristics of WRS
Activities & developments
Policies & institutions
Problems & measures
Objectives & criteria
Data availability
Approach
Analysis steps
Delineation system
Computational framework
Analysis conditions
Workplan
Inception report
Data collection and modeling
NRS: natural resource system
SES: socio-economic system
AIS: administrative-institutional system
Preliminary analysis
Base case analysis
Bottleneck analysis
Screening of measures
Interim reports
Detailed analysis
Design of alternative strategies
Impact assessment
Evaluation of alternatives
Sensitivity & scenario analysis
Presentation of results
Final report
Triggers
Decisionmakers / Stakeholder Representatives

1.Inception phase.

- The first phase of the analysis is inception phase.
- Subject of analysis is analyzed.
- its objectives (the desired results of the analysis) are specified.
- 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 phase are presented in the inception report, which includes the work plan for the other phases of the analysis process.

2.development phase

- In this 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 analyses will be made to ensure that the tools developed for the purpose are appropriate for solving the WRM problems.
- Scanning of possible measures should also start as soon as possible during this phase.
- Interactions with decision makers are facilitated through the presentation of interim results in interim reports.

3.Selection phase

- The purpose of the selection phase is to prepare a limited number of promising strategies based on a detailed analysis of 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.

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

Adaptive Integrated policies

- First issue is to address the product desired.
- Report should contain a discussion of the water resources management issues and options.
- List of strategies for addressing existing problems
- Desire to keep more options open for future generations
- Desire to be adaptive to new information and to respond to surprises.

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

- What are the hydrological ,ecological and economic consequences of clustering or dispersing human land uses such as urban and commercial developments and large residential areas?
- Should large intensive developments be best located in upland or valley areas?
- To what extent can riparian conservation and enhancement mitigate upland human land use effects? How do the costs of upland controls compare with the costs of riparian mitigation measures?

- What are the economic and environment quality tradeoffs associated with different areas of various classes of land use such as commercial/urban, residential, agriculture and forest?
- Can adverse effect on hydrology, aquatic ecology and water quality of urban areas be better mitigated through upstream or downstream management approaches?
- Is there a threshold size for residential/commercial areas that yield marked ecological effect?
- Mitigating flood risk by minimizing floodplain developments coincides with conservation of aquatic life in streams. What are the economic costs of this type of risk avoidance?

- What are the economic limitations and ecological benefits of having light residential zones between waterways and commercial, urban or agricultural lands?
- What are the economic development decisions that are irreversible on the landscape?

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 data bases be updated.

Post planning and management Issues

- 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.


Thank you!

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Department of Civil Engineering

MODULE-5

WATER HARVESTING AND CONSERVATION

INTRODUCTION

- Water is an important natural resource and very basic to our life
- We use water for drinking,irrigation,industry,transport and for the production of hydro-electricity.

Definitions

Water Conservation: Preservation, control and development

Water harvesting: collection, storage and resuse of water

What is rain water harvesting?

- Rainwater harvesting is a technology used for collecting and storing rainwater from rooftops, the land surface or rock catchments using simple techniques such as jars and pots as well as more complex techniques such as underground check dams.
- **Rainwater harvesting** is the accumulation and deposition of rainwater for reuse on-site, rather than allowing it to run off.

Uses of rain water

- Recharge under ground water
- Gardening
- Livestock
- Drinking purpose
- for irrigation purpose

Advantage

- Rainwater harvesting technologies are simple to install and operate.
- Local people can be easily trained to implement such technologies, and construction materials are also readily available.
- Running costs, also, are almost negligible.
- Water collected from roof catchments usually is of acceptable quality for domestic purposes.

Need of rain water harvesting

- To overcome the inadequacy of surface water to meet our demands.
- To arrest decline in ground water levels.
- To enhance availability of ground water at specific place and time.
- To increase infiltration of rain water in the subsoil.
- To improve ground water quality by diversion
- To increase agriculture production.
- To improve ecology of the area by increase in vegetation.
- To reducing the load on treatment plants.
- To reduces urban flooding , soil erosion, effects of drought.

Water Harvesting Techniques

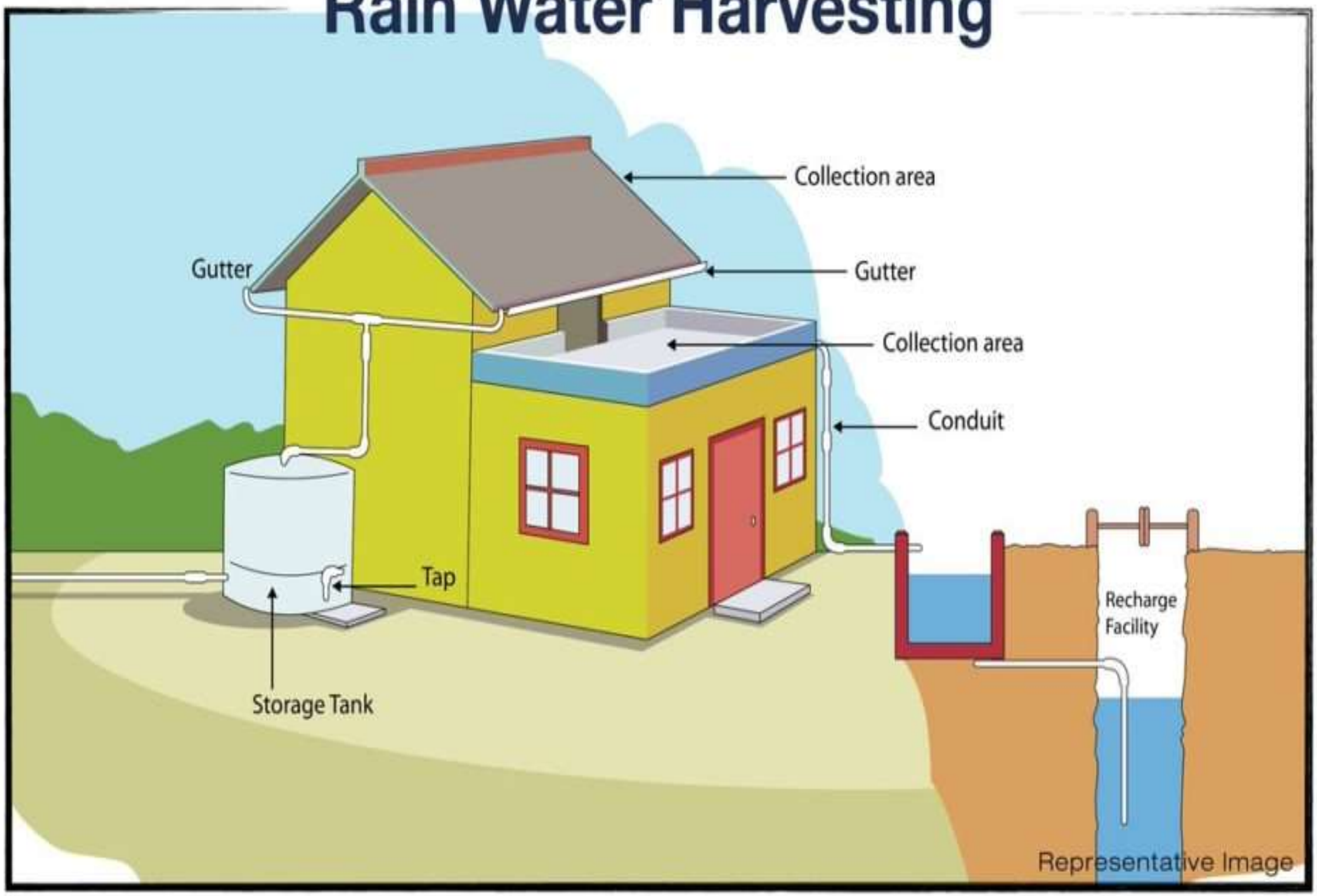
- Terraces
- Cisterns
- Recharge wells
- Roof top harvesting
- Percolation tank
- Check dams
- Gabion structure
- Farm pond
- Ground water
- Dams

