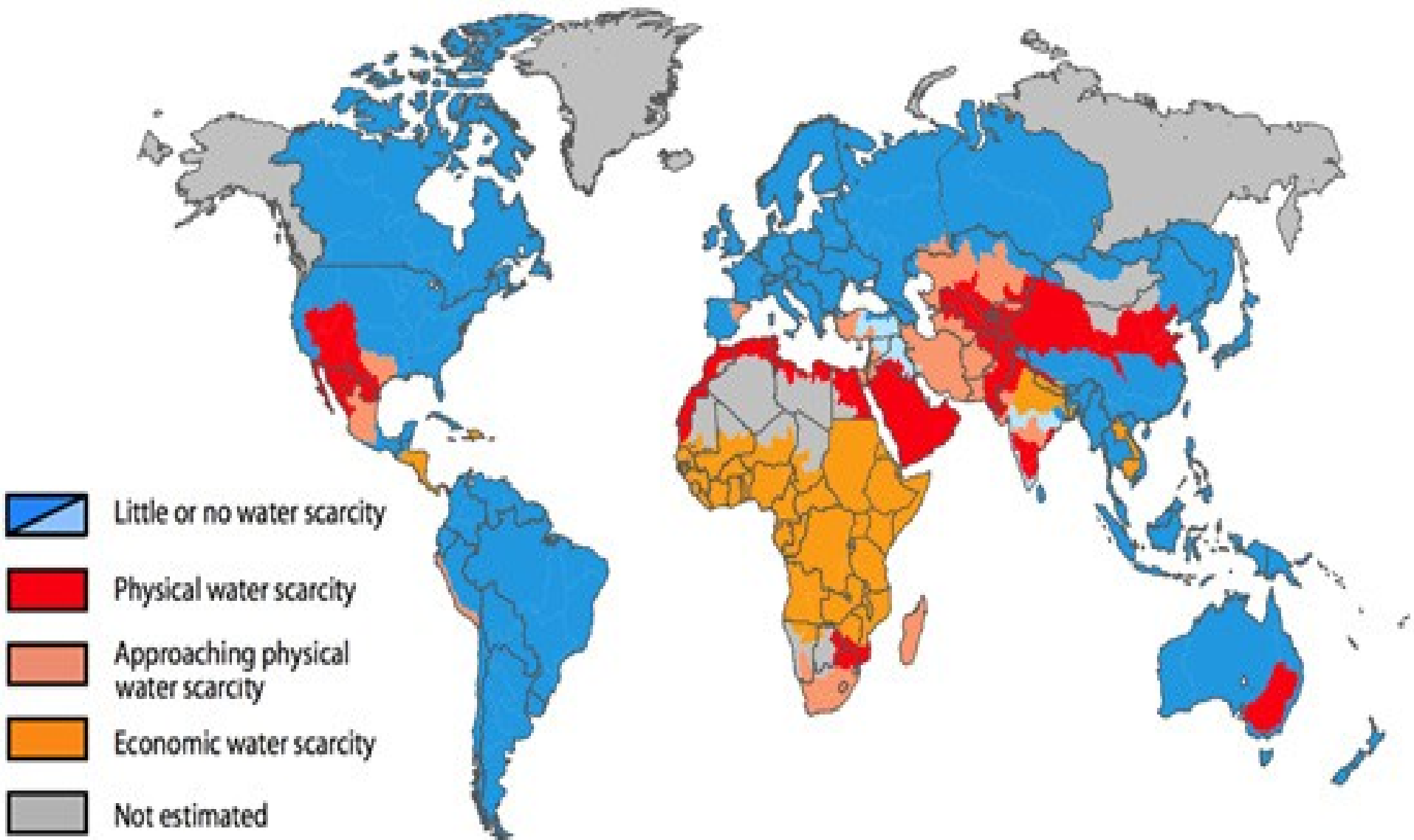


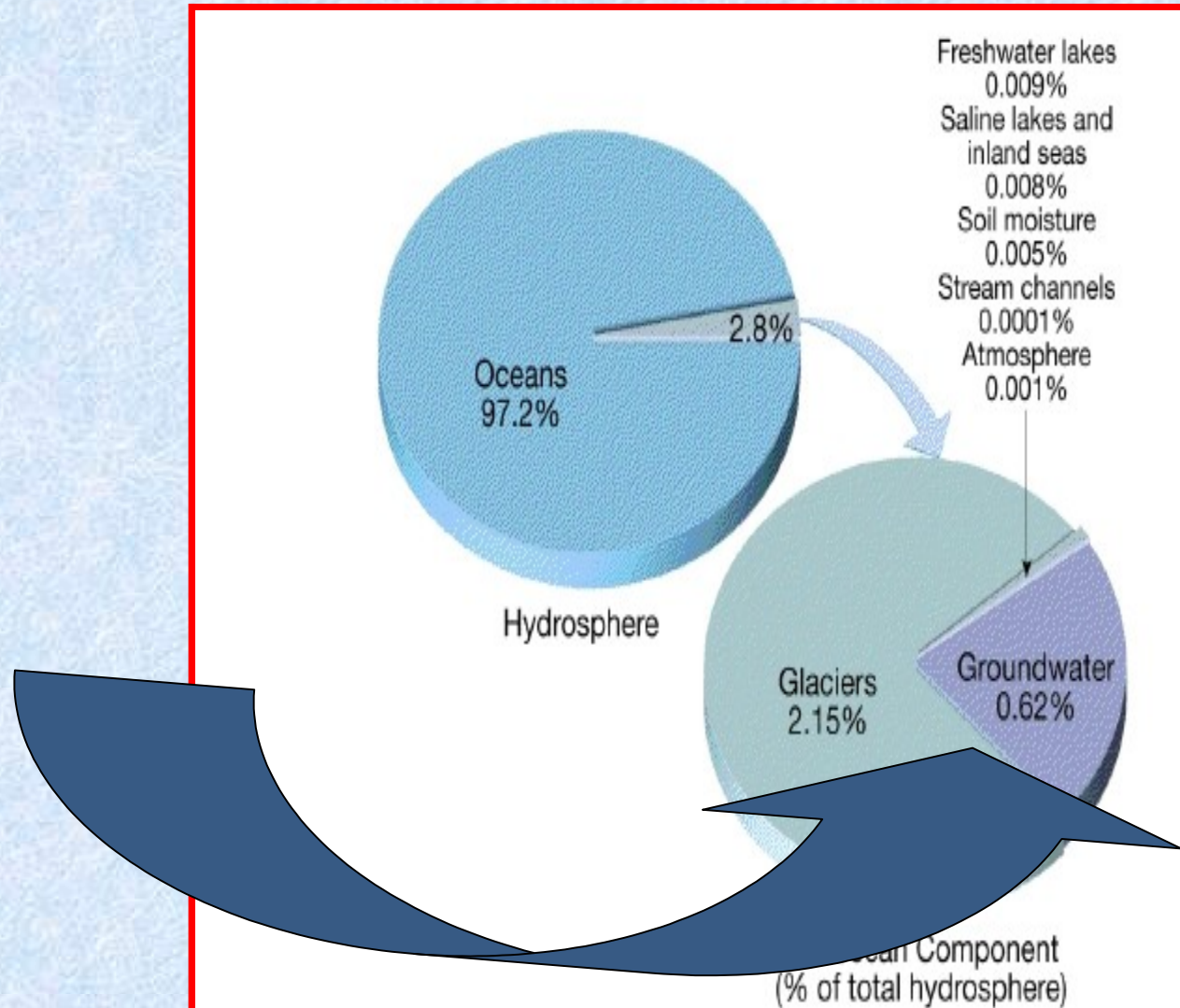
State of groundwater in the coastal cities of Bangladesh and regulatory measures for sustainability

