

WATER RESOURCES

Resources

- They are the means to fulfil economic and other needs of people

1) There are two types of resources:- Natural or Physical

- They are unchanged by man (physical form)
- Examples are sunlight, water, minerals, etc.

2) Human or Economic

- Developed by man for own benefit
- Examples are:- skilled labour, machinery and capital, etc (man)

3) Natural

- There are two types of natural resources:-
 - Renewable
 - They can be reused
 - Examples are sunlight, wind, water, forests, fish, etc.
 - Non-renewable
 - They cannot be reused
 - Examples are fossil fuels and other minerals

So water is a renewable natural resource

Water

- Salty (covers 97% of Earth's surface)
- Fresh water (covers 3% of which 70% is snow and 10% is surface water and 20% is ground water).
- So 1% is used by humans

Water Cycle

Importance of rivers

- They provide alluvium to increase the fertility of soil
- They promote tourism due to their scenic beauty
- They are a source of fishing as most fishermen catch fish in rivers due to more quantity and variety
- Domestic uses of water are washing
- Industrial uses of water are processing
- Used in irrigation i.e artificial supply of water to canals in agriculture
- Source of producing HEP

River systems of Pakistan

- Indus River System
 - River Indus and its tributaries
 - Eastern tributaries
 - Western tributaries
 - Eastern places :- Sutlej, Beas, Jhelum, Ravi, Chenab
 - Western places :- Swat, Kabul, Gomal, Kurram, Tochi, Zhob

River Discharge

- It is the amount of water passing through a specific point of a river or a stream at a specific time. It is mostly measured in cusecs (cubic feet per second) or cumecs (cubic metre per second)
- Discharge of River Indus is very high in June / July because:-
 - Large glaciers of Karakoram and Hindu Kush melt in summer and provide water to Indus.
 - Water from monsoon rainfall
- Water of this river is given to Pakistan as per Indus water treaty... so India does not use its water.
- It has a lot of tributaries which contribute to Indus like Chenab and Kurram
- Lowest discharge is of Ravi because..
 - The water of this river is being used by India as per Indus Water Treaty.

Rivers of Balochistan characteristics

- Less water

- Small rivers
- Inland rivers
- Temporary / seasonal
- Thus, not suitable for irrigation / HEP production / for barrages, because of less water.

Uses of Water

Domestic

- Cooking
- Drinking
- Sanitation
- Washing

Industrial

- Iron and steel – to cool down furnaces.
- Chemical – to dilute / make acids e.g. Sulphuric acid or for solutions
- Pharmaceutical – Injections, syrups
- Textile – washing, dyeing, humidity
- Tanning (lether) – washing, dyeing
- Food processing – juices, squashes, beverages
- Mineral water – water is the main raw material

Agriculture

- Irrigation (artificial supply of water to plants / crops for better output / growth)

Q: Why is irrigation important to Pakistan?

- Insufficient rainfall
- Unreliable rainfall
- High rate of evaporation due to intense heat
- Long dry spells
- Monsoon rainfall comes in heavy showers so quick surface run-off
- Other factors favor agriculture e.g. Flat land / alluvial soil of Upper Indus Plain and Lower Indus Plain

Factors affecting canal construction

- Soft soil of plains therefore easy to dig canals
- Flat land of Upper Indus Plain and Lower Indus Plain for easy construction / better use of machinery
- Large pool of unskilled labour due to high population. Therefore cheap labour is available for construction
- Availability of cement makes the construction of lined canal easier.
- Natural slope of water from north to south makes it easy to construct canals as water smoothly flows into canals.

Ground Water

- Water which is below the surface of the earth is called ground water.

Water table

- The upper most layer of underground water is called water table
- Importance: Ground water is especially suitable in those areas where water is not available / available in less amount e.g. Karachi.
- Problems: Contamination of water by toxic elements through poor disposal of domestic and industrial waste.
- Solutions :-
 - Must be used after laboratory test
 - Water treatment plants
 - Water should be used after boiling
- Source of ground water :-
 - Persian wheel

- Boring wells
- Tube wells

Indus Water Treaty

- It was signed in 1960
- It is a treaty between Pakistan and India (with the help of the UN) on water distribution of different rivers.
- Pakistan was given authority of three rivers (Indus, Chenab and Jhelum) while India uses water of 3 eastern rivers (Beas, Sutlej and Ravi).
- New Zealand, Canada, Australia, UK, India provided financial assistance to Pakistan for construction of barrages, dams and link canals.

Q: Why was Indus Water Treaty necessary?

- Punjab was divided between Pakistan and India in 1947
- The headworks of many rivers of Pakistan were in India e.g. Ravi at Madhupur, Sutlej at Firozpur.
- Pakistan needed water of these rivers for irrigation because:-
 - Rainfall in Pakistan is insufficient
 - Rainfall in Pakistan is unreliable
 - Increasing population means more need of food.
- Could only be provided from irrigated lands.
- India stopped water of these rivers in 1948 ... this threatened Pakistan's agro-based economy.
- Pakistan had to purchase water from India.
- A permanent solution was essential to save Pakistan from Indian exploitation

Dams and Barrages

- They are the barriers that are built across the cross-section of a river or a stream to hold back water for specific purposes e.g. Irrigation

Dams

Large

- Mangla on River Jhelum
- Tarbela on River Indus
- Warsak on River Kabul

Small

- Khanpur on Haro River
- Rawal on Kurrang River
- Hab on Hab River
- Nari – bolan on Bolan river

Comparison between large and small dams

- Both are used for irrigation, flood control, fishing
- Both are used for recreational purposes
- Both are used for the production of HEP
- Large dams are more multi-purpose than small dams
- Large dams irrigate larger area than small dams e.g. Warsak dam irrigates 48,000 hectares of land while Rawal dam irrigates only 5,000 hectares
- Large dams produce large amount of HEP while small dams either produce small amount of electricity or no electricity
- Large dams are more expensive to build and maintain
- Large dams are more time consuming to build
- More people are resettled at large dams as compared to small dams.

Barrages

- Guddu (River Indus)
- Taunsa (River Indus)
- Rasul (River Jhelum)
- Jinnah (River Indus)
- Kotri (River Indus)

- Chasma (River Indus)

Comparison between dams and barrages

- Barrages are longer than dams
- Dams are higher than barrages
- No electricity is produced through barrages because barrages are built on flat area while large/small dams produce electricity when built on slopes
- Both are used for flood control, recreation, irrigation and fishing

Main purpose of a barrage

- It is used for irrigating fields through canals

Q: How is this purpose achieved?

- Gates are closed
- Water is held back in a barrage
- Link canals take water and distribute it into a network of smaller canals
- Link canals take away water from western rivers to eastern rivers to compensate water lost to India from Eastern rivers

Q: Explain the changes brought by the construction of barrages in Lower Indus Plain

- More area for agriculture due to irrigation facilities
- More crops e.g. Wheat, rice, pulses, bananas are grown therefore agricultural yield increased
- It led to more settlement in Lower Indus Plain
- However, due to poor farming practices, the water was overused by the farmers which led to water logging and salinity.

Link canal examples

- Rasul to Qadirabad
- Qadirabad to Balloki
- Balloki to Sulaimanki I
- Balloki to Sulaimanki II

Q: Name a link canal and explain its purpose

- Rasul to Qadirabad
- Rasul – Qadirabad takes water from Rasul to Qadirabad
- They take water from western rivers to eastern rivers
- They compensate the water lost to India from eastern rivers
- They provide water for irrigation through perennial canals

Methods of irrigation

- Traditional
 - Charsa
 - Persian wheel
 - Karez
 - Inundation canals
- Modern
 - Perennial canals
 - Tubewells
 - Sprinklers

Traditional methods

Charsa

- It is a well from which water is pulled out with the help of animal power
- It is 7 – 10 metres deep
- It can dry up easily when its water table goes down
- Less water is available for irrigation
- Less important due to more use of modern methods
- Government is less interested as it prefers modern methods
- However, it is relatively cheaper to build and maintain due to its traditional nature
- Less manual power is needed because of the use of animal (pair of bullocks) power

Persian wheel

- Worked by animal or man power
- Uses wooden shaft / pole
- Turns horizontal wheels
- .. which is attached to a vertical wheel
- With buckets to raise water
- Water goes into pipe / channels for irrigation
- It irrigates relatively more land than charsa
- It is cheaper to build and maintain due to its traditional nature
- Less manual power is needed due to the use of animal power
- However, it cannot irrigate large amount of land as compared to modern methods i.e. Tubewells.
- May also dry up when water table goes down.
- Slower than tubewells
- Less important due to more use of modern methods
- Government is less interested as it prefers modern methods

Karez

- It is an old method of irrigation used in Balochistan
- An underground horizontal canal is dug for several kilometres
- It mostly starts from a foothill and comes on the surface which reaches near those fields which it is to irrigate
- Many vertical shafts are also dug down at different points of canal for maintenance and clearing
- This is a better method in very hot and dry areas because:-
 - It reduces evaporation
 - Its supply is constant
- However, it is difficult and costly to construct as it is underground.
- It irrigates far less area than modern methods like tubewells
- It is less important due to use of modern methods
- Government is less interested due to the use of modern methods

Inundation canals

- These are the canals which provide water for irrigation only in rainy or flood seasons (seasonal canals)
- They are unreliable as they are weather dependant
- Also, water cannot be controlled in inundation canals
- They may have no water when there is a need of water.
- Less important due to the use of modern methods
- Government is not interested due to the use of modern methods
- However, they provide ample water for irrigation of kharif crops, if there is enough monsoon rainfall or flooding in river Indus and its tributaries..

Modern methods

Perennial canals

- These canals provide water throughout the year from the reservoirs of a dam or a barrage via link canal.
- They provide water whenever it is needed
- Water can also be controlled in these canals
- They are reliable because they are not weather dependant
- Therefore they are much better than inundation canals
- However, since a lot of water is available in these canals throughout the year, some farmers overuse / misuse it and the water table rises to the surface and causes water logging and salinity.
- Some of them are unlined (Kacha canals) so water seeps into the ground which results in high water table and eventually water logging and salinity is caused.

Tubewells

- These are the wells hundreds of feet deep (up to 300 feet)
- Pipes are inserted into these wells and with the help of either electric motors or diesel engines, water is lifted up.
- These wells have large amount of water due to their great depth, so can irrigate large areas.
- They are also time-saving and fast because electric motors, etc are used to pump out water.
- There are very rare chances of it being dried up because of its great depth so continuous supply of water.
- It reduces water logging and salinity as it lowers the water table and its excessive water is also used to flush out salts from the surface.
- Less labour required due to the use of electricity
- They are eco-friendly (run on solar energy)
- However, it is expensive to install due to modern machinery like pumps
- It is also expensive to maintain as it uses electricity / diesel which is expensive

Sprinklers

- They are mostly placed in the mid of an orchard field or lawn to provide water
- They get water mostly from a public water supply or any other source
- This is effective as it does not cause water logging and salinity
- It is efficient as water is not wasted
- It does not require surface shaping or levelling
- ... And can be applied to areas of variable topography
- Faster and continuous supply of water
- However, it is not suitable for large scale irrigation
- It is expensive to install and maintain
- Lack of technology and experts in Pakistan

Siltation

- Siltation is the accumulation of silt / mud / sand / sediment in a reservoir

Q: How is it caused?

- River erodes material from its bed and sides
- They carry a large load of small sediments when they flow
- This process is assisted by deforestation and soil erosion
- These sediments eventually settle in still water of a reservoir

Problems caused by silting

- It may weaken the foundation of a dam
- It may block pipes
- It may damage dam machinery
- Water capacity of reservoirs may reduce
 - Therefore less production of HEP
 - Also less water for irrigation
- More risks of flood as water can easily overflow due to less capacity
- Water has to be cleaned / silt has to be removed before water is used for drinking
- Removal of silt is expensive and difficult

Solutions

- Silt traps at entrance of reservoirs
- Afforestation on foothill e.g. Terrace farming and through contour ploughing so less soil erosion
- Increase the height of reservoirs to improve their capacity
- If silt has reached canals, de-silt them
- Lined / cemented canals as they are easy to de-silt

Water logging and Salinity

- When water table rises to the surface, it is called water logging. Due to heat this water evaporates and leaves white, salty patches on the surface, called salinity (as ground water contains minerals)

Q: How are they caused?

- Due to unlined canals (Kacha), more seepage of water into ground
- Because of poor management of water / poor farming practices, the farmer's use excessive water from perennial canals which eventually penetrates into the ground and rises the water table to the surface

Problems

- Due to water logging and salinity, land becomes infertile and unsuitable for cultivation
- So reduces cultivable area
- Reduces crop yield
- Reduces income / profit
- Expensive to reclaim land / treat soil
- May increase rural to urban migration

Solutions

- Plant eucalyptus trees because they lower the water table as they absorb a lot of water
- Lined canals to reduce water seepage
- Install tubewells as they lower the water table due to their great depth
 - and they provide ample water to flush out salts from the surface
- Make surface drains to flush out salts
- Culverts should be constructed to drain extra water to a nearby water body like river / stream
- The government has started the project of SCARP (Salinity Control And Reclamation Project)
 - It started in 1959
 - It is supervised by WAPDA
 - Punjab has been divided into 28 zones
 - Tubewells and surface drains have been constructed to lower water table
 - Provide ample water to flush out salts from the surface
 - Not very successful but some areas have been reclaimed

Water pollution

- Dumping of domestic and industrial waste... may contaminate ground water and surface water... if used for drinking may cause cholera, hepatitis, etc.
- Seepage of oil by ships... pollute sea water... threat to aquatic life
- Use of pesticide / insecticides in agriculture ... may contaminate ground water and surface water ... if used for drinking may cause cholera, hepatitis, etc
- Eutrophication :-
 - Fertilizers are often used in farming, sometimes these fertilizers reach a nearby water body through sub soil causing algae to grow.
 - The algae use up all the oxygen in water, leaving none for fish, which need oxygen in water to live
 - The bloom of algae may also block sunlight for aquatic plants

Management of water resources

- Desalination of salty water of oceans / seas will increase fresh water
- Canals must be lined to reduce water seepage (up to 70%)
- Ground water and surface water must be protected from contamination of toxic elements, etc. By strict implementation of environmental laws)
- Programs should be started by NGO's / medical educational institutions to increase awareness about the importance of conservation of water.
- Small dams should be constructed for conserving water. They suit Pakistan's developing economy

Difference between lined and unlined canals

- Lined canals are cemented canals whereas unlined are non-cemented / Kacha canals
- Lined canals are better because:-
 - They reduce water seepage
 - They reduce water logging
 - They are easy to desilt

Q: Why is there not enough water supply from canals to meet the needs of all users?

- Due to siltation which reduces the amount of water present
- Less rainfall
- Quick evaporation due to intense heat
- Water seeps into unlined canals which seeps away
- More demand of water but less is available
- Less river water due to restriction by India
- Water pollution due to domestic and industrial waste
- Lack of investment

Q: How can the amount of water in canals be increased?

- Desilting of canals
- Increase the height of reservoirs
- Lined canals
- Awareness programs by media
- Afforestation / reforestation
- Silt traps to reduce silting
- Education / awareness of water

Q: Why is Pakistan termed as a water deficit country?

- Insufficient rainfall
- Unreliable water
- Growing need of water
 - Due to growing population
 - Due to the growth of industries
 - Green revolution / agriculture

Q: State three problems caused by storage of water in reservoirs and due to its use in agriculture

- Storage of water in reservoirs
- Silting
- People have to resettle
- Less water / less silt available down the stream
- Use in agriculture
- Water logging
- Salinity

Q: using examples, explain why there are conflicts over the water available and its use

- Examples:-
 - Industry VS agriculture VS domestic VS HEP ..
 - India VS Pakistan (background of Indus Water Treaty)
 - NWFP, Punjab VS Sindh
 - Problem due to Kalabagh dam
- Explanation:-
 - Industry needs water for processing, boiling, washing, dyeing, etc.
 - Agriculture needs water for irrigation
 - People need water for drinking, cooking, etc
 - Due to growing population, more need of energy
 - More electricity also required due to technological advancements
 - There are conflicts between different users because there is not enough water
 - Sindh accuses NWFP and Punjab for excessive use of water and in the end less amount available for different purposes like irrigation because NWFP and Punjab are in North to South. As the water flows first to them, they use extra water and thus less water is available in Sindh
 - In Kalabagh dam, there are conflicts between NWFP, Punjab and Sindh as NWFP and Sindh are of the view that the maximum electricity and other advantages of this dam will be enjoyed by Punjab while there are more flood risks / displacements for the people of NWFP and very less water will be available to Sindh.