Components of a rainwater Harvesting System

- Catchments
- Coarse mesh
- Gutters
- Conduits
- First-flushing
- Filter
- Recharge Structures
- Storage Facility.

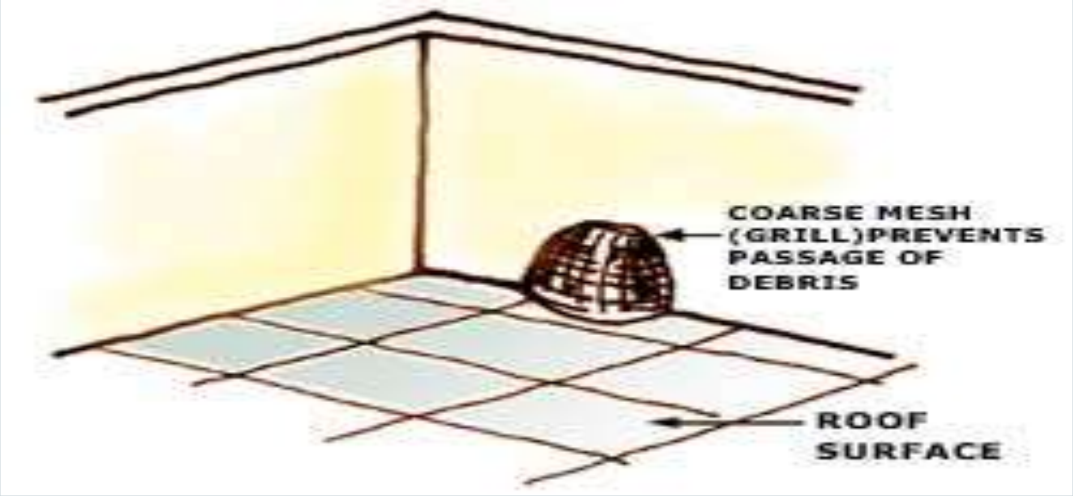

CATCHMENT
CONDUIT
RECHARGE
FACILITY
STORAGE
FACILITY
ELEMENTS OF A TYPICAL WATER HARVESTING SYSTEM

Rain Water Harvesting



Components of a rainwater Harvesting System

- Catchments :The surface that receives the rainfall directly and transfers water to the system is called catchment area. It can be a paved area such as a building's terrace or an unpaved area such as a lawn or open field. Often usable for water harvesting is a roof made of reinforced cement concrete (RCC), galvanized iron or corrugated sheets.
- Coarse mesh: Coarse Mesh In Rainwater Harvesting – It prevents the passage of debris, provided in the roof.



Components of a rainwater Harvesting System

- Gutters: Channels that circle the edge of a sloping roof to capture rainwater to the storage tank and move it. Gutters may be semi-circular or rectangular and made mainly from simple galvanized sheet of iron. Gutters need to be protected so that when filled with water, they don't sag or fall off. The way gutters are installed depends mainly on building the house, usually iron or timber brackets are fastened into the walls.
- The size of the gutter during the highest intensity rain should be according to the river. It is advisable to over dimension them by 10 to 15 per cent.
- Gutters need to be protected so that when filled with water, they don't sag or fall off. The manner in which gutters are mounted depends on the structure of the house; iron or timber brackets may be fastened into the walls, but some form of attachment to the rafters is required for houses with wider eaves.

Components of a rainwater Harvesting System

- Conduits: The conduits are pipelines or drains that bring rainwater to the irrigation system from the catchment or rooftop area. Conducts may be of any type, such as polyvinyl chloride (PVC) or galvanized iron (GI), commercially available materials.
- First-Flushing: A first flush device is a valve which ensures that the runoff from the first rain spell is flushed out and is not entering the system.
- Filters: Using the filter, suspended contaminants are separated from rainwater accumulated over the roof. A filter unit is a chamber filled with filter media such as fibre, coarse sand and gravel layers to remove sediment and soil from water until it reaches the storage tank or recharges structure. For additional filtration Charcoal may be added.

(i) Charcoal water filter: A simple charcoal filter can be made in a drum or an earthen pot. The filter consists of gravel, sand and charcoal which are all generally available.

(ii) Sand filters: Sand filters have commonly available sand as filter media. Sand filters are easy to set up and are inexpensive. These filters can be used to treat water to efficiently reduce turbidity (suspended particles such as silt and clay), color, and microorganisms.

The top layer contains coarse sand followed by a 5-10 mm layer of gravel followed by another 5-25 cm layer of gravel and boulders in a basic sand filter that can be built domestically.

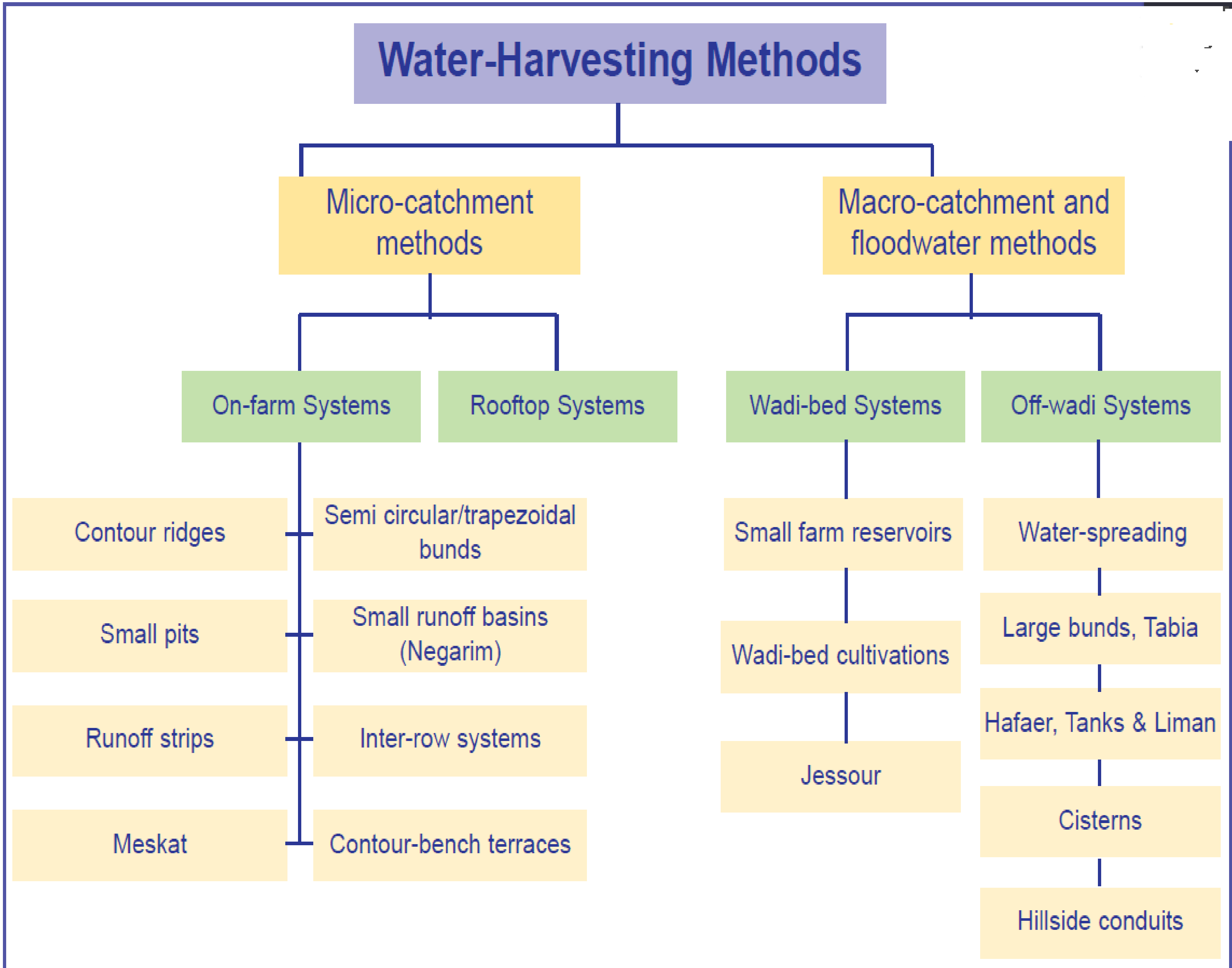
Components of a rainwater Harvesting System

- **Storage Facility:** There are different options available for the construction of these tanks in terms of form, height, construction material and tank location and they are: – Shape: Cylindrical, Square and Rectangular.

Material of construction: Reinforced cement concrete, (RCC), ferrocement, masonry, plastic (polyethylene) or metal (galvanized iron) sheets are commonly used.

Position of tank: Depending on space availability these tanks could be constructed above ground, partly underground or fully underground. Some maintenance measures like cleaning and disinfection are required to ensure the quality of water stored in the container.

- **Recharge Structures:** Rainwater can be charged into groundwater aquifers through any appropriate structures such as dug wells, bore wells, trenches for recharge and pits for recharge.


Water-Harvesting Methods
Micro-catchment methods
Macro-catchment and floodwater methods
On-farm Systems
Rooftop Systems
Wadi-bed Systems
Off-wadi Systems
Contour ridges
Semi circular/trapezoidal bunds
Small pits
Small runoff basins (Negarim)
Runoff strips
Inter-row systems
Meskat
Contour-bench terraces
Small farm reservoirs
Wadi-bed cultivations
Jessour
Water-spreading
Large bunds, Tabia
Hafaer, Tanks & Liman
Cisterns
Hillside conduits

Micro-catchment Systems

- Micro-catchment systems are those in which surface runoff is collected from a small catchment area with mainly sheet flow over a short distance.
- Runoff water is usually applied to an adjacent agricultural area, where it is either stored in the root zone and used directly by plants, or stored in a small reservoir for later use.
- The target area may be planted with trees, bushes, or with annual crops. The size of the catchment ranges from a few square meters to around 1000 m2 Land catchment surfaces may be natural, with their vegetation intact, or cleared and treated in some way to induce runoff, especially when soils are light.
- Non-land catchment surfaces include the rooftops of buildings, courtyards and similar impermeable structures.

Methods of Rainwater Harvesting

1. Surface Runoff Harvesting

- In urban areas, rainwater flows away as surface runoff. This runoff can be caught and used for recharging aquifers by adopting appropriate methods.

2. Rooftop Rainwater Harvesting

- It is a system of catching rainwater where it falls. In rooftop harvesting, the roof becomes the catchment, and the rainwater is collected from the roof of the house/building.

Components of the roof top rainwater harvesting system.

1- Catchment area
2- Transportation
3- First flush
4- Storage system
5- Delivery system
6- Filtration system

Catchment area

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

Transportation

- **Rainwater from rooftop should be carried through down take water pipes or drains to storage/harvesting system. Water pipes should be UV resistant (ISI HDPE/PVC pipes) of required capacity.**

First Flush

- First flush is a device used to flush off the water received in first shower. The first shower of rains needs to be flushed-off to avoid contaminating storable/rechargeable 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.

Storage system

- All collected rain water are store in tank or barrels used.

Delivery system

- It is a system to delivered of water for uses. There are use of pumps to take out water from tank and deliver for many purpose . Water is deliver by pips .

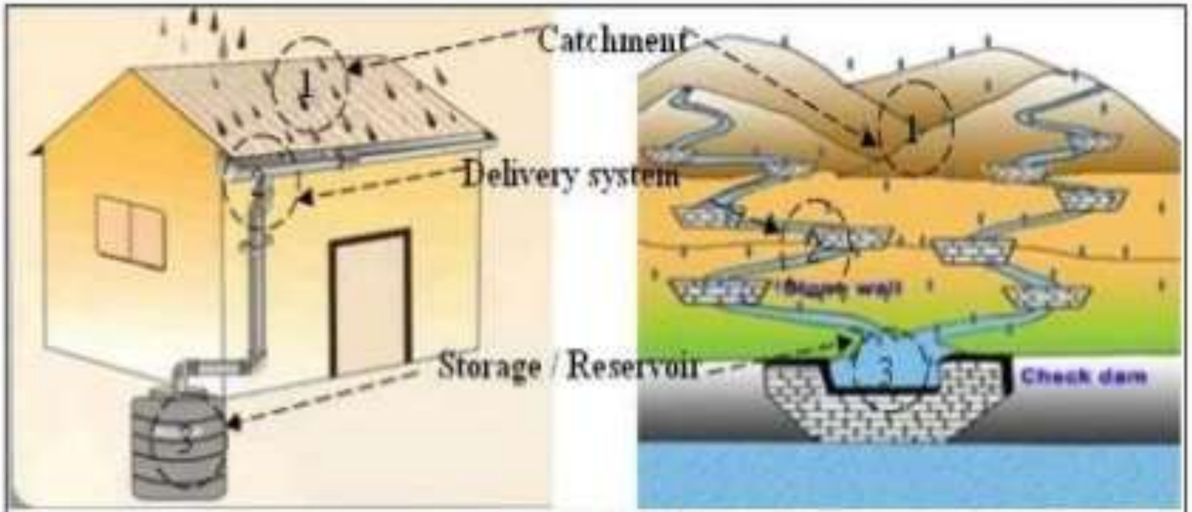


Figure 3.1 RWH Component

Filtration system

- Filters are used for treatment of water to effectively remove turbidity, colour and microorganisms. After first flushing of rainfall, water should pass through filters. There are different types of filters in practice, but basic function is to purify water.

Sand Gravel Filter

- These are commonly used filters, constructed by brick masonry and filleted by pebbles, gravel, and sand as shown in the figure. Each layer should be separated by wire mesh.

Charcoal Filter

- Charcoal filter can be made in-situ or in a drum. Pebbles, gravel, sand and charcoal as shown in the figure should fill the drum or chamber. Each layer should be separated by wire mesh. Thin layer of charcoal is used to absorb odor if any.

"A Cheap and Easy Way to Make a Filter."

PVC- Pipe filter

- **This filter can be made by PVC pipe of 1 to 1.20 m length; Diameter of pipe depends on the area of roof. Six inches dia. pipe is enough for a 1500 Sq. Ft. roof and 8 inches dia. pipe should be used for roofs more then 1500 Sq. Ft. Pipe is divided into three compartments by wire mesh.**

METHODS OF ROOF TOP RAINWATER HARVESTING?

1. *Storage of Direct use*
2. *Recharging ground water aquifers*
3. *Recharging of bore wells*
4. *Recharge Pits*
5. *Soak away or Recharge Shafts*
6. *Recharging of dug wells*
7. *Recharge Trenches*
8. *Percolation tanks*

On-Farm Systems

- On-Farm micro-catchment systems are simple in design and may be constructed at low cost, making them easily replicable and adaptable.
- They have higher runoff efficiency than macro-catchment systems and do not usually need a water conveyance system.
- They allow soil erosion to be controlled and sediments to be directed to settle in the cultivated area.
- Suitable land-based micro-catchment techniques exist for any slope or crop. However, these systems generally require continuous maintenance with a relatively high labour input.
- Unlike macro-catchment systems, the farmer has control within his farm over both the catchment and the target areas.
- All the components of the system are constructed inside the farm boundaries. This is an advantage from the point of view of maintenance and management, but because of the loss of productive land it is only in the drier environments, where cropping is most risky, that farmers are willing to allocate part of their farm to a catchment.

Contour ridges

- These are bunds or ridges constructed along the contour line, usually spaced between 5 and 20 m apart.
- The first 1–2 m above the ridge is for cultivation, whereas the rest is the catchment.
- The height of each ridge varies according to the slope's gradient and the expected depth of the Runoff water retained behind it.
- Bunds may be reinforced by stones if necessary. Ridging is a simple technique that can be carried out by farmers. Ridges can be formed manually, with an animal-driven implement, or by tractors with suitable implements.
- They may be constructed on a wide range of slopes, from 1% to 50%. The key to the success of these systems is to locate the ridge as precisely as possible along the contour.
- Otherwise water will flow along the ridge, accumulate at the lowest point, eventually break through and destroy the whole down slope system.

Design of Small Water Harvesting Structures

There are many ways of harvesting water. All these methods basically fall under three main categories viz.:

- Surface water collection
- Ground water collection
- Augmentation of ground water recharge

Design Example

- If, for example, 40 lpd (q) is agreed upon and a dry period of 80 days (t) is normally not exceeded, a storage volume of 16 m3 would be required for a family of 5 members (n). [V = 80 (t) × 5 (n) × 40 (q) = 16,000 litres or 16 m3]
- The required catchment area (i.e. the area of the roof) can be determined by dividing the volume of the tank by the accumulated average rainfall volume (in litres) per unit area (in m2) over the preceding wet months and multiplying this with the runoff coefficient, which can be set at 0.8 for galvanized iron or tiled roofs. Experience shows that with the water storage tanks next to their houses, people use between 20-40 litres of water per person per day (lpd). However, this may rise in time as people relax their water use habits because of easy access. This contrasts with a maximum of lo lpd consumption levels under similar environments with people fetching water from distant sources. Together with the community/ family, a decision must be taken on how the water will be used or what affordable service level can be provided.

PERCOLATION TANK

- Percolation tanks are artificially created surface water bodies, submerging a land area with adequate permeability to facilitate sufficient percolation of impounded surface runoff to recharge the ground water.
- These have come to be recognized as a dependable mode for ground water recharge in the hard rock terrain covering two-third of the country.
- The hard rock areas with limited to moderate water holding and water yielding capabilities often experience water scarce situations due to inadequate recharge, indiscriminate withdrawal of ground water and mismanagement.
- These are quite popular in the states of Maharashtra, Andhra Pradesh, Madhya Pradesh, Tamil Nadu, Karnataka and Gujarat. The percolation tank is more or less similar to check dams or nala bund with a fairly large storage reservoir.
- A tank can be located either across small streams by creating low elevation check dams or in uncultivated land adjoining streams, through excavation and providing a delivery canal connecting the tanks and the stream.

General Guidelines

(i) Percolation tanks should normally be constructed in a terrain with highly fractured and weathered rock for speedy recharge. In case of alluvium, the boundary formations are ideal. However, the permeability should not be too high that may result in the percolated water escaping in the downstream as regenerated surface flow.

(ii) The aquifer to be recharged should have sufficient thickness of permeable vadose zone to accommodate recharge. The Vadose zone should normally be about 3 m below the ground level to minimize the possibility of water logging.

(iii) The benefited area should have sufficient number of wells, hand pumps etc. A minimum well density of 3 to 5 per square kilometres is desirable. The aquifer zone should extend up to the benefited area.

(iv) Submergence area should be uncultivated as far as possible.

(v) The nature of the catchment is to be evaluated based on Stranger's Table for classification under Good, Average and Bad Category. It is advisable to have the percolation tank in a good/ average catchment.

(vi) Rainfall pattern based on long-term evaluation is to be studied so that the percolation tank gets filled up fully during monsoon (preferably more than once).

(vii) Soils in the catchment area should preferably be of light sandy type to avoid silting up of the tank bed.

(viii) The location of the tank should preferably be downstream of runoff zone or in the upper part of the transition zone, with a land slope gradient of 3 to 5%.

General Guidelines

(ix) The yield of a catchment area is generally from 0.44 to 0.55 MCM/sq.km in a low catchment area. Accordingly, the catchment area for small tanks varies from 2.5 to 4 sq.km and for larger tanks from 5 to 8 sq.km.

(x) The size of percolation tank is governed more by the percolating capacity of the formation under submergence rather than the yield of the catchment. Therefore, depending on the percolation capacity, the tank is to be designed. Generally, a percolation tank is designed for a storage capacity of 2.25 to 5.65 MCM. As a general guide the design capacity should normally not be more than 50 percent of the total quantum of utilizable runoff from the catchment.

(xi) While designing, due care should be taken to keep the height of the ponded water column about 3 to 4.5 m above the bed level. It is desirable to exhaust the storage by February since evaporation losses become substantial from February onwards. It is preferable that in the downstream area, the water table is at a depth of 3 to 5 m below ground level during the post monsoon period, implying that the benefited area possesses a potential shallow aquifer.

(xii) Construction-wise there is not much difference between a percolation tank and a minor irrigation tank, except for providing outlets for surface irrigation and the depth of the cut-off trench. The cut-off trench is to be provided below the earthen bund with depth limited to one fourth of the height between bed level and full storage level

Design Aspects

The design of percolation tanks involves detailed consideration of the following aspects:

(i) The catchment yield is to be calculated for long-term average annual rainfall, using Stranger's Table. Table A-3.1 of Appendix-III gives the yield from 1 hectare of Catchment for different values of monsoon rainfall.

(ii) The design of the dam is to be done on the basis of

(a) the topographical setting of the impounded area, to calculate the height and length of the dam wall, its gradient, width and the depth of the foundation, taking into account the nature of the underlying formation;

(b) Details of the cut-off trench, to reduce seepage losses;

(c) Height of stone pitching on the upstream slope to avoid erosion due to ripple action and on the downstream slope from rain by suitable turfing;

(d) Upstream and downstream slopes to be moderate so that shear stress is not induced in the foundation beyond a permissible limit; and

(e) Stability of the dam.

Design Aspects

(iii) Percolation tanks are normally earthen dams with masonry structures only for the spillway. Construction materials consist of a mixture of soil, silt, loam, clay, sand, gravel, suitably mixed and laid in layers and properly compacted to achieve stability and water tightness. The dam is not to be over-tapped, by providing adequate length of waste weir and adequate free board.

(iv) A waste weir is provided to discharge surplus water when the full pond level is reached. Maximum permissible discharge from the catchment is to be calculated using the formula approved by the competent authority based on local conditions. In the absence of such a formula, Inglis, or Dicken's formula may be used based on the observed or design discharge and catchment areas for local culverts under road or railway bridges. Once the discharge is known the length of the waste weir is decided depending on the maximum flood discharge and permissible flood depth the crest of Waste weir.

Design Aspects

(v) Finally, measures indicated for the protection of catchment areas of rock dams hold good in the case of percolation tanks also.

(vi) The percolation tanks in a watershed may not have enough catchment discharge though a high capacity tank is possible as per site conditions. In such situations stream from nearby watershed can be diverted with some additional cost and the tank can be made more efficient. Such an effort was made in Satpura Mountain front area at Nagadevi, Jalgaon district, Maharashtra. The existing capacity of the tank of 350 TMC was never utilized after its construction. This could however be filled by stream diversion from adjacent watershed.

DESIGN OF FARM POND

Farm ponds are small tanks or reservoirs constructed for the purpose of storing water essentially from surface runoff. Farm ponds are useful for irrigation, water supply for the cattle, fish production etc. The design and construction of farm ponds require a thorough knowledge of the site conditions and requirements. Some sites are ideally suited for locating the ponds and advantage of natural conditions should always be taken. Types of Ponds Depending on the source of water and their location with respect to the land surface, farm ponds are grouped into four types.

These are (1) Dugout ponds (2) Surface ponds (3) Spring or Creek fed ponds and (4) Off-stream storage ponds.

DESIGN OF FARM POND

Types of Ponds

- **Dugout Ponds** are excavated at the site and the soil obtained by excavation is formed as embankment around the pond. The pond could either be fed by surface runoff or groundwater wherever aquifers are available. In case of dugout ponds, if the stored water is to be used for irrigation, the water has to be pumped out.

- **Surface water ponds** are the most common type of farm ponds. These are partly excavated and an embankment is constructed to retain the water. Generally a site which has a depression already is chosen for this pond construction.

- **Spring or creek fed ponds** are those where a spring or a creek is the source of water supply to the pond. Construction of these ponds, therefore, depends upon the availability of natural springs or creeks.

- **Off-stream storage ponds** are constructed by the side of streams which flow only seasonally. The idea is to store the water obtained from the seasonal flow in the streams. Suitable arrangements need to be made for conveying the water from the stream to the storage ponds.

DESIGN OF FARM POND

Components of a Farm Pond:

Figure below shows a typical layout of a farm pond. The pond consists of the storage area, earthen dam, mechanical spillway and an emergency spillway. The mechanical spillway is used for letting out the excess water from the pond and also as an outlet for taking out the water for irrigation. The emergency spillway is to safeguard the earthen dam from overtopping when there are inflows higher than the designed values.

Design of Farm Pond

The design of farm ponds consists of

(1) Selection of site

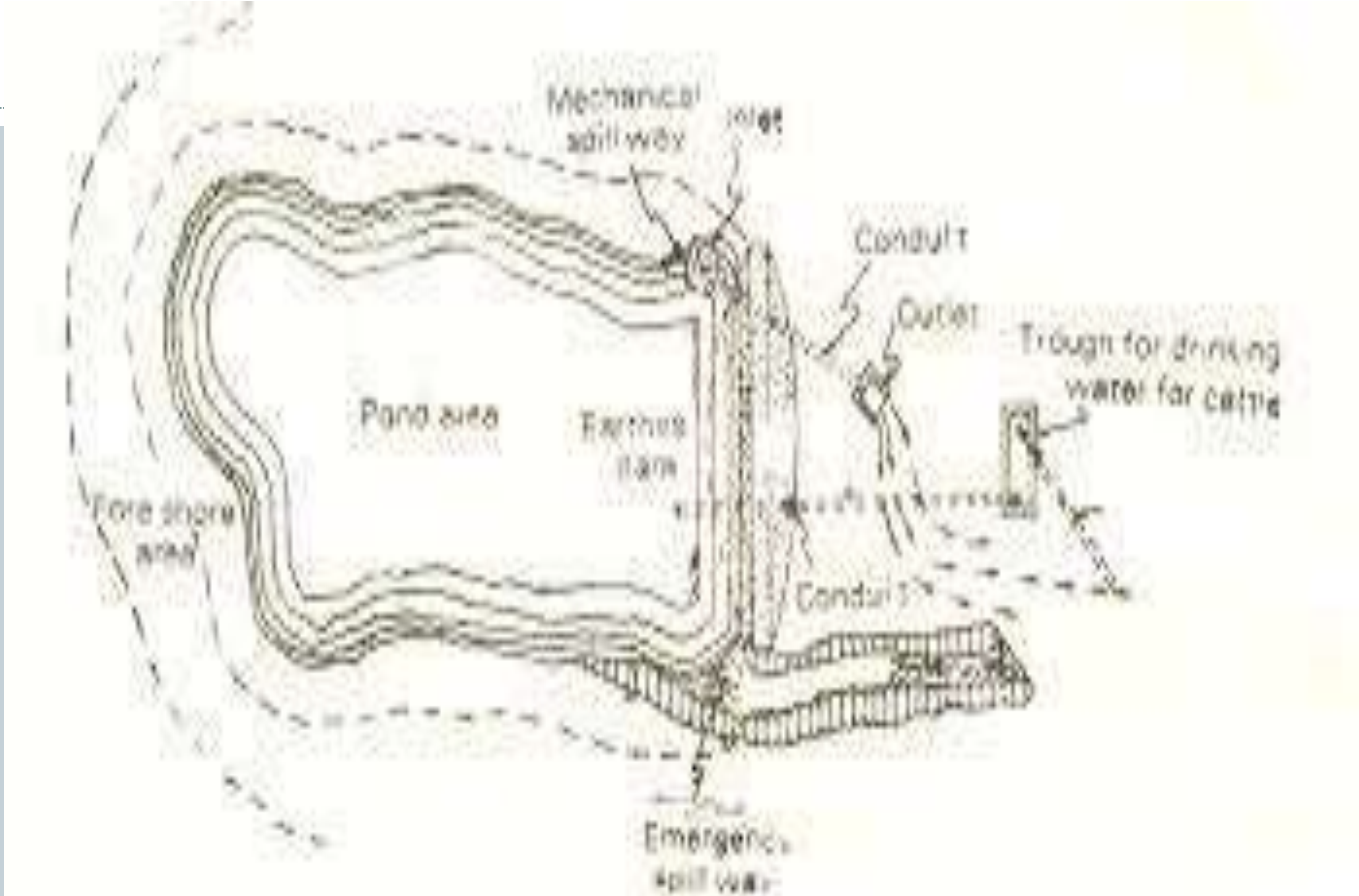
(2) Determination of the capacity of the pond

(3) Design of the embankment

(4) Design of the mechanical spillway

(5) Design of the emergency spillway

(6) Providing for seepage control from the bottom


Mechanical spill way
Conduit
Outlet
Trough for drinking water for cattle
Pond area
Earthen bank
Fore shore area
Conduit
Emergency spill way

Design of Farm Pond

Selection of site Selection of suitable site for the pond is important as the cost of construction as well as the utility of the pond depend upon the site. The site for the pond is to be selected keeping in view of the following considerations:

1. The site should be such that largest storage volume is available with the least amount of earth fill. A narrow section of the valley with steep side's slopes is preferable.

2. Large areas of shallow water should be avoided as these will cause excessive evaporation losses and also cause water weeds to grow.

3. The site should not cause excessive seepage losses.

4. The pond should be located as near as possible to the area where the water will be used. When the water is to be used for irrigation, gravity flow to the areas to be irrigated is preferable.

Techniques of Rain Water Harvesting in Urban and Rural Areas

What is Rain Water Harvesting ?

a. Conscious collection and storage of rain water for drinking, domestic purposes and irrigation is termed as rain water harvesting.

b. It is a process of artificially enhancing ground water recharge at a rate exceeding natural rate of recharge by putting proper structures.

Techniques of Rain Water Harvesting in Urban and Rural Areas

Why to harvest rainwater ?

a. To conserve surface water run-off during monsoon and to augment ground water table.
b. To improve quality of ground water.
c. To save energy in lifting water : 1m rise in water level saves 0.4kWh of energy.
d. To reduce soil erosion
e. Prevention of sea water ingress in coastal areas.
f. Decrease in choking of storm water drains and flooding of roads
g. To create a culture of water conservation

Techniques of Rain Water Harvesting in Urban and Rural Areas

Rain water harvesting in urban area and rural area:

Urban Area	Rural Area
Roof top rain water/run-off harvesting through	Rain water harvesting through
• Recharge Pit	• Gully plug
• Recharge Trench	• Contour bunding
• Tube well	• Check dam/Nala bund
• Recharge well	• Percolation tank
	• Recharge shaft
	• Dug well recharge
	• Sub surface dyke (U.G.C.D)

Techniques of Rain Water Harvesting in Urban and Rural Areas

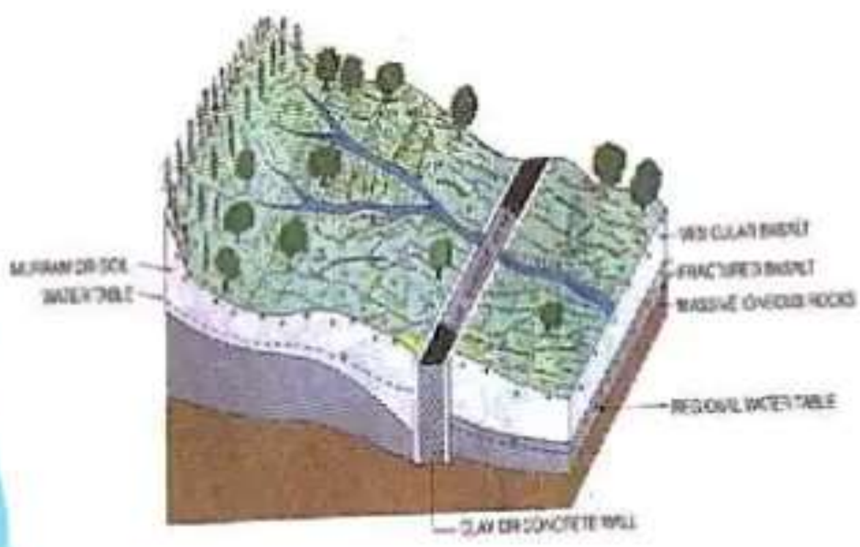
Salient features of Ground water recharge techniques:

- Quantum of water to be recharged is large.
- Space available for recharge is also in plenty.
- Therefore, surface spreading techniques are common for rural ground water recharge.
- Watershed is considered as a unit.

Techniques of Rain Water Harvesting in Urban and Rural Areas

Techniques for Ground water recharge in rural areas:

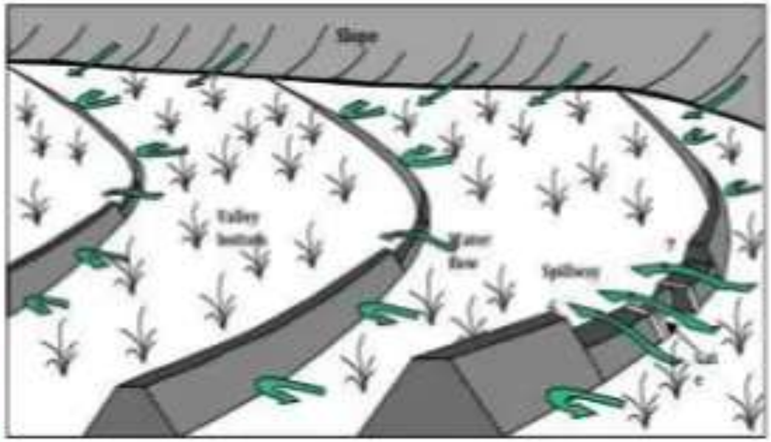
1.Gully Plug



- Built along hilly slopes across gullies/ small streams using locally available stones, clay etc.
- Better selection where slope breaks so as to have some storage behind
- Prevents soil erosion and conserves soil moisture

Techniques of Rain Water Harvesting in Urban and Rural Areas

2. Contour Bund



- These are suitable in low rain fall areas by constructing bunds on sloping grounds all along the contour of equal elevation
- Flowing water is intercepted before it attains erosive velocity by keeping suitable spacing between bunds
- Effective method to conserve soil moisture in watershed for long duration
- Spacing between two bunds depends on slope, area and permeability of soil

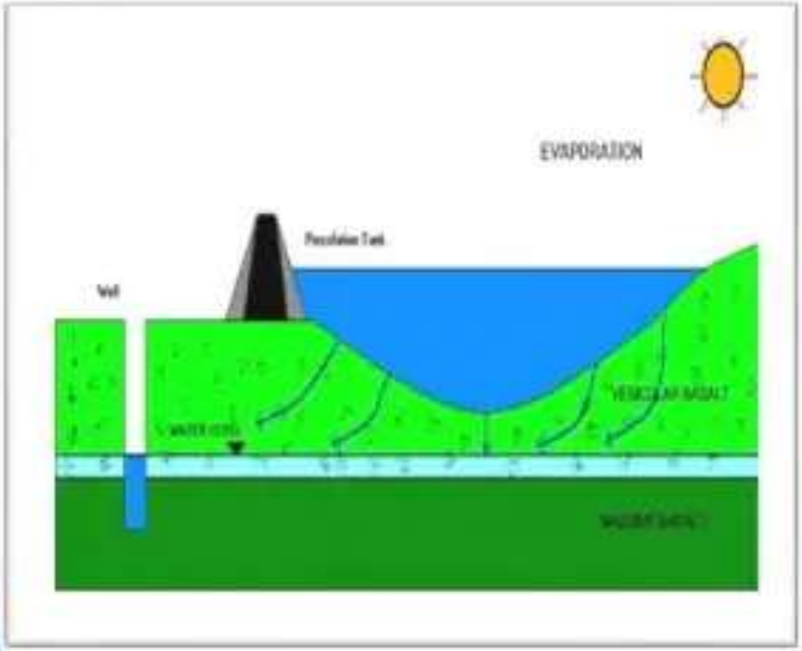
Techniques of Rain Water Harvesting in Urban and Rural Areas

3. Check Dam/Nala Bund

- Constructed across streams with gentle slopes.
- Should have sufficient thickness of permeable bed
- Water confined within the bank of stream
- Height not to exceed 1.5 to 2 meter in general
- Excess water flows above wall
- May be constructed with masonry/ concrete
- Downstream water cushion chamber required to prevent scouring.

Techniques of Rain Water Harvesting in Urban and Rural Areas

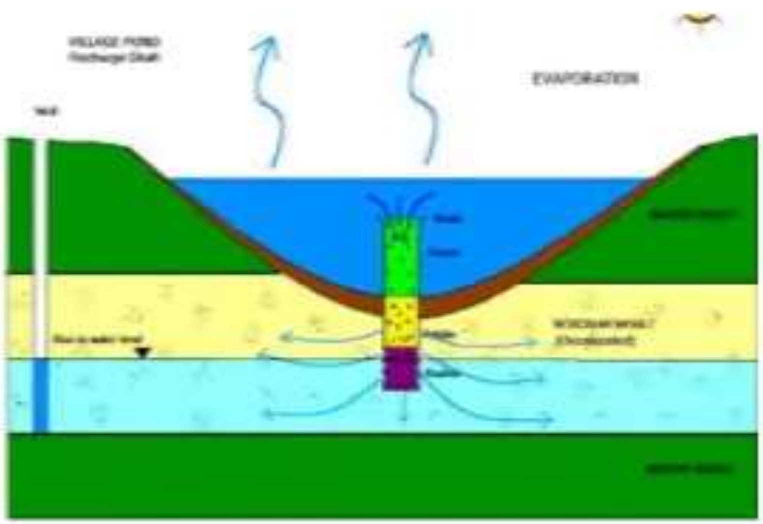
4.Percolation tank



- To be constructed on highly fractured and weathered rocks having lateral continuity downstream with number of wells
- It's a water body created by submerging highly permeable land so that surface run-off percolates and recharges ground water storage
- Normally having storage capacity of 0.1-0.5 MCM.
- Designed to provide water column of 3-4.5m.
- They are mostly earthen dams with masonry spillway.

Techniques of Rain Water Harvesting in Urban and Rural Areas

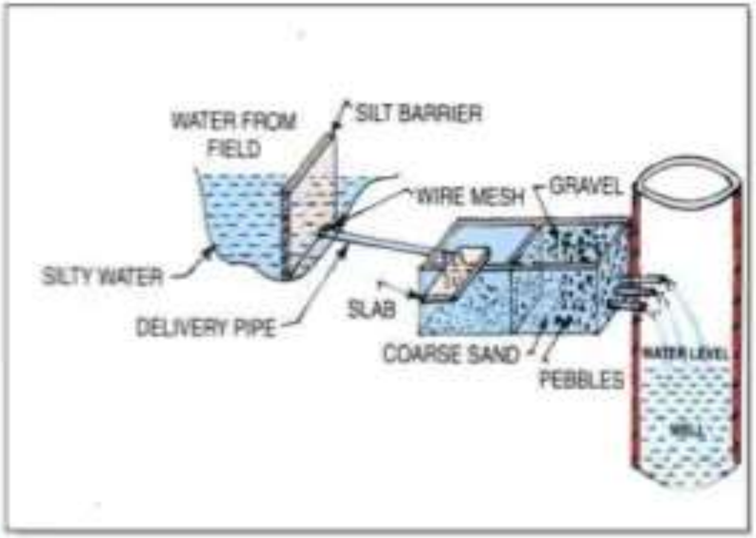
5. Recharge Shaft



- In rainy season, village tanks are filled up but water does not percolate due to siltation in the tanks and this water gets evaporated after some months.
- By constructing recharge shafts in tanks, this water can be recharged to ground water.
- Diameter: 0.5-3.0m, Depth: 10.0-15.0m, Depending upon the availability of water
- Top of shaft is kept at half of full supply depth of tank.
- Shaft is filled with filter material like boulders, gravel and coarse sand.
- Shaft should end in more permeable strata, below the top impermeable strata.
- Most efficient and cost effective technique to recharge unconfined aquifer.

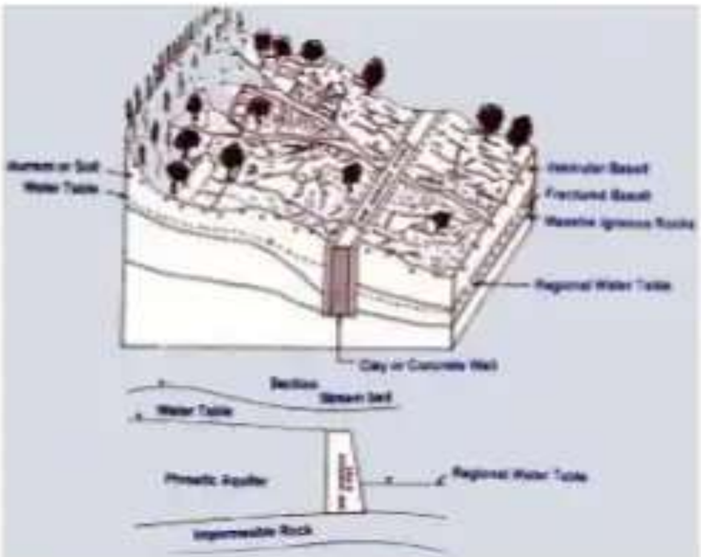
Techniques of Rain Water Harvesting in Urban and Rural Areas

6. Dug-Well Recharge



- Existing and abandoned dug wells may be utilized as recharge structure after cleaning and desilting the same.
- The recharge water is guided through a pipe from desilting chamber to the bottom of well or below the water level to avoid scouring of bottom and entrapment of air bubbles in the aquifer.
- Recharge water should be silt free and for removing the silt contents, the runoff water should pass either through a desilting chamber or filter chamber.
- Periodic chlorination should be done for controlling the bacteriological contaminations

7. Sub-surface Dyke



- Sub surface dyke or under-ground dam is a subsurface barrier across stream which retards the base flow and stores water upstream below ground surface. By doing so, the water levels in upstream part of ground water dam rises saturating otherwise dry part of aquifer.
- The site where sub-surface dyke is proposed should have shallow impervious layer with wide valley and narrow out let.

Techniques of Rain Water Harvesting in Urban and Rural Areas

- After selection of suitable site, a trench of 1-2 m wide is dug across the breadth of stream down to impermeable bed. The trench may be filled with clay or brick/ concrete wall up to 0.5m. below the ground level.
- For ensuring total imperviousness, PVC sheets or low-density polythene film can also be used to cover the cut out dyke faces.
- Since the water is stored within the aquifer, submergence of land can be avoided and land above the reservoir can be utilized even after the construction of the dam.
- No evaporation loss from the reservoir and no siltation in the reservoir takes place.
- The potential disaster like collapse of the dams can also be avoided.

Techniques of Rain Water Harvesting in Urban and Rural Areas

Salient features of Ground water recharge techniques for urban areas:

- The collection and recharge system In urban areas needs to be designed in such a way that it does not occupy large space.
- Rain water available from rooftop of building , paved and unpaved areas needs to be harvested.
- The quantum of water is comparatively small.

Techniques of Rain Water Harvesting in Urban and Rural Areas

1. Recharge Pit

- To recharge shallow aquifers.
- In alluvial areas, where permeable rocks are at shallow depth, this technique is used.
- Recharge pits generally, 1-2m wide and 2-3m deep.
- Filled with boulders at the bottom, gravel in between and course sand at the top.
- Suitable for buildings having a roof area of 100s square meters.
- A mesh is provided at the roof to avoid leaves/debris etc.

Techniques of Rain Water Harvesting in Urban and Rural Areas

- A collection/ de-silting chamber is provided at the ground to arrest finer particles entering the recharge pit
- Bypass arrangement is to be provided before collection chamber to reject first showers
- Top layer of sand to be periodically cleaned to maintain recharge rate.

Techniques of Rain Water Harvesting in Urban and Rural Areas

2.Recharge Trench.

- Suitable for buildings having roof area of 200-300 square meter
- Suitable for permeable strata having shallow depths.
- 0.5-1.0m wide, 1.0-1.5m deep and 10.0-15.0m long trenches to be backfilled with boulders at bottom , gravel in between and graded course sand at top
- Bypass arrangement to be provided before collection chamber to reject water of first shower.
- Top sand layer to be periodically cleaned

Techniques of Rain Water Harvesting in Urban and Rural Areas

3.Tube Wells.

- Suitable for areas where shallow aquifers have dried up and existing tube-wells are tapping deeper aquifers.
- PVC pipes are connected to roof drains to collect rainwater
- After rejecting rain water of first shower, subsequent rain showers are taken through a T to an online PVC filter.
- Filter is 1-1.2m in length and its diameter depends on roof area
- Filter is divided into 3 chambers by PVC screens
- Chamber 1 filled with gravels(6-10mm), middle one with pebbles(12-20mm) and last one with stones 20-40mm size.

Recharge volume of widely used recharge structures:

Type of recharge structures	Recharge rate (MCM/year)
Percolation tank with recharge shaft	0.04
Check dams	0.03
Recharge wells (Up to 200m deep)	0.02
Modification of dug wells	0.001

Techniques of Rain Water Harvesting in Urban and Rural Areas

Recharge technique for defunct bore-well:

- Recharging is feasible if bore-well accepts water poured in it at a constant rate from tanker of 5000-6000 litre capacity.
- If bore-well overflows, its not suitable for research.
- Around bore-well, pit of size 10.0ft*10.0ft*10.0ft to be excavated.
- PVC casing pipe with vertical slits of 50mm*2mm is provided up to 6 feet height from the bottom of the pipe.
- Cement concrete bed is put at pipe bottom for fixity. (Clamp can also be provided)

Techniques of Rain Water Harvesting in Urban and Rural Areas

- Big boulders are filled around pipe up to six feet height of pit.
- In next layer, smaller size stones are provided for 1 feet height.
- If borewell is for drinking purpose, 1 feet layer of wood charcoal to be provided to avoid micro bacterial contaminants entering the well.
- On this layer spread HDPE mesh and 1 feet thick layer of coarse sand to stop leaves, silt ,etc. entering and choking filter media.
- A wall of small height to be built around pit to avoid collapse of surrounding soil and also to help water to remain on sand bed for longer time before percolating into well.
- Water flow is diverted from surrounding area which through filter layers and PVC pipe reaches bore-well and thus recharge occurs.
- Top sand layer to be replaced every 2-3 years to maintain percolation efficiency.