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Global Water Scarcity

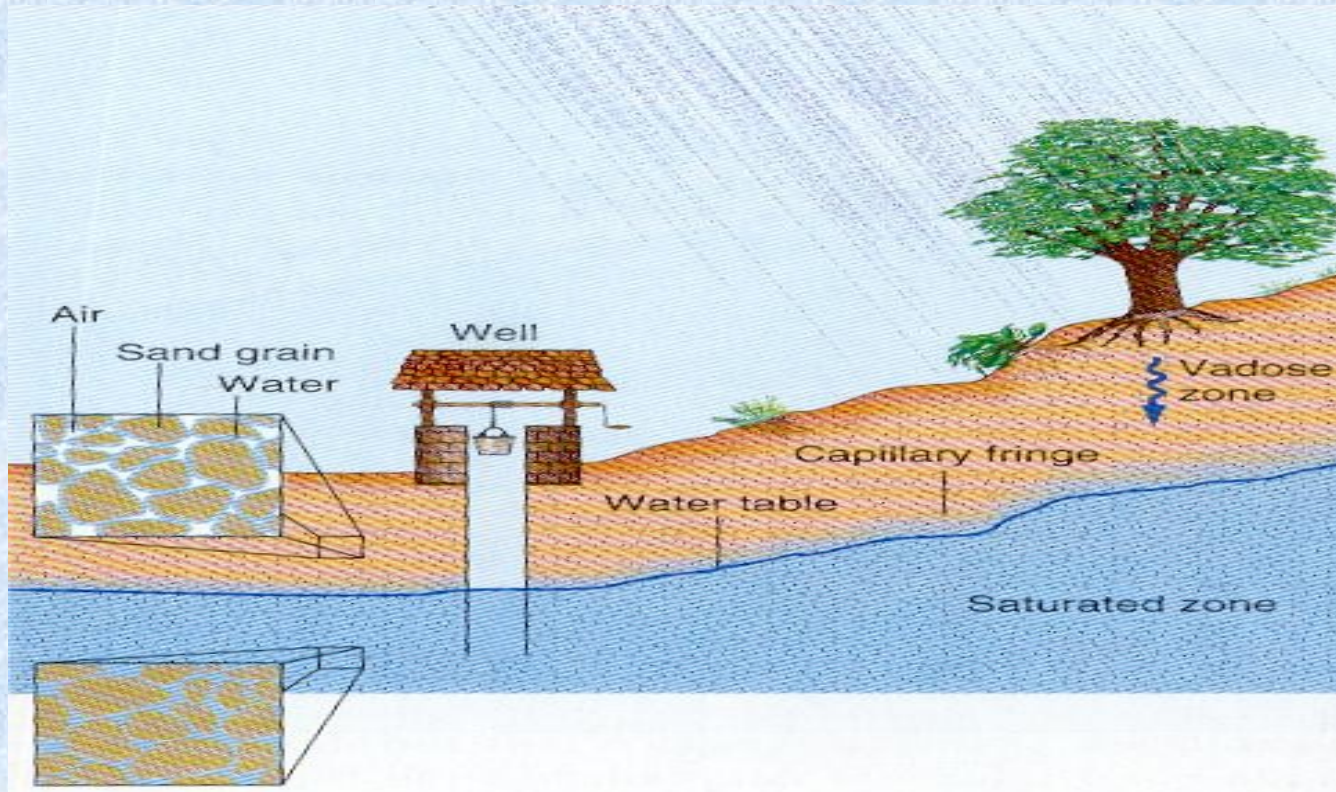


Global Water Scarcity (CONT.)

