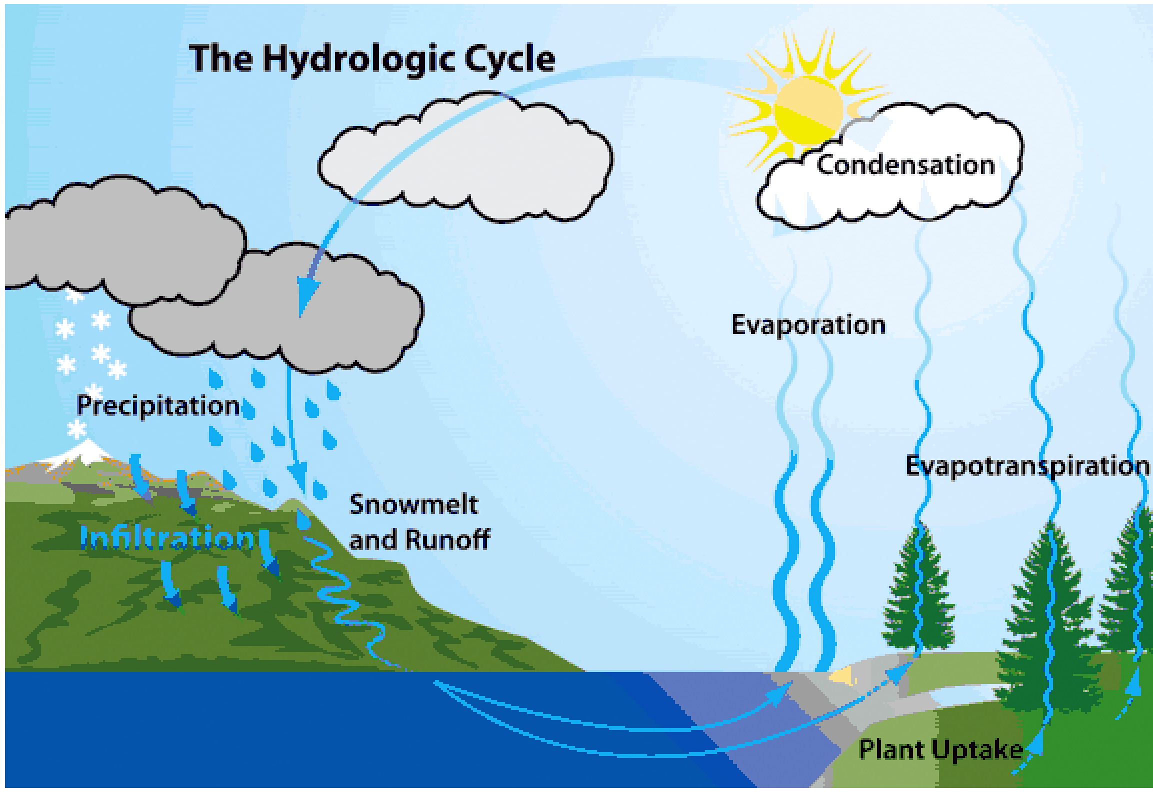
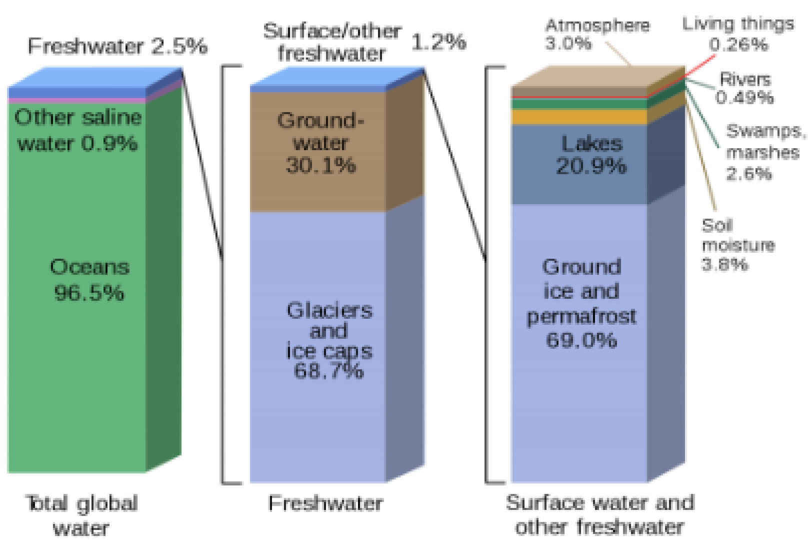
Water resources management VTU question paper solutions (JUNE/JULY 2018)

1.
   a. Hydrological cycle:
      - The continuous movement of water on, above and below the surface of the Earth.
      - The mass of water on Earth remains fairly constant over time but the partitioning of the water into the major reservoirs of ice, fresh water, saline water and atmospheric water is variable depending on a wide range of climatic variables.
      - The water moves from one reservoir to another, such as from river to ocean, or from the ocean to the atmosphere, by the physical processes of evaporation, condensation, precipitation, infiltration, surface runoff, and subsurface flow. In doing so, the water goes through different forms: liquid, solid (ice) and vapor.
      - This cycle derives its energy for the movement from the sun. Following processes occur:
      - Precipitation: Condensed water vapor that falls to the Earth's surface. Most precipitation occurs as rain, but also includes snow, hail, etc.
      - Runoff: the draining away of water from the surface of an area of land.This includes both surface runoff and channel runoff.
      - Infiltration: The flow of water from the ground surface into the ground. Once infiltrated, the water becomes soil moisture or groundwater.
      - Subsurface flow:The flow of water underground, in the vadose zone and aquifers.
      - Evaporation: The transformation of water from liquid to gas phases as it moves from the ground or bodies of water into the overlying atmosphere.Evaporation often implicitly includes transpiration from plants, though together they are specifically referred to as evapotranspiration.
      - Transpiration:The release of water vapor from plants and soil into the air.
      - Percolation:Water flows vertically through the soil and rocks under the influence of gravity.

- Sketch:

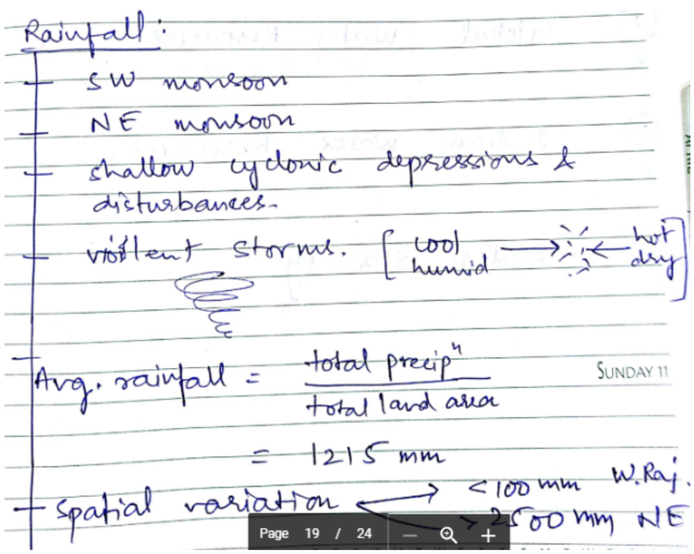


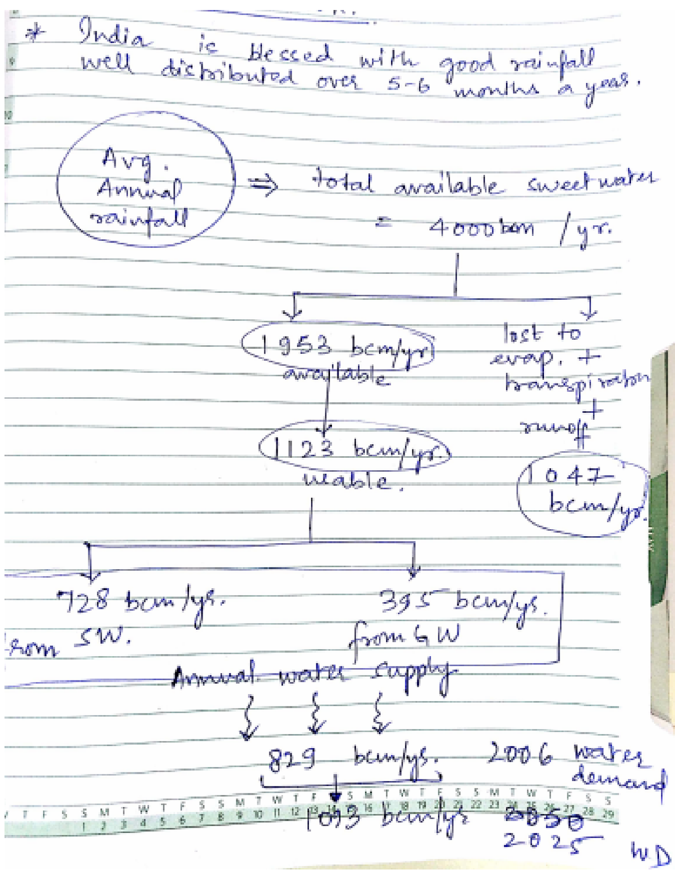
b. Global water resources:



The total quantity of water in the world is estimated to be about 1386 million cubic kilometers. About 96.5% of this water is contained in the oceans as saline water. Some of the water on land amounting to 1% of the total water is also saline. Thus, only about 35 M Km3 of freshwater is available. Out of this about 10.6 M Km3 is both liquid and fresh while the rest 24.4 M Km3 is frozen as glaciers and ice in polar regions. There is uneven distribution of water across different continents. Skewed growth of population influences the global reserve and with rise in quality of living, per capita water available is decreasing.

Indian water resources:





THURSDAY 29
MARCH

* An increasing no. of aquifers are reaching unsustainable levels of exploitation

↓ If this continues,

In 20 yrs, about 60 % of all India's aquifers will be in critical condition [World Bank]

sustainability of agri (I) ↓ economic growth (I) → long-term food security (I)

GW acts as a critical buffer against vulnerability of monsoon rains.

eg, 1963 – 1966 : rainfall deficit

↓ India's food prodn ↓ by 20%

1987 – 1988 : severe drought

↓ negligible impact due to widespread use of GW by that time.

India : SW availability > GW but owing to decentralised availability of GW, it is easily accessible & forms largest share of India's agriculture & drinking water supply.

2.

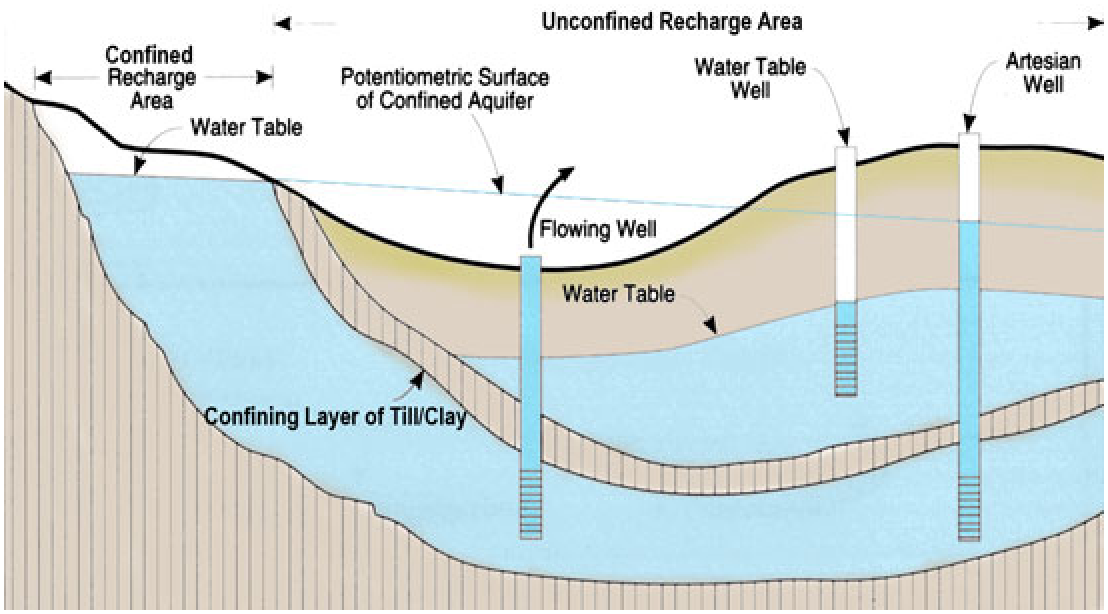
a. Confined and unconfined aquifer:

- Confined Aquifers:
- permeable rock units that are usually deeper under the ground than unconfined aquifers.

overlain by relatively impermeable rock or clay that limits groundwater movement into, or out of, the confined aquifer.

- Groundwater in a confined aquifer is under pressure and will rise up inside a borehole drilled into the aquifer. The level to which the water rises is called the potentiometric surface. An artesian flow is where water flows out of the borehole under natural pressure.
- Confined aquifers may be replenished, or recharged by rain or streamwater infilitrating the rock at some considerable distance away from the confined aquifer. Groundwater in these aquifers can sometimes be thousands of years old.
- Unconfined Aquifers:

- Where groundwater is in direct contact with the atmosphere through the open pore spaces of the overlying soil or rock, then the aquifer is said to be unconfined.
- The upper groundwater surface in an unconfined aquifer is called the water table.
- The depth to the water table varies according to factors such as the topography, geology, season and tidal effects, and the quantities of water being pumped from the aquifer.
- Unconfined aquifers are usually recharged by rain or streamwater infiltrating directly through the overlying soil.
- Typical examples of unconfined aquifers include many areas of coastal sands and alluvial deposits in river valleys.

○ 

b. Water scarcity and its contributing factors:
   - Water scarcity involves water crisis, water shortage, water deficit or water stress. It's the lack of sufficient available water resources to meet the demands of water usage within a region. It can be due to physical water scarcity and economic water scarcity. Physical water scarcity refers to a situation where natural water resources are unable to meet a region's demand and economic water scarcity is a result of poor water management resources.
   - The concept of water scarcity may also refer to the difficulty in obtaining fresh water sources and the deterioration and depletion of the available water sources. Some of the contributing factors to water scarcity are climate change, water overuse, and increased pollution. Many areas around the globe are affected by this phenomenon, and about 2.7 billion people experience water scarcity each and every year.

        - Causes of water scarcity:
        - Over-exploitation and non-judicial use of Water-resources:
        - The rapid increase in human population combined by massive growth in industry sector have have transformed water ecosystems and resulted in loss of biodiversity. As population is increasing at an ever increasing rate, the demand for new resources will result in additional pressure on freshwater sources. With increasing demand as well as change in lifestyle, over exploitation and non-judicial use of water results.
        - Pollution of available water resources: The sources of water pollution include pesticides and fertilizers that wash away from farms, industrial and human waste that is directly dumped into rivers without treating it in water treatment plant. Oil spill on the ground, waste water leakage from landfills can seep underground and may pollute the groundwater making it unfit for human consumption.
        - Conflict: If there is conflict over an area of land, it may be difficult to access the water that is located there.
        - Distance: There are a number of areas throughout the entire world that deal with water scarcity because they just aren't close to anywhere that has water. Areas that are considered to be desert, or areas that are secluded, may not have somewhere that the people can get water effectively.
        - Drought: A drought is, in short, an area which is not getting enough rainfall to be able to sustain the life that is residing there. Some areas are in perpetual drought, whereas other areas may be dealing with a drought on occasion.
        - Governmental Access: In some countries, specifically those with dictatorships, the use of water may be strictly controlled by those in power, causing a scarcity for those who may be located in those areas of the world. These governments use it as a source of control over those that they are governing, which can be a huge problem.

3.
    a. Necessity:
        - Water, although plentiful, is not distributed as we might wish. It is available either too much (frequent floods, waterlogging etc.) , or too little (scarcity) or too polluted or too expensive (uneconomical exploitation) to be readily available!
        - Water situation will further deteriorate due to global changes like climate change, population growth, change in land-use and land-cover, rapid urbanisation, migration from rural to urban areas etc.
        - Water dynamics are unsustainably non-linear. For instance, in 20th century, population has increased 3 fold but corresponding water demand has increased 6 folds.
        - Existing water systems are failing due to numerous reasons like:

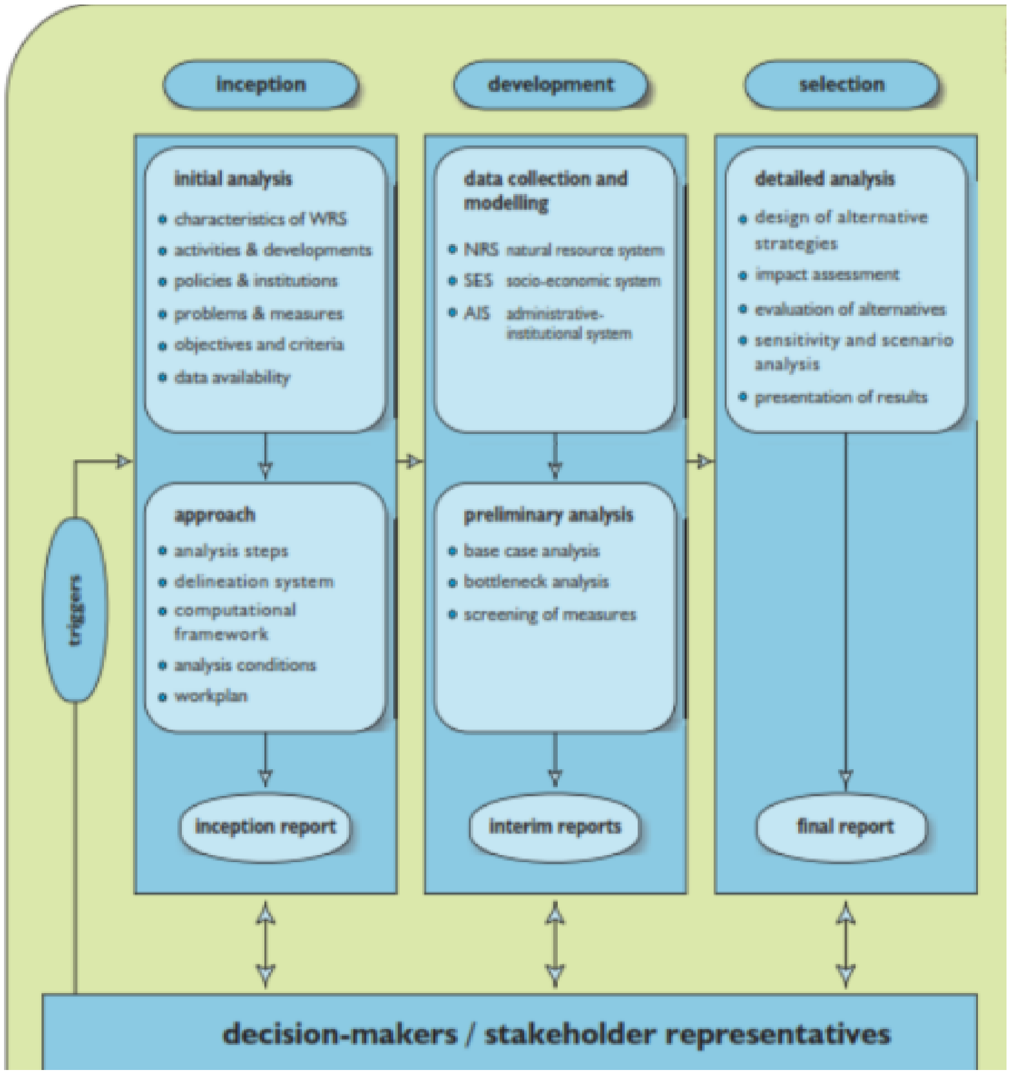
        - Degraded infrastructure
        - Excessive withdrawals of river flows
        - Pollution from industrial and agricultural activities
        - Eutrophication from excessive nutrient loads
        - Salinization from irrigation return flows
        - Infestation of exotic plant and animals
        - Excessive fish harvesting
        - Habitat and floodplain alteration due to development
        - Changes in water and sediment flow regimes
    - Water woes also have to be addressed against following socio-economic factors:
        - Inadequate education
        - Population pressure
        - Poverty
    - To make the water resources sustainable, change in thought process has to be ensured: one dimensional to multidimensional. For instance, the problem of providing more high quality water to irrigation areas in the basin at acceptable costs→ has to be modified to→problem of considering how the withdrawals would affect the downstream water quantity and quality regimes and in turn aquatic and riparian ecosystems.
    - Planning and management is needed as problems and opportunities change over time. This leads to change in goals of water management, processes in planning and new perceptions of how to plan more effectively.
    - Planning is needed to answer following concerns:
        - How can the renewable yet finite resources be best managed and used?
        - How can this be accomplished in an environment of uncertain supplies and uncertain & increasing demands; consequently increasing conflicts among individuals having different interests in management of a water resources?

b. Spatial and temporal scales of planning and management:
    - Causes and problems can be widely scattered. For example, if salinity is causing the problem in a lower basin, the sources of salinity may be in an upper basin. Thus, the entire river basin becomes an area of influence or problemshed even though the upper basin isn't going to benefit directly from the solution.
    - To determine a water quality issue's problemshed, for example, we should ask:
        - What is the watershed basin (e.g.,geographic, physical boundaries)?
        - How and where does the problem manifest itself (e.g., drinking water,wetlands, fish)

- Who and what uses the water (e.g., farmers, trees, fish)?
- What do they use the water for (e.g.,agricultural, ecosystem, etc.)?
- Where is the source of pollution (e.g.pesticides, sewage, mine drainage, etc)?

-
- Thus, spatial scale may include either river basin or watershed; or problemshed.
- Temporal Scale of planning refers to planning for now and distant future
- Since planning is a continuing sequential process : updation and adaptation by incoming forecasts, new info, new problems etc. is continually required.
- No. and duration of within-year planning periods depend upon nature of water-related activity(Irrigation and recreation v/s municipal water supply)

4.

a. 

inception
development
selection
initial analysis
characteristics of WRS
activities & developments
policies & institutions
problems & measures
objectives and criteria
data availability
data collection and modelling
NRS natural resource system
SES socio-economic system
AIS administrative-institutional system
detailed analysis
design of alternative strategies
impact assessment
evaluation of alternatives
sensitivity and scenario analysis
presentation of results
triggers
approach
analysis steps
delineation system
computational framework
analysis conditions
workplan
preliminary analysis
base case analysis
bottleneck analysis
screening of measures
inception report
interim reports
final report
decision-makers / stakeholder representatives

→ During each phase, processes have a cyclic component [comprehensive cycle]

① interaction c̄ decision makers / stakeholder representatives .. essential throughout.

② Regular reporting through inception & interim reports improves effectiveness of communication.

→ I phase : inception. ⇒ what is analysed under what conditions.
specifies ↓ subject of analysis ⇒
\+
object ⟹ Desired results of the analysis.

✓ Based on initial analysis [communication with decision makers is essential] ⟹ approach for policy analysis is specified.

✓ Result of inception phase presented in inception report. ⟶ work plan for other phases.

→ II phase : development
↓
tools for identifying possible solutions → data collection and modelling

✓ preliminary analysis ⟶ to check tools developed are appropriate to solve WRM problems.

✓ this phase has an ↑sed understanding of the functioning of water resources system.

✓ scanning of possible measures starts also during this phase.

→ III phase: selection.
↓
to prepare limited number of promising strategies based on a detailed analysis of their effects on the evaluation criteria. → presented before decision-makers.
↓
final selection is made.

✓ important activities are:
- strategy design
- evaluation of strategy
- presentation.

✓ results included in final report.

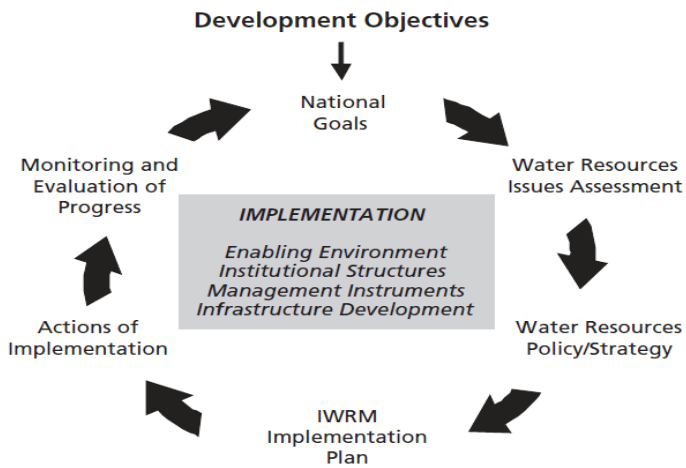
→ Analyses are made to support the decision making processes, but it's not clear who will make the final decision or who is the decision-maker.

b. Questions addressed in adaptive integrated policy:
  - 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? Similarly, what are the consequences of concentrated versus dispersed patterns of reserve lands, stream buffers and forestland?
  - What are the costs and ecological benefits of a conservation strategy based on near-stream measures (e.g., riparian buffers) versus near-source (e.g., upland/site edge) measures? What is the relative cost of forgone upland development versus forgone valley or riparian development? Do costs strongly limit the use of stream buffer zones for mitigating agriculture, residential and urban developments?
  - Should large intensive developments be best located in upland or valley areas? Does the answer differ depending on economic, environmental or aquatic ecosystem perspectives? From the same perspectives, is the most efficient and desirable landscape highly fragmented or highly zoned with centres of economic activity?

- 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?
- 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 environmental quality tradeoffs associated with different areas of various classes of land use such as commercial/urban, residential, agriculture and forest?
- Can adverse effects on hydrology, aquatic ecology and water quality of urban areas be better mitigated through upstream or downstream management approaches? Can land controls like stream buffers be used at reasonable cost within urban areas, and if so, how effective are they?
- Is there a threshold size for residential/commercial areas that yield marked ecological effects? What are the ecological states at the landscape scale that, once attained, become irreversible with reasonable mitigation measures? For example, once stream segments in an urban setting become highly altered by direct and indirect effects (e.g., channel bank protection and straightening and urban runoff), can they be restored with feasible changes in urban land use or mitigation measures?
- 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? For example, once land is used for commercial development, it is normally too costly to return it to agriculture. This would identify limits on planning and management for conservation and development.
- What are the associated ecological and economic impacts of the trend in residential, commercial and forest lands replacing agricultural lands?

5.

a. Integrated water resources management is based on the equitable and efficient management and sustainable use of water and recognizes that water is an integral part of the ecosystem, a natural resource, and a social and economic good, whose quantity and quality determine the nature of its utilization.
This summary emphasizes the importance of an integrated approach as well as clearly articulating the link between water resources management and the “3Es” of sustainable development: economic efficiency in water use, social equity, and environmental and ecological sustainability.



The major components in the implementation of IWRM are,

1) Enabling Environment
2) Institutional structures
3) Management Instruments
4) Infrastructure Development

<u>1) Enabling Environment:</u> The enabling environment essentially consists of rules that are laid out to achieve a sustainable balance between the social, economic and environmental needs for water. These rules can be defined by the use of: **a) Policies b) Legislative Frameworks c) Financing and Investment Structures.** The enabling environment is determined by national, provincial and local policies and legislation that constitute the rules and facilitates all stakeholders to play their respective roles in the sustainable development and management of water resources.

- ***Policies*** – Setting goals for water use, protection and conservation. Policy development gives an opportunity for setting national objectives for the management of water resources and water service delivery with concerns for the overall development goals.
- ***Legal Frameworks*** – The rules to follow to achieve policies and goals. The required water laws cover ownership of water, permits to use (or pollute) it, the transferability of those permits, and customary entitlements. They underpin regulatory norms for e.g. conservation, protection, priorities, and conflict management.
- ***Investment and Financing Structures*** **–** Allocating financial resources to meet water needs. Water projects tend to be indivisible and capital-intensive, and many countries have major backlogs in developing water infrastructure. Countries need smart national and international financing approaches and appropriate incentives to achieve development goals. Financial resources need

also be allocated to public sector financing e.g. for the management of the resource, not only the water services.

2)Institutional structures: In the context of IWRM, governance is defined as the range of political, social, economic and administrative institutions that are in place (or need to be in place) to develop and manage water resources in sustainable manners. Four institutional roles are important for water governance systems to achieve sound IWRM practices.

1) Regulation and Enforcement
2) Water Supply and Sanitation Services
3) Coordination and Facilitation
4) Capacity Building.

3) Management Instruments: Management instruments are specific methods that enable decision makers to make rational and informed choices when it comes to water management. In order to make water governance most effective, decision makers need to select the instruments that are best suited to the specific circumstances, i.e. the context and framing of the problem, social and political consensus, available resources, as well as geographical, social, and economic contexts. For this purpose, they need to have an overview of the management instruments available and the experiences and lessons that have been acquired in the course of applying these instruments in other contexts.

These instruments can be grouped into nine categories, according to their objectives:

1) Understanding Water Endowments
2) Assessment
3) Modelling and Decision-Making
4) Planning for IWRM
5) Communication
6) Efficiency in Water Management
7) Economic Instruments
8) Promoting Social Change

- ***Understanding Water Endowments*** – Helps to understand water as a physical resource. Considers the analysis of Demand and Supply, the collection of data on the hydrological cycle, the monitoring of water quality and the evaluation of water policies

- ***Assessment -*** Helps to understand the connections between water resources and their users as well as to calculate the impacts of uncertain events or policy measures on the resource and its users. The aspects considered are risk and vulnerability, social structures and effects, ecosystems, environment, and economics.

- ***Modelling and Decision-Making***– Visualizes the information that has been gathered and helps to make decisions based on that information according to jointly established criteria with stakeholders. It includes further information on GIS, Stakeholder Analysis, Shared Vision Planning, and Decision Support Systems.

- ***Planning for IWRM*** – On the basis of knowledge gained through assessments and modelling processes, plans can be made that integrate environmental, social and economic aspects of water management on different scales: on the national level, river basin level, with regards to ground water, or coastal areas.

- ***Communication*** –Water management involves a variety of stakeholders and relies heavily on sharing knowledge in order to design effective plans and foster participation. For that reason, an overview on Communication Tools is given and measures to prevent and deal with conflict are explained, such as Consensus Building and Conflict Management.

- ***Efficiency in Water Management*** – Refers to measures that improve the management of demand and supply by enhancing water Demand Efficiency and Supply Efficiency.

- ***Economic Instruments*** –Water Pricing, Water Markets, Tradable Pollution Permits, Pollution Charges, Subsidies, and Payments for Environmental Services are examples for economic instruments.

- ***Promoting Social Change*** – Social attitudes also play a big role in WRM. A change in attitudes can be fostered through the integration of water management into Youth Education, and through Raising Public Awareness. The concept of the Water Footprint can be helpful to explain the relationship between water and agricultural and industry, and Virtual water to learn about how much water is used in the industrial production of goods.

b. The Dublin Statement on Water and Sustainable Development was agreed at the International Conference on Water and the Environment (ICWE), on 26-31 January 1992, a preparatory meeting of the United Nations Conference on Environment and Development (UNCED).

   The Dublin Statement, which included four principles on water, was submitted to the UNCED in Rio de Janeiro, 3-14 June 1992, in 'The Earth Summit'. These were hence known as **Dublin- Rio principles**.

GWP adapted and elaborated these principles to reflect an international understanding of the “equitable and efficient management and sustainable use of water”.

- **Principle 1: Water is a finite and vulnerable resource**
  - Fresh water is a finite and vulnerable resource, essential to sustain life, development, and the environment. This principle recognizes all the characteristics of the hydrological cycle and its interaction with other natural resources and ecosystems.
  - The statement also recognizes that water is required for many different purposes, functions, and services; holistic management, therefore, has to involve consideration of the demands placed on the resources and the threats to it.
  - Holistic management not only involves the management of natural systems; it also necessitates coordination between the range of human activities which create the demands for water, determine land uses and generate water borne waste products.
- **Principle 2: Participatory approach**
  - Water development and management should be based on a participatory approach, involving users, planners, and policy-makers at all levels. Water is a subject in which everyone is a stakeholder. Real participation only takes place when stakeholders are part of the decision making process. This can occur directly when local communities come together to make water supply, management and use choices.
  - Participation also occurs if democratically elected or otherwise accountable agencies or spokespersons can represent stakeholder groups. The type of participation will depend upon the spatial scale relevant to particular water management and investment decisions and upon the nature of the political economy in which such decisions take place.
- **Principle 3: Role of women**
  - It is widely acknowledged that women play a key role in the collection and safeguarding of water for domestic and, in many cases, agricultural use, but have much less influence than men in management, problem analysis, and decision

making related to water resources.

        - Attention to gender is essential to sound development practice and is at the heart of economic and social progress. Development cannot be maximised and sustained without recognition that every policy, program and project affects women and men differently.
        - Gender needs should be part of the overall policy framework which can ensure that policies, programs, and projects address the differences in experiences and situations between and among women and men.
        - Equal participation in social and political issues involves women's equal right to articulate their needs and interests, as well as their vision of society, and to shape the decisions that affect their lives. Their ability to do this can be strengthened through community organizations and institutions, and building participatory capacity.
    - **Principle 4: Social and economic value of water**
        - Within this principle it is vital to recognize the basic right of all human beings to have access to clean water and sanitation at an affordable price. Past failure to recognize the economic value of water has led to wasteful and environmentally damaging uses of the resource.
        - 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.
        - Value and charges are two different things. The value of water in alternative uses is important for the rational allocation of water as a scarce resource, whether by regulatory or economic means. Charging for water is applying an economic instrument to affect behaviour towards conservation and efficient water usage, to provide incentives for demand management, ensure cost recovery, and to signal consumers' willingness to pay for additional investments in water services.

6.

    a. IWRM is a process which promotes the coordinated development and management of water, land and related resources in order to maximise economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. IWRM is not an end point, but a continuous process of participation, learning and adaptation. The IWRM framework consists of three pillars (the Three Es):

- Economic efficiency in water use
- Equity
- Environmental and ecological sustainability

The IWRM challenge is to integrate these three Es, focusing on key areas that affect how water resources are managed: the enabling environment, the institutional framework, and management roles. There is no blue-print IWRM system. It must be tailored to each institutional environment and local development context.

The IWRM approach focuses on the following elements:

- Enabling environment:
    - Regulatory framework
    - Policies and plans
    - Sector funding
- Institutional framework:
    - Organisations and their capacity (management capacity; technical capacity)
- Management instruments:
    - Planning framework for IWRM
    - Implementation of structural interventions
    - Knowledge base
    - Disaster risk management
    - Interagency coordination mechanisms
    - Social development and safeguards
    - Environmental safeguards

b. Sectors benefitted by IWRM:

Sector	Benefits
Environment	-A voice for environmental needs in water allocation - Raising awareness among other users of the needs of ecosystems - More attention to an ecosystem approach to water management - Protecting upper catchments, pollution control, and environmental flows - Safeguarding common resources such

	as forests, wetlands and fishing grounds on which communities depend
Agriculture	-Implications for agriculture of water use by other sectors considered in the management process - Rational decision making on water use in which costs and benefits are considered - More effective use of water within the sector and hence increased returns - Multi-purpose water resource development and cros-ssectoral recycling (e.g. use of reclaimed municipal wastewater for irrigation)
Water supply & sanitation	-Increased security of domestic water supplies - Reduced conflicts between water users - Increasing recognition of the economic value of water leading to more efficient use - Increased use of water demand management - Improved waste management considering environmental effects and human health and hygiene - Reduced costs of providing domestic water services

7.

a. Existing legislative framework:
   - The existing legal framework for water law in India, both at the National and state level is embodied in the nine major Acts at the National and state level. The National Legislations as applicable to water are:
   - Water prevention and Control of Pollution Act 1974;
   - Air prevention and Control of Pollution Act 1977;
   - Environment Protection Act 1986;
   - Forest Conservation Act 1980 and amended in 1988;
   - Public Liability Insurance Act 1991;
   - Environment Assessment Development of Projects, 1994;
   - The Ministry of Environment and Forest is the nodal agency in the administrative structure of the central government for planning promotion

and coordination and overseeing the implementation of environment legislation and programs and regulatory functions like environment clearance.

- Ground water rights:
- Groundwater rights are under totally private legal regime. These rights belong to the land owner, since it forms part of the dominant heritage and land ownership is governed by the tenancy laws of the state.
- There is no limit to the volume of ground water a landowner may draw.
- Few attempts have been made at the state level.
- In Gujarat, groundwater rules have been reframed by amending the Bombay irrigation Act.
- Tamil Nadu water Board had framed certain model water Bills.
- These attempts have proved inadequate for the larger private and common property legal regimes, nor do they take into account the ecological and social diversities in which the laws needs to operate.
- The need for conjunctive use and integration of groundwater and surface water laws have also been conveniently ignored by the state governments.

Constitutional provisions for water:

- The constitution defines the allocation of functions relating to water resource development between the centre and state governments.
- Water is designated as a state subject to the central intervention for coordination and facilitation.
- Entry 17 List II i.e. State List 7th Schedule of the Constitution States “water that is to say water supplies, irrigation and canal, drainage and embankments, water storage and water power subject to the provisions of entry 56 to the List I”. States are thus free to enact the water law and frame policies in accordance with this provision.
- Entry 56 of List I (Union List) refers to above states “regulation and development of interstate rivers and river valleys to the extent to which such regulation and development under the control of the union, is declared by parliament by law to be expedient in the public interest.” (The River Boards Act and the Interstate Water Disputes Act). The central government can also intervene in the interest of protecting environment and forest , and under provisions regarding national planning for development.
- Under Article 262 of the Constitution, Parliament may by law
- Provide for the adjudication on any dispute or complaint with respect to the use, distribution or control of the waters of, or in, any interstate river or river valley.” and
- Neither the Supreme Court or any other Court shall exercise jurisdiction in respect of any dispute or complaint referred to in (1)

b. DEFICIENCIES IN THE EXISTING LEGAL FRAMEWORK:

- Absence of the Uniform Water Law:
  Constitutionally water is a state subject. In the absence of uniform law and policy, water management in India remains by and large uncoordinated. Various states have varied legal positions on water ownership. Water is a natural heritage to be protected and not a commercial property for absolute private use and exploitation, it has to be governed by different set of laws which meet the requirement of the contemporary society.
- Laws concerning water have grown in a piecemeal and ad hoc manner without a clearly articulated conceptual basis in respect to fundamental, as the nature and content of water.
- There are serious questions in relation to the state's authority in regulating the use of water and the manner in which this authority is to be exercised. Governments, both central and state, claim the right of eminent domain over water and absolute right. Where and how it is to be developed and how it is to be managed and to make and change entitlements and allocation is at their discretion. Vesting eminent domain in the sate without setting any limits to the exercise of its discretionary power leaves too much room for arbitrariness.
- Since the state is supposed to serve the interest of its citizenry, the regulatory functions regarding development and management of the resource should be vested with the bodies independent of the executive agencies. Making and changing rules of allocation and entitlement should be decided through a transparent process.
- Another lacuna is the lack of clearly defined criteria for determining the entitlements of different claimants to the common pool resources in a river basin. Thus, central legislation does not specify the basis for deciding the entitlement of riparian states. In India there is no formal recognition of any principle (for instance, Dublin or Harmone principles for international waters) even in respect of interstate rivers. Tribunals have tended to use a combination of these two principles.

8.

a. Salient features of National water policy:
   1.Emphasize on the need for a national water framework law, comprehensive legislation for optimum development of inter-state rivers and river valleys, amendment of Irrigation Acts, Indian Easements Act, 1882, etc.

   2. Water, after meeting the pre-emptive needs for safe drinking water and sanitation, achieving food security, supporting poor people dependent on agriculture for their livelihood and high priority allocation for minimum eco-system needs, be treated as economic good so as to promote its conservation and efficient use.

3. A portion of river flows should be kept aside to meet ecological needs ensuring that the proportional low and high flow releases correspond in time closely to the natural flow regime.

4. Adaptation strategies in view of climate change for designing and management of water resources structures and review of acceptability criteria has been emphasized.
5. A system to evolve benchmarks for water uses for different purposes, i.e., water footprints, and water auditing be developed to ensure efficient use of water. Project financing has been suggested as a tool to incentivize efficient & economic use of water.

6. Setting up of Water Regulatory Authority has been recommended. Incentivization of recycle and re-use has been recommended

7. Water Users Associations should be given statutory powers to collect and retain a portion of water charges, manage the volumetric quantum of water allotted to them and maintain the distribution system in their jurisdiction.

8. Removal of large disparity in stipulations for water supply in urban areas and in rural areas has been recommended.

9. Water resources projects and services should be managed with community participation.

10. Adequate grants to the States to update technology, design practices, planning and management practices, preparation of annual water balances and accounts for the site and basin, preparation of hydrologic balances for water systems, and benchmarking and performance evaluation.

b. Community involvement in irrigation management is generally implemented through the formation and operation of Water User Associations (WUAs). WUAs comprise all farmers sharing water from the same source (tertiary canal or groundwater). They are responsible for managing and maintaining the irrigation and drainage system at their level. They also contribute to higher level irrigation and water resources management.
As member needs differ from one association to another, a WUA is normally established in response to aspirations of its members. WUAs are created through state level legislation in many Indian states to manage canals and irrigation. The WUAs form managing committees for attending day to day functioning through voting of WUA members.

Scope:
1. With greater participation of the farmers, the investments in the canal infrastructure and other irrigated agriculture related services will be need based and hence more effective
2. Optimal use of water and land resources will lead to better agricultural productivity and raised income levels of the farmers
Functions:
1. Irrigation structure development and maintenance
2. Efficient and equitable water supply and distribution to members
3. Coordinate in recovering irrigation water rates from beneficiary farmers
4. Contribute to irrigation modernisation
5. Protection of ecological and environmental balance
6. Handle disputes internally
WUAs in the long run shall be autonomous, cost-efficient, financially self-sufficient, transparent, well-managed, accountable, and user oriented to deliver efficient and reliable services.

9.

a. Rain water harvesting (RWH) is a technique of collection and storage of rainwater into natural reservoirs or tanks, or the infiltration of surface water into subsurface aquifers (before it is lost as surface runoff).
   Objectives of Rainwater Harvesting:
   - To meet the increasing demand of water.
   - To reduce the run-off which chokes the drains.
   - To avoid the flooding of roads.
   - To raise the underground water table.
   - To reduce ground water pollution.
   - To reduce soils erosion.
   - Supplement domestic water needs.
b. Different types of lining done to control seepage in ponds:
   - Clay: Areas dominated by coarse grained materials and lacking sufficient amounts of clay to prevent seepage can be sealed by adding material containing at least 20% clay.
   - Bentonite: Bentonite is a fine-textured colloidal clay that will absorb several times its own weight of water. When Bentonite is mixed with coarse grained materials, then thoroughly compacted and saturated, it will fill pores in the material and make it virtually impervious.
   - Flexible Membranes (geomembranes): Flexible membranes include polyethylene, PVC, vinyl, and butyl rubber. Although structurally weak, these materials are water-tight if kept from puncture and properly sealed.
   - Vinyl: more resistant to damage from impact than other flexible membranes, and is easily sealed and patched with a solvent cement.

    - Polyethylene: sealed or patched by heat sealing.
    - Butyl rubber: joined and patched with rubber cement.
    - Chemical Treatment: The two types of chemical treatment discussed below can be used to line ponds if the specific products selected are chemically stable (i.e. are not leached into the water column) once they are applied.
    - Dispersing Agents. Dispersing agents are used to "seal" the porous holes that form between fine-grained clay particles. To be effective, the soils in the pond area should contain more than 50% of the fine-grained material (silt and clay finer than .074 mm diameter) and at least 15% of clay finer than .002 mm diameter). Soils should contain less than 0.5% soluble salts based on dry soil weight.
    - Cationic Emulsion. In order to use cationic emulsion, the top 2 inches of soil should be sandy, very fine through very coarse, or loamy sands and sandy loams.

10.

a. 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. It is constructed in highly weathered and fractured rocks. Which helps in recharging aquifers around 1km downstream. 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 Strange's Table. (ii) The design of the dam is to be done on the basis of:
    - 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;
    - details of the cut-off trench, to reduce seepage losses;
    - height of stone pitching on the upstream slope to avoid erosion due to ripple action and on the down stream slope from rain by suitable turfing;
    - upstream and downstream slopes to be moderate so that shear stress is not induced in the foundation beyond a permissible limit; and
    - stability of the dam.

(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,Ryves or Dicken's formula may be used based on the

observed or design discharge and catchment areas. 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.

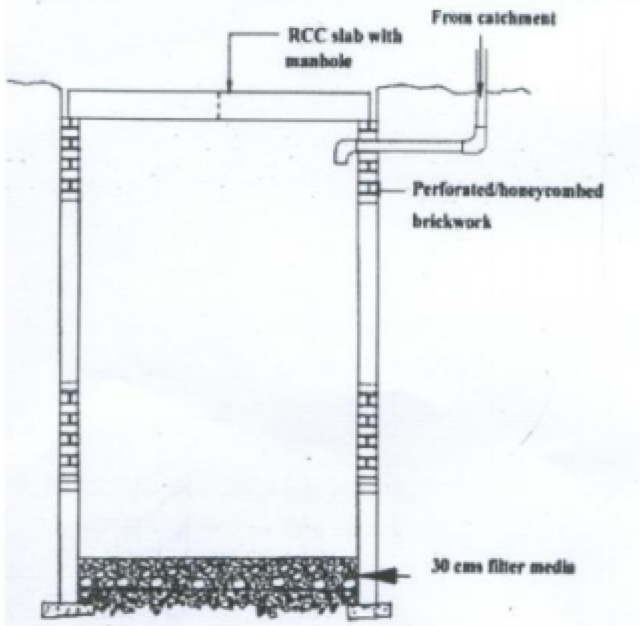
(v) The percolation tanks in a watershed may not have enough catchment discharge though a high capacity tank is possible as per site conditions. In such situations stream from nearby watershed can be diverted with some additional cost and the tank can be made more efficient.

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

   <u>Recharge pit</u> –
   - To recharge shallow aquifers.
   - Used in alluvial areas, where permeable rocks are at shallow depth, this technique is used.
   - Recharge pits are 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 also provided at the roof to avoid leaves/debris etc.

   <u>Recharge Trench</u>-
   - Suitable for permeable strata having shallow depths
   - Suitable for buildings having roof area of 200- 300 square meter
   - Trenches to be backfilled with boulders at bottom , gravel in between and graded course sand at top
   - Top sand layer to be periodically cleaned
   - Bypass arrangement to be provided before collection chamber to reject water of first shower.

   <u>Tube well</u>-
   - 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 divided into 3 chambers - Chamber 1 filled with gravels(6- 10mm), middle one with pebbles(12-20mm) and last one with stones 20-40mm



Typical recharge pit

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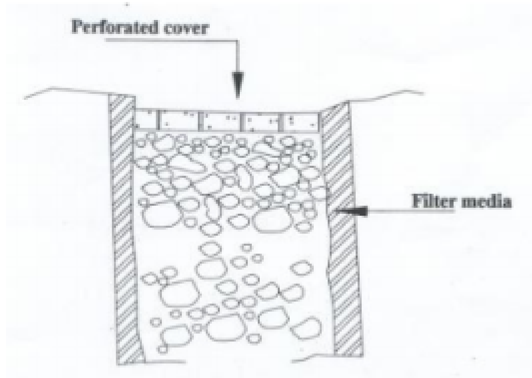

Recharge Trenches

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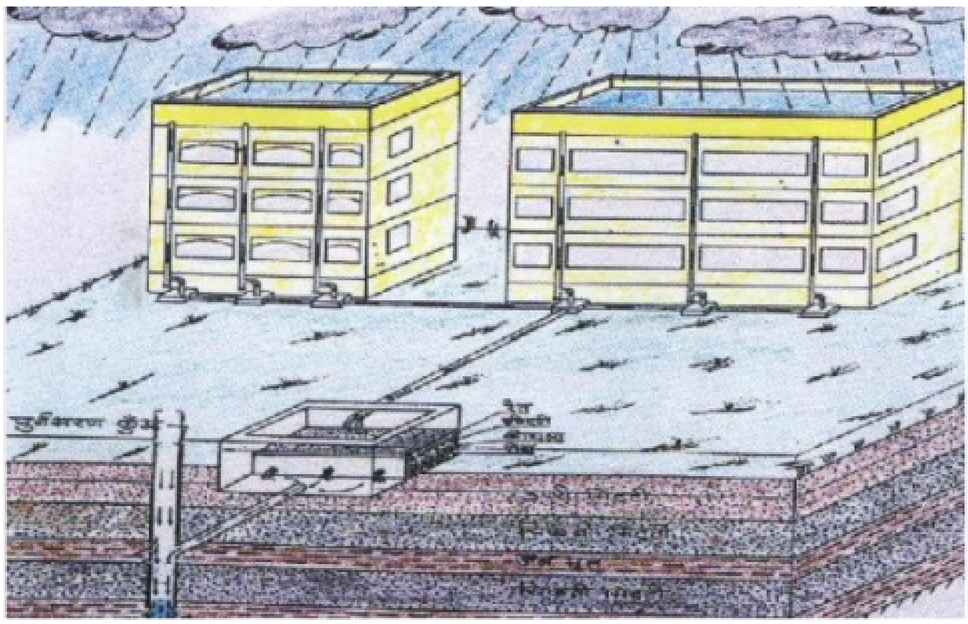

(tube well)