Scheme and Solution

IAT1 – WRM (Water Resources Management)-10CV661

Part A

1. What is meant by a renewable water resource? Explain briefly.

Renewable water resource is defined as the average annual flow of rivers and recharge of aquifers generated from precipitation. It is computed on the basis of the water cycle. They represent the long-term average annual flow of rivers (surface water) and groundwater.(2M)

Renewable Water Resource	
Natural	Actual
a. 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. b. The amount is computed on a yearly basis.	a. 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. b. Vary with time and consumption patterns and, therefore, must be associated to a specific year.

(3M)

2. Explain the necessity of water resources planning and management?

a. Water, although plentiful, is not distributed as we might wish. There is often too much or too little, or what exists is too polluted or too expensive. A further problem is that the overall water situation is likely to further deteriorate as a result of global changes (climatic change, population growth, land use changes, urbanization and migration from rural to urban areas). (1M)

b. Water has its own dynamics that are fairly non-linear. For example, while population growth in the twentieth century increased three-fold – from 1.8 billion to 6 billion people – water withdrawal during the same period increased six-fold! That is clearly unsustainable. (1M)

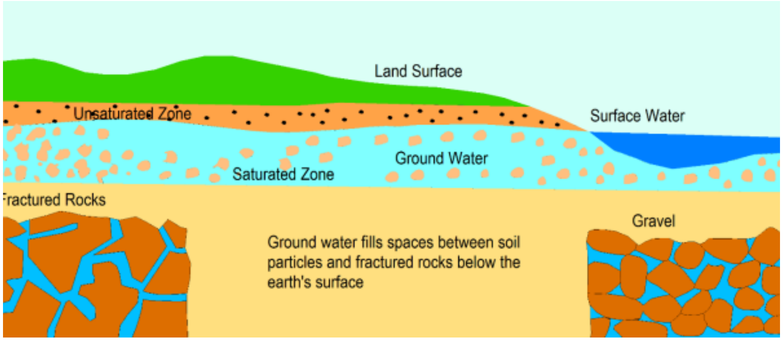
c. Human activities tend to be based on the 'usual or normal' range of river flow conditions. Rare or 'extreme' flow or water quality conditions outside these normal ranges will disrupt the efficiency of riparian activities. River-dependent, human activities that cannot adjust to these occasional extreme conditions will incur losses. (1M)

d. Problems and opportunities change over time. Planning processes evolve not only to meet new demands, expectations and objectives, but also in response to new perceptions of how to plan more effectively. (1M)

e. Planning and management of W.R. is needed to find out: (1M)
How can the renewable yet finite resource be best managed?
How to achieve this in an environment of "uncertain supplies",

3. Briefly explain how ground water acts as a storage medium.

Ground water is the water that seeps through rocks and soil and is stored below the ground. The rocks in which ground water is stored are called aquifers. Aquifers are typically made up of gravel, sand, sandstone or limestone. Water moves through these rocks because they have large connected spaces that make them permeable. Just below the surface the pores of soil will be filled with air and water known as the unsaturated zone. The area where water fills all the pores in the aquifer is called the saturated zone. The depth from the surface at which saturated zone of aquifer exists is called the water table. The water table can be as shallow as a foot below the ground or it can be a few hundred meters deep. (1M)



(1M)

Thus the following properties of aquifer decide its water storage and yielding capacity.

Porosity – The amount of pore space per unit volume of aquifer material is called porosity. Aquifers with porosity greater than 20% are considered large and less than 5% as small.(1.5M)

Specific yield –While porosity gives a measure of water storage capability of formation, not all water available in pores is not available for extraction by pumping or gravity. It depends on permeability of aquifers. The pores hold back some water by molecular attraction and surface tension. Thus actual volume of water that can be extracted from unit volume of aquifer material is known as specific yield of aquifer. (1.5M)

Thus depending upon the above properties of an underground formation in an area the ground water availability will also vary.

4. Write a note on water resources planning scales.

Spatial scale: (1M)

To maximize the economic and social benefits obtained from the entire basin, and to ensure that these benefits and accompanying costs are equitably distributed, planning and management is often undertaken on a basin scale. While basin boundaries make sense from a hydrological point of view, they may be inadequate for addressing particular water resources problems that are caused by events taking place outside the basin. the physically based 'river basin' focus of planning and management should be expanded to include the entire applicable 'problem-shed'. (1.5M)

Temporal scale: (1M)

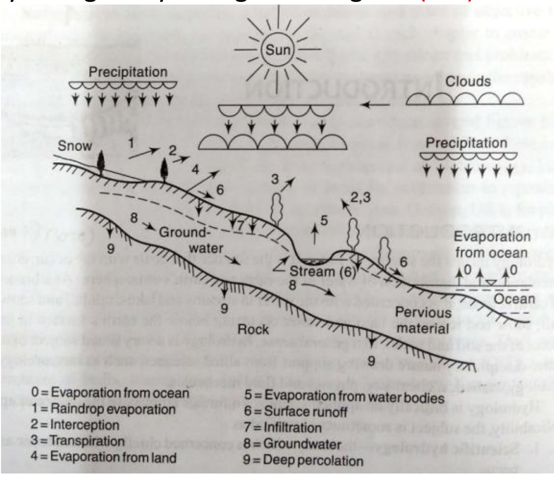
Water resources' planning requires looking into the future. The question of just how far into the future one need look, and try to forecast, is directly dependent on the influence that future forecast has on the present decisions. Planning is a continuing sequential process.

Water resources plans need to be periodically updated and adapted to new information, new objectives, and updated forecasts of future supplies, demands, costs and benefits. (1.5M)

5. **Explain hydrological cycle with a neat sketch.**

Water can occur in three physical phases: solid, liquid, and gas and is found in nature in all these phases in large quantities. Depending upon the environment of the place of occurrence, water can quickly change its phase.

Hydrologic cycle is defined as "the pathway of water as it moves in its various phases to the atmosphere, to the earth, over and through the land, to the ocean and back to the atmosphere". This cycle has no beginning or end and water is present in all the three states. A pictorial view of the hydrological cycle is given in figure. (1M)



(2M)

The major components of the hydrologic cycle are precipitation (rainfall, snowfall, hale, sleet, fog, dew, drizzle, etc.), interception, evaporation, transpiration, infiltration, percolation, and runoff (surface runoff, interflow, and baseflow).

Evaporation – Water in the oceans evaporate due to solar heat energy and forms clouds. Much of the clouds condense and fall back to oceans while a part is driven to land by clouds.

Precipitation – The clouds condense and precipitate on to land mass.

Interception – A part of precipitation is intercepted by vegetation, structures and other surface modifications. A portion of it might fall to earth and a portion gets evaporated.

Transpiration – Process by which vegetation sends a portion of water back to atmosphere.

Infiltration – A portion of water reaching ground surface enters soil and enhance moisture it called infiltration.

Percolation - Rainfall seeps underground through a process called percolation, where water travels downwards through the tiny spaces between rocks and soil particles. The water eventually saturates the underlying rock to form underground water.

Runoff – The portion of precipitation which by variety of paths above and below the surface of the earth reaches the stream. It can be surface flow, interflow or base flow. (2M)

Part B

3(a). In a month a lake received an average infiltration of 8m3/s from surface runoff sources. Outflow from the basin is 8.5m3/s. The basin receives an average rainfall of 150mm and incurs an evaporation loss of 6.1 cm from Lake Surface. The lake surface area is 5000 Ha. Calculate the increase in water level in lake over a period of one month.

Water Balance equation **– 2 M**

Net inflow – **2 M**
Net outflow- **2 M**
Increase in water level **– 1M**

1.) Inflow = $8 m^3/s$
Outflow = $8.5 m^3/s$
P = 150 mm
E = 6.1 cm
A = 5000 Ha

Increase in water level over one month period?

Water Balance equation

Net Inflow – Net outflow = change in storage

Net Inflow = $8 m^3/s$ + Flow due to 150mm precipitation

$$= 8 + \frac{(150 \times 10^{-3} m) \times (5000 \times 10^4) m^2}{30 \times 60 \times 60 \times 24 \ s} \quad \left[\frac{P \times A}{t}\right]$$

$$= 10.89 m^3/s$$

Net outflow = 8.5 + Outflow due to 6.1cm evap

$$= 8.5 + \frac{0.061 \times 5000 \times 10^4}{(30 \times 24 \times 60^2)}$$

$$= 9.68 m^3/s$$

∴ Change in storage = Net inflow – Net outflow

$$= 10.89 - 9.68$$

$$= 1.21 m^3/s$$

∴ Ise in water level = $\frac{\text{Ise in discharge} \times \text{time}}{\text{Area}}$

$$= \frac{1.21 \times 30 \times 24 \times 60^2}{5000 \times 10^4}$$

$$= 0.0627 m$$

$$= 62.7 mm$$

3. (b) Explain Dublin's principles.

1. Water is a finite, vulnerable and essential resource, essential to sustain life, development and the environment.
2. Water resources development and management should be based on a participatory approach, involving users, planners and policy makers at all levels.
3. Women play a central role 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.

4 principles – 4M

Explaination -4 M

4 (a). Describe a typical analytical framework for water resources studies.

- The analytical framework that is used by Delft Hydraulics for WRM studies is depicted in the following figure. The three elementary phases of that framework are:
  - inception

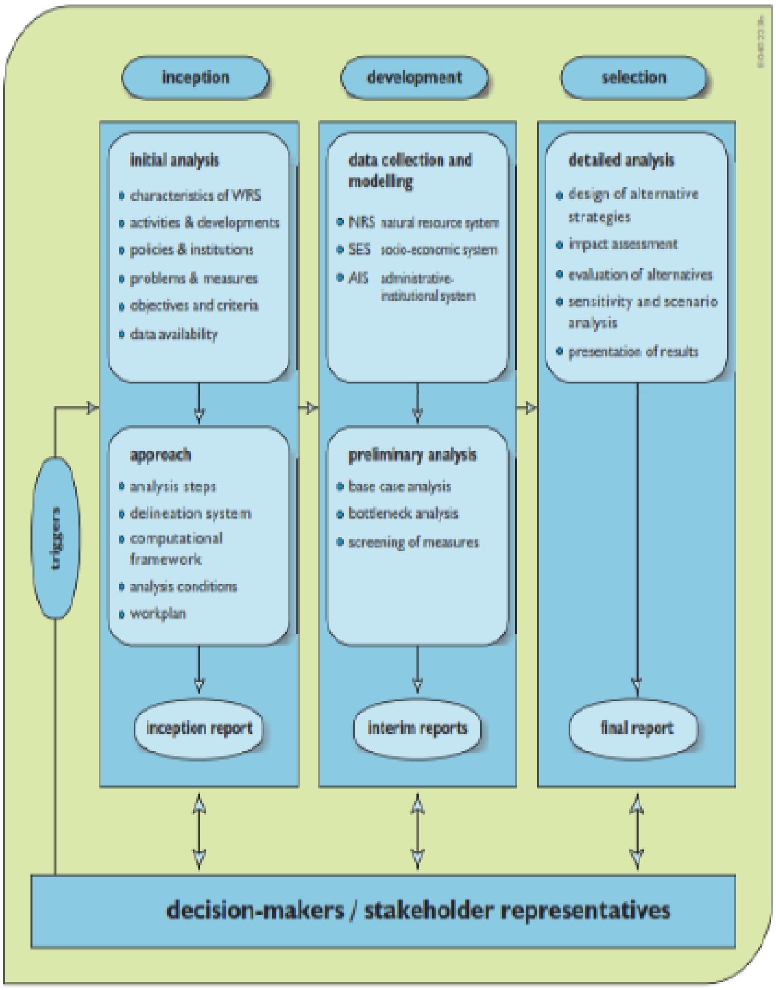
- development
- selection.

➢ During each phase the processes have a cyclic component (comprehensive cycle). Interaction with the decision-makers, or their representatives, is essential throughout the process. Regular reporting through inception and interim reports will improve the effectiveness of the communication.

➢ The first phase of the process is the **inception phase**. Here the subject of the analysis (what is analysed under what conditions) and its object (the desired results of the analysis) are specified. Based on this initial analysis, 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 (project). (2M)

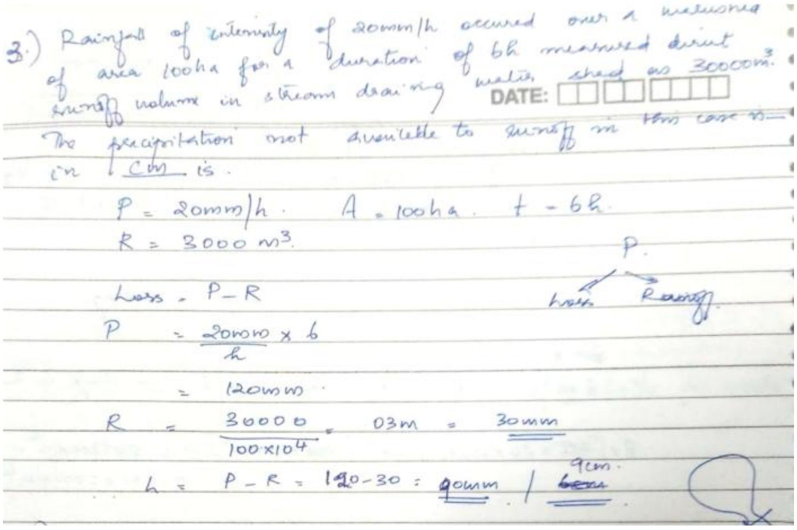
➢ In the **development phase** tools are developed for analysing and identifying possible solutions to the WRM problems. The main block of activities is usually related to data collection and modeling. Various preliminary analyses will be made to ensure that the tools developed for the purpose are appropriate for solving the WRM problems.(2M)

➢ 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. (2M)



4M

4 (b) Rainfall of intensity of 20mm/h occurred over a watershed of area 100 Ha duration of 6 hours measured direct runoff volume in stream draining water shed as 3000 m^3. The precipitation not available to runoff in this case is…



3.) Rainfall of intensity of 20mm/h occurred over a watershed of area 100ha for a duration of 6h measured direct runoff volume in stream draining water shed as 3000 m^3. The precipitation not available to runoff in this case in cm is.

$P = 20mm/h$. $A = 100ha$. $t = 6h$.

$R = 3000 m^3$.

Loss = P − R

$P = \frac{20mm}{h} \times 6$

$= 120mm$.

$R = \frac{3000}{100 \times 10^4} = 03m = 30mm$

$L = P - R = 120 - 30 = 90mm$ / 9cm.

P -1M; R – 2M; L -2M;

5 (a) Briefly explain the effect of human activities on water balance.

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).

1. Land Use Changes **(2M)**

Decline in vegetative cover and shift from forest cover to crops, increases the surface runoff in the stream. Increasing stream flow will be useful for human activities but it raises water resources issues such as the frequency of flood and drought events in the future. Destruction of forest cover also reduces evapo transpiration and will reduce local precipitation. Urbanization and increase in industries will have a negative impact on water quality and quantity.

2. Dams **(2M)**

Major change taking place is that the water in reservoir area is becoming stagnant from running. More evaporation losses will happen and can also bring in ecological challenges. Reservoir sedimentation takes place affecting water quality. The creation of a large body of water as a result of reservoir filling leads to changes in the microclimate of the storage lake area. Flood attenuation due to dam has a major impact on flow variability downstream and rivers tend to narrow if major tributaries do not help to restore the flow and sediment balance downstream.

3. Climate change **(2M)**

Intensive rainfall due to climate changes leads to higher peaks of discharge in the rainy season. This results in a decline of water availability and less groundwater recharge. Under such climatic conditions the sediment load also increases, affecting the water quality.

4. Withdrawals, Diversions **(2M)**

Excess diversion and withdrawal of water during low flood season will have serious effect on the ecosystem in the area. Excessive withdrawal will also affect the natural water balance of the area.

5 (b). A catchment has 3 subareas. The annual precipitation and evaporation from each of the subareas is given below. Determine the annual average values of precipitation and evaporation. Also determine runoff coefficients of sub areas and catchment as a whole.

Sub Area	**Area (Mm^2)**	**Annual Precipitation (mm)**	**Annual Evaporation (mm)**
A	10.7	1030	530
B	3	830	438
C	8.2	900	430

Net precipitation = Total volume of rainfall/ total area

= **953.9269 mm** **(1M)**

Net evaporation = Total volume of evaporation/ total area

= **479.9543 mm** **(1M)**

Net runoff = Net precipitation – Net evaporation = **473.9726 mm** **(1M)**

Runoff coefficient as whole = Net runoff/net precipitation= **0.496865mm** **(2M)**

Sub Area	**Area (Mm^2)**	**Runoff**	**Run off coe**
A	**10.7**	**5350**	**0.4854369**
B	**3**	**1176**	**0.4722892**
C	**8.2**	**3854**	**0.5222222**

(2M)