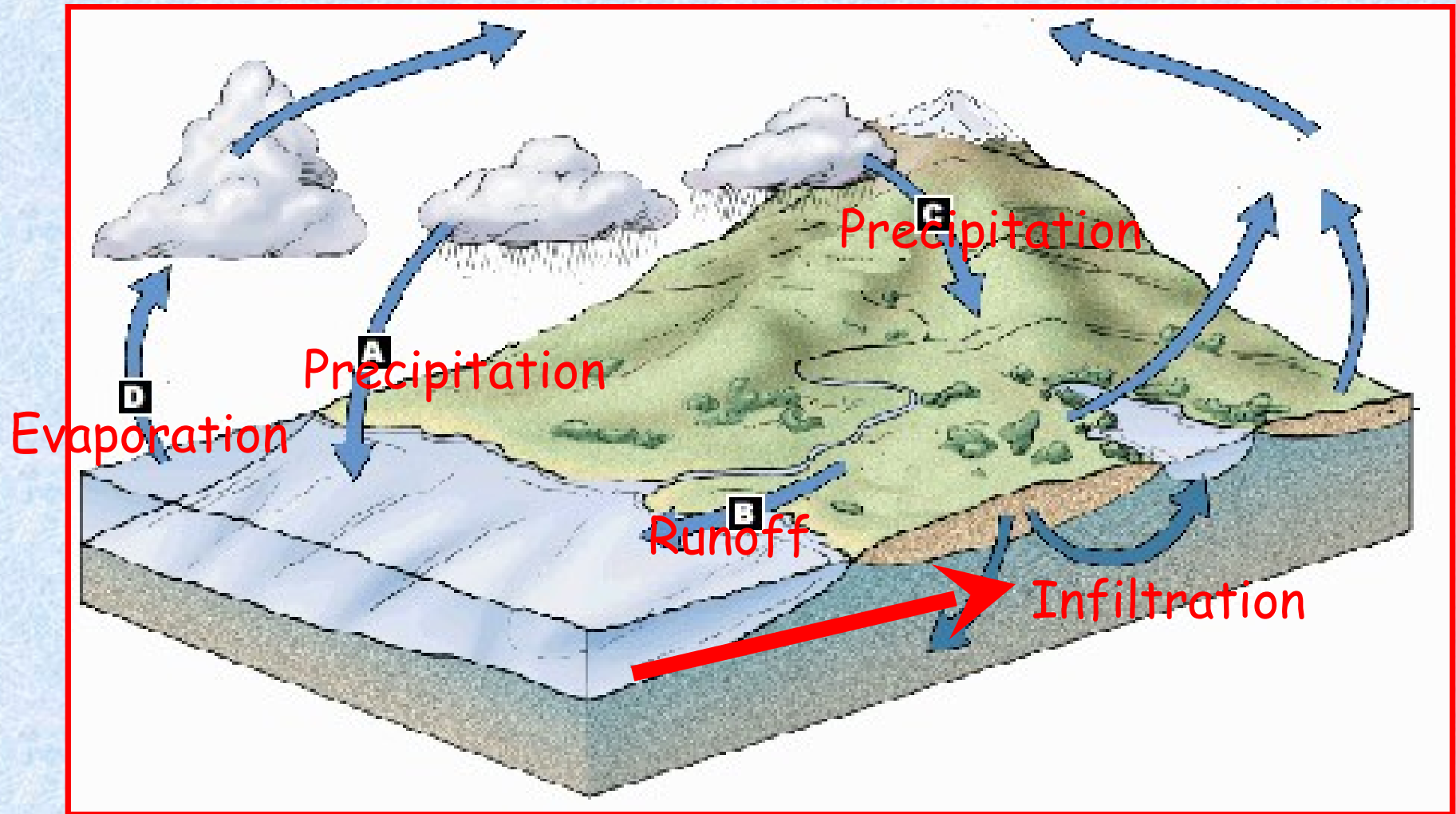


GROUND WATER

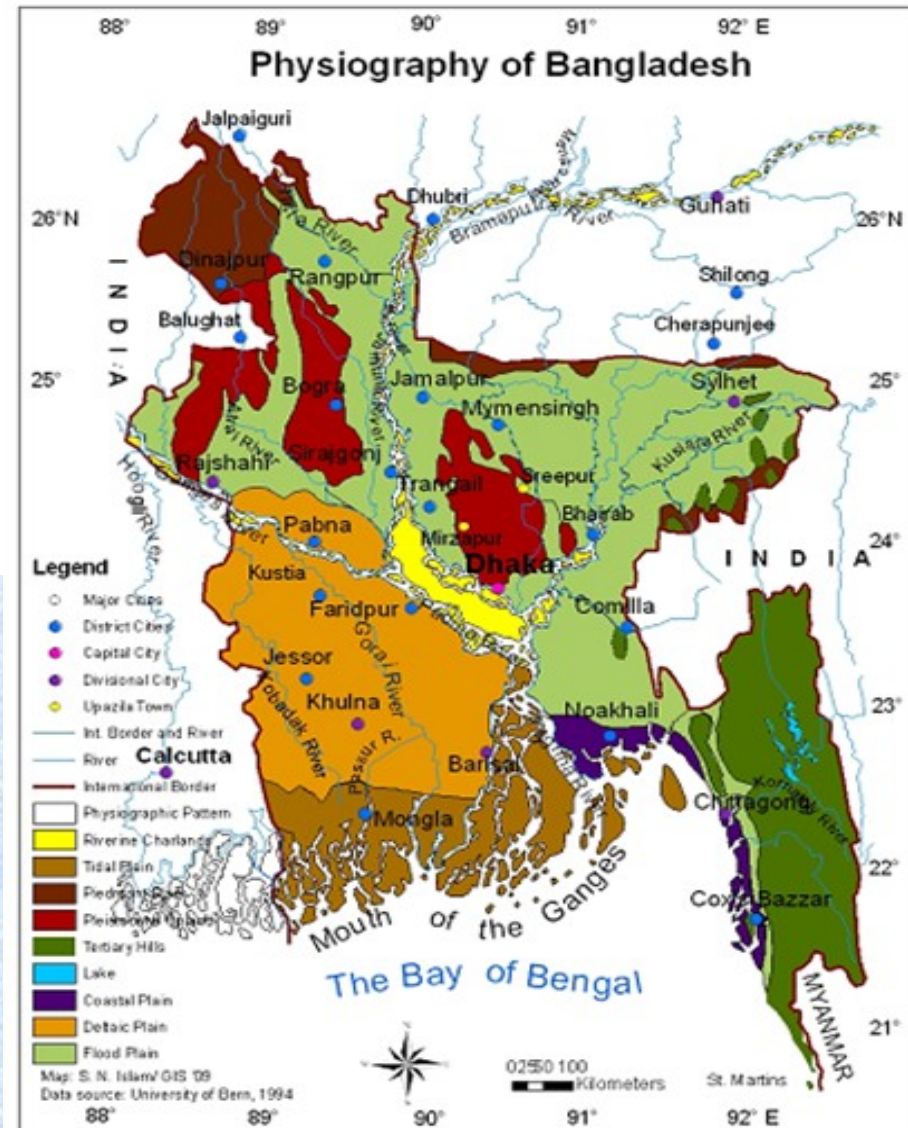
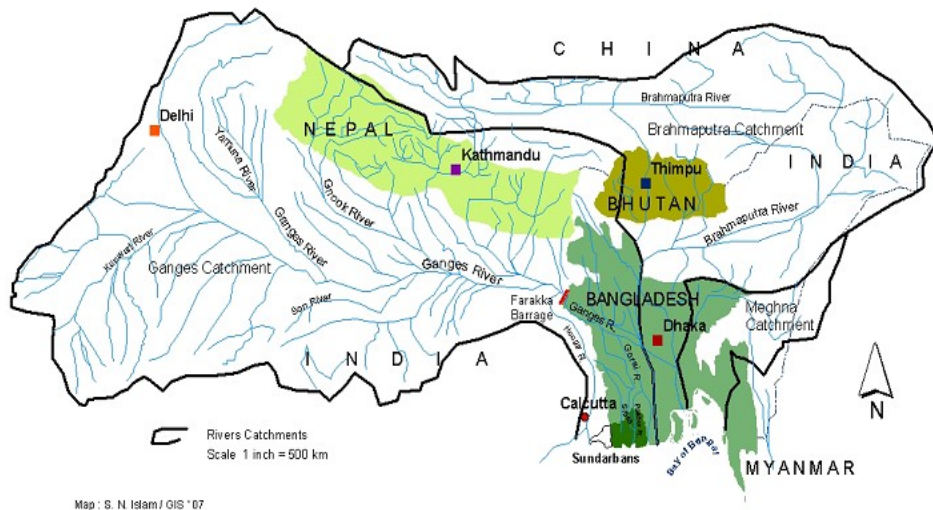
- **Ground water** is water, which originates from the infiltration of fluids through the soil profile and accumulates below the earth's surface in a porous layer.
- source of ground water is rain and snow that falls to the ground a portion of which percolates down into the ground to become ground water.



Hydrologic Cycle



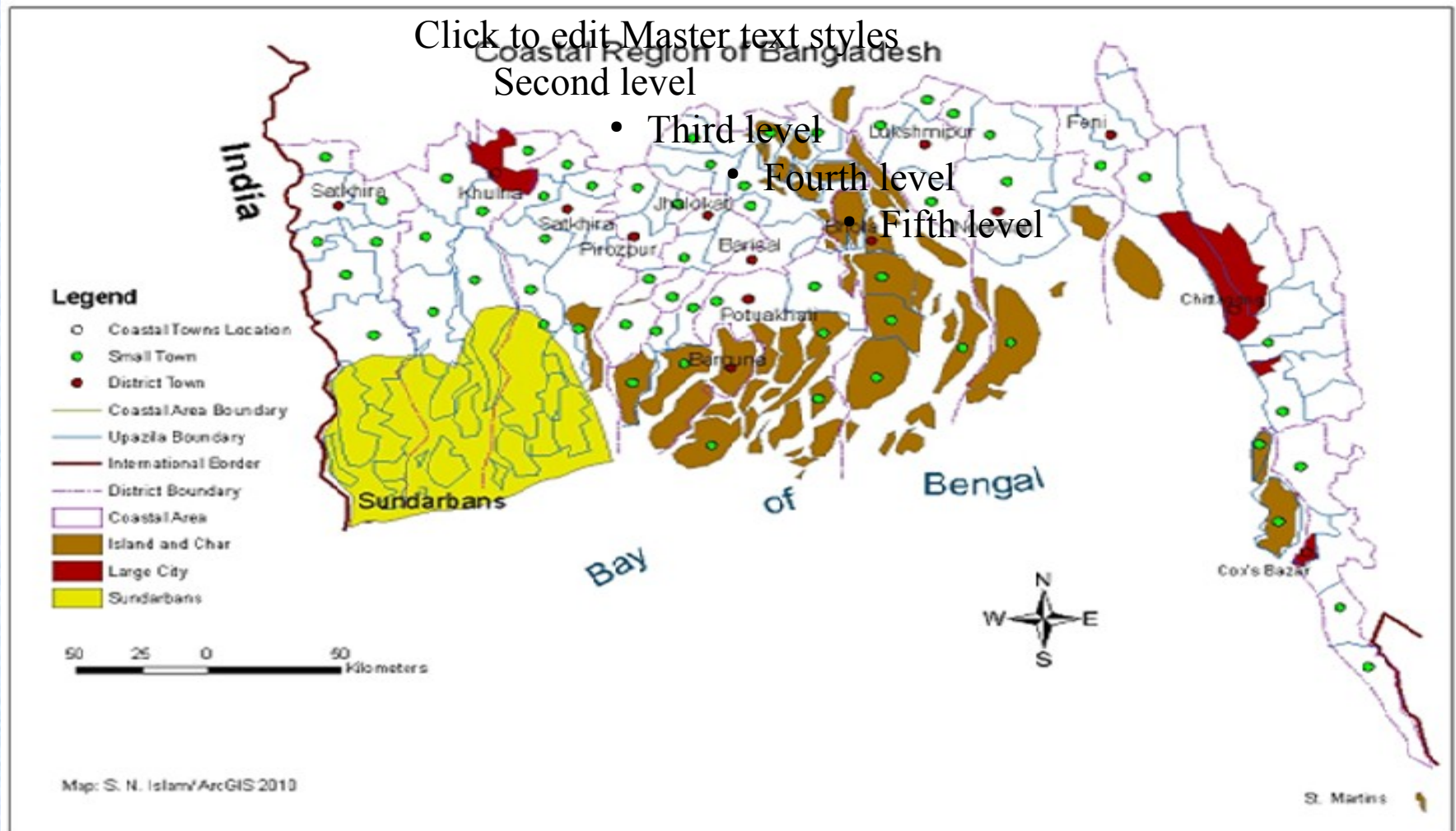
Physiography of Bangladesh



§ Bangladesh is located in the Ganges-Brahmaputra-Meghna Rivers catchments

§ The area is 144,570 km²

Coastal region of Bangladesh



§The coastal area is 36,500 km² where 35 million people are living

§There are 19 districts (101 towns) are located in the coastal region in Bangladesh

Present state of ground water and problems

- § In coastal areas about 82% drinking water is collected from ground water
- § Sustainability of the livelihoods of over 35 million inhabitants depending on availability of potable water

However, the availability of ground water in coastal cities for drinking purpose has become a problem for the following reasons:

- § **Excessive Salinity**
- § **Arsenic contamination**
- § **Bacteria contamination in upper aquifer(in some cases)**
- § **Lowering of water table**
- § **Dissolved iron**

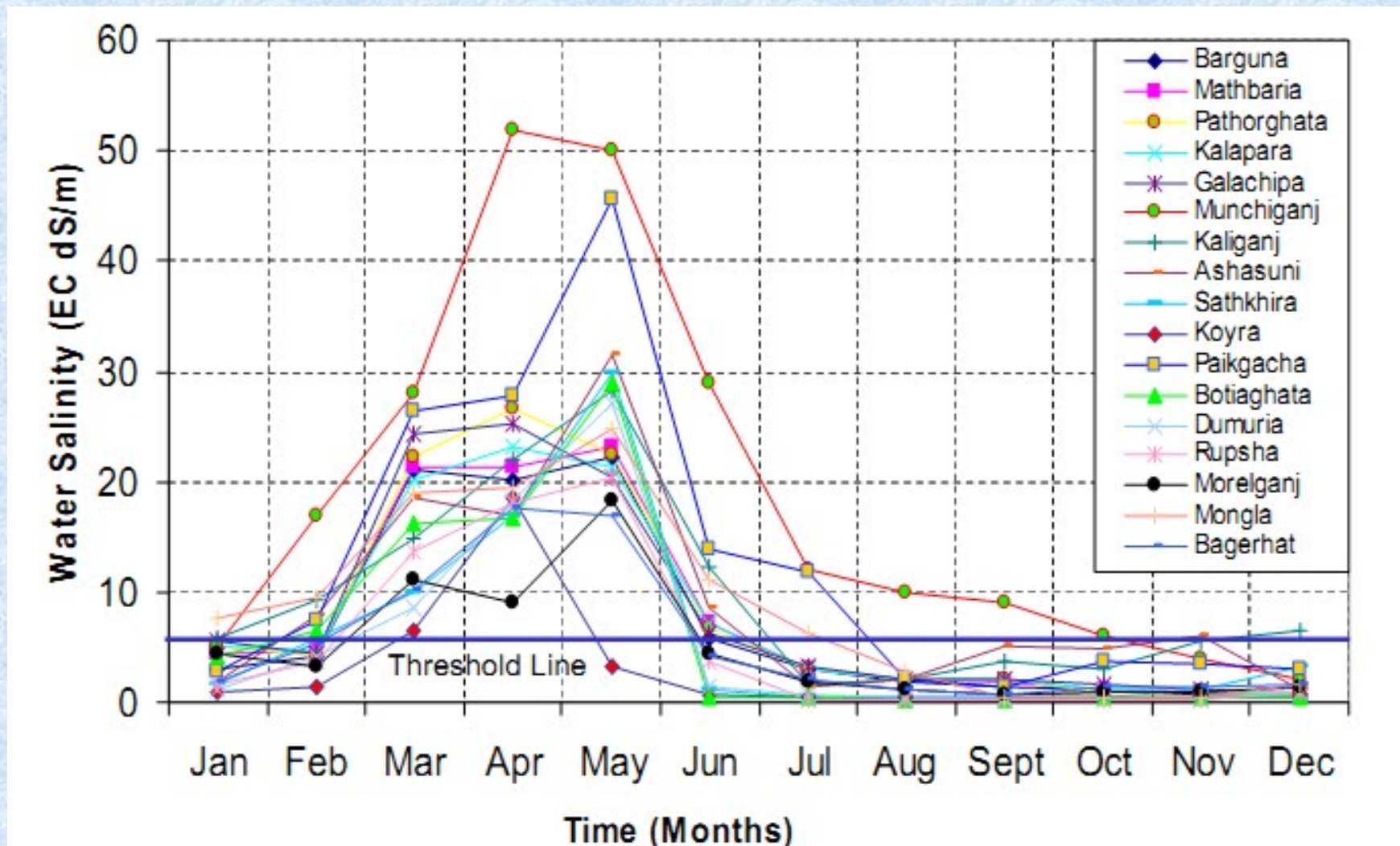
Salinity in the coastal areas

The ground water salinity has been categorized into the following groups (ESCAP/UN, 1987);

- * <1 dS/m fresh water
- * 1-2 dS/m slightly saline
- * 2-5 dS/m slightly to moderately saline
- * 5-10 dS/m moderately to high saline
- * >10 dS/m high saline

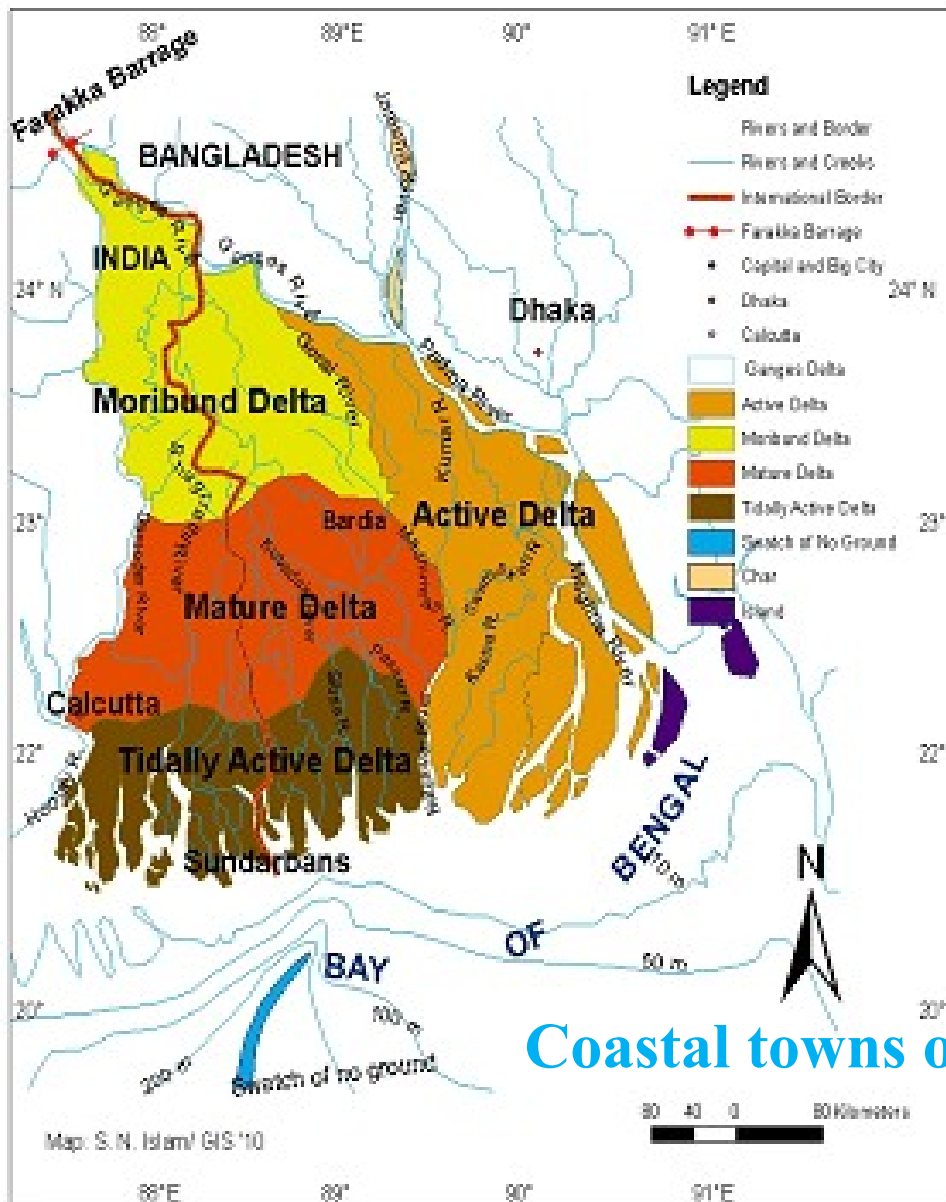
The Bangladesh standard for groundwater salinity is **600 mg** Chloride per liter. As this value is widely exceeded in coastal areas, a more practical level of **1000 mg/l** of Chloride has been suggested (ESCAP/UN, 1987). This would approximately correspond to a threshold of 2 dS/m (1000mg/l Chloride solution generates EC of 1.5 to 2 dS/m at 20-30 0C).

Salinity in the coastal areas (Cont.)

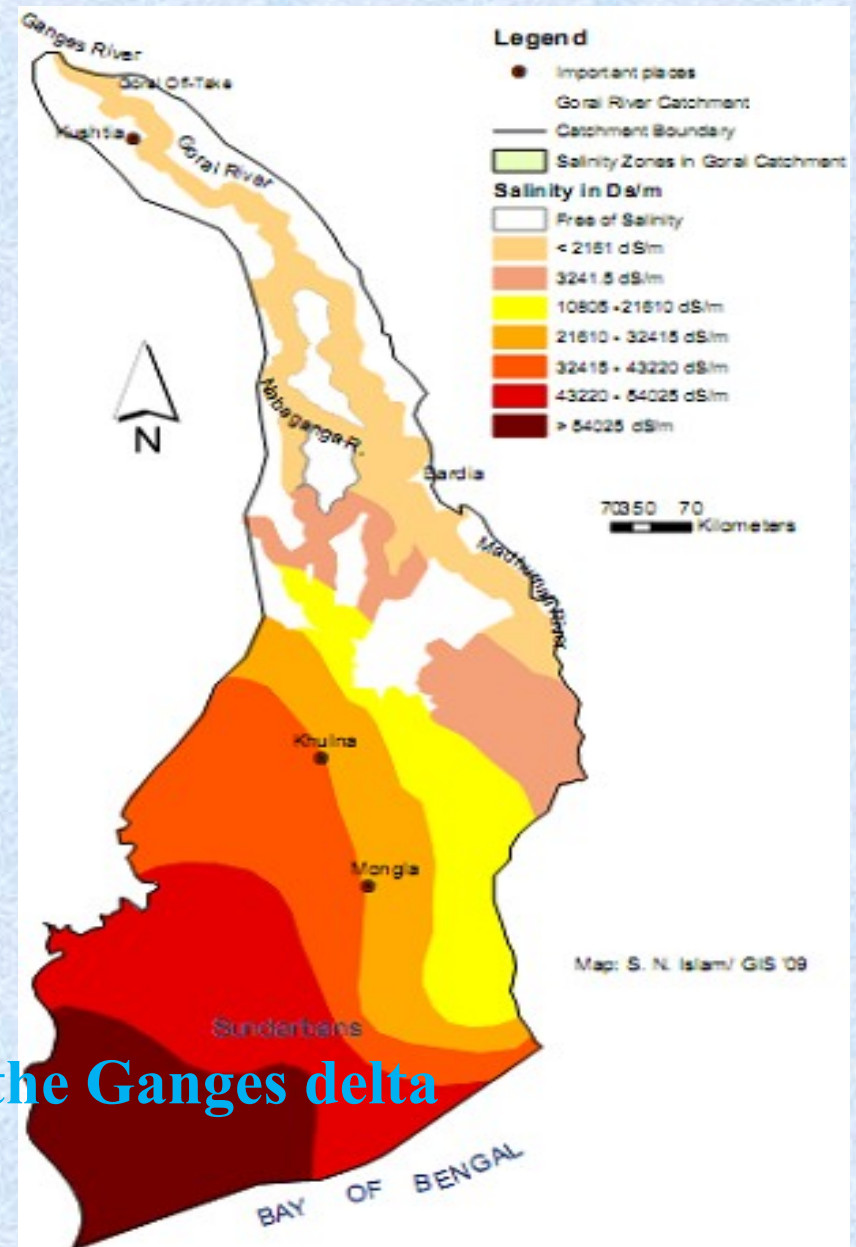


2 dS/m is the threshold value for potable drinking water in Bangladesh

Salinity intrusion in surface and ground water



Coastal towns of the Ganges delta



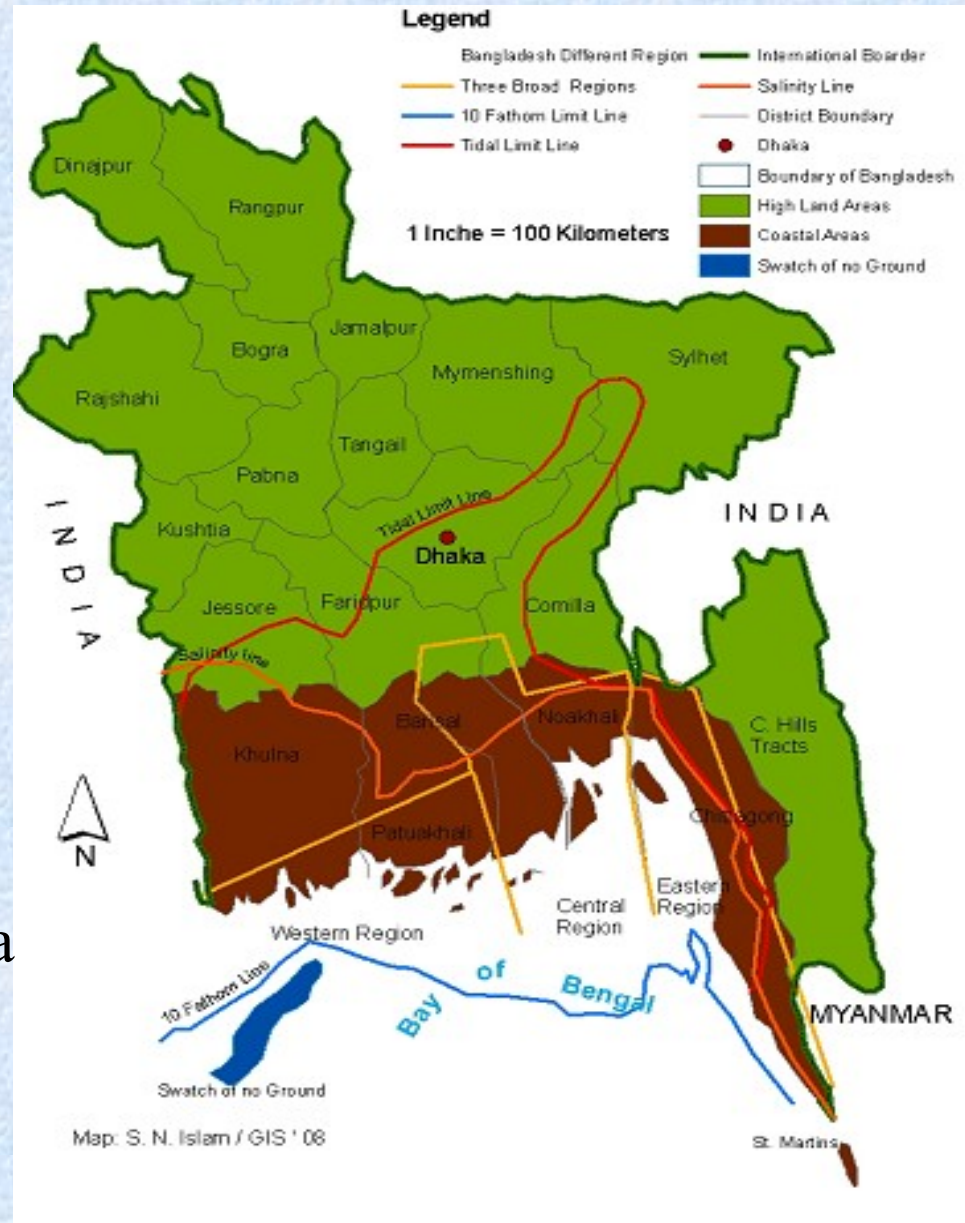
Causes of Salinity

The main causes of salinity in the coastal areas are as follows:

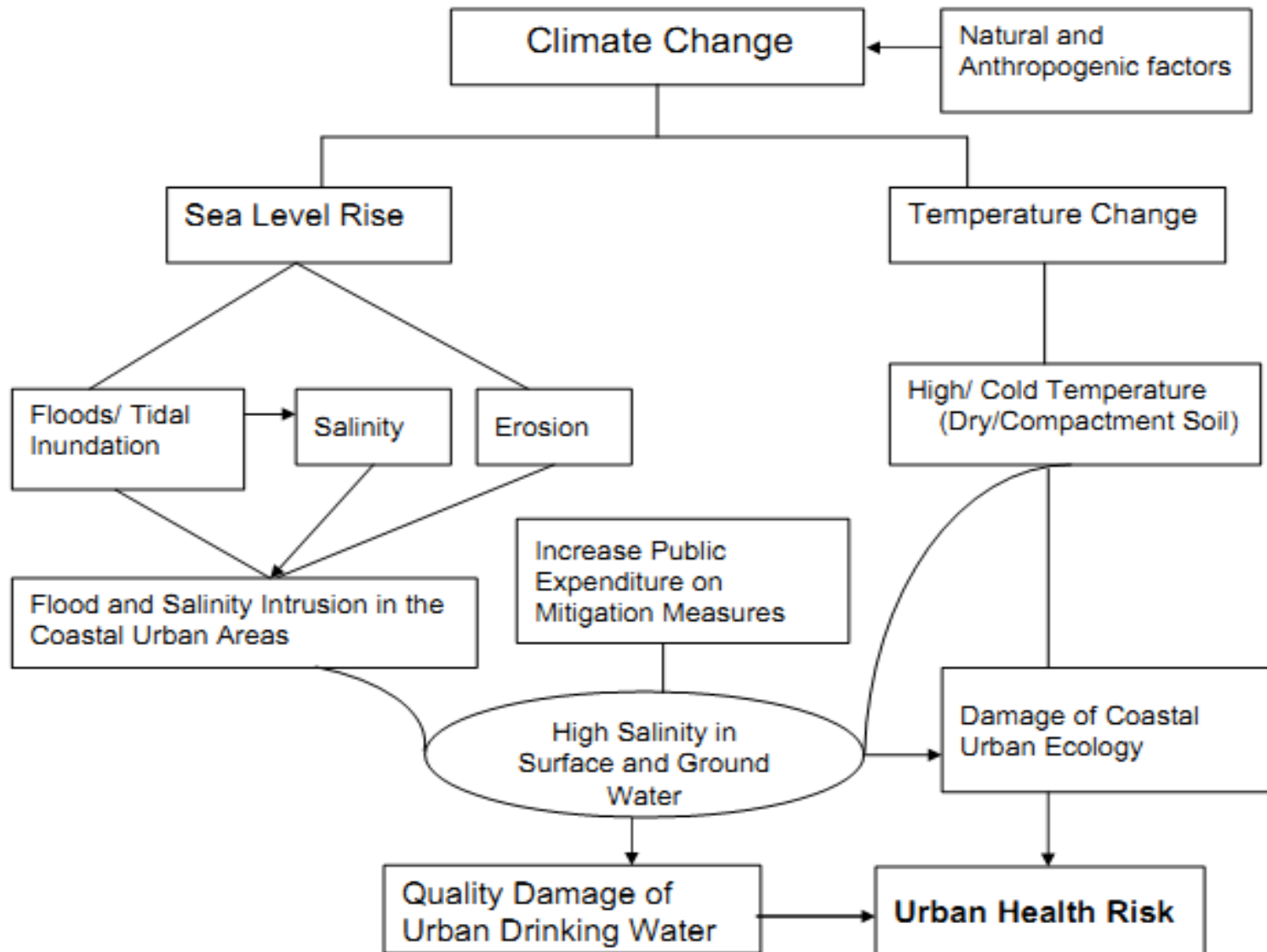
- § Salinity is expected to be exacerbated by climate change and sea-level rise.
- § Decrease of upstream flow due to excessive pumping for irrigation water and Farrakka Barrage in the upstream of the Ganges River.
- § Horizontal Expansion of shrimp farms
- § CEP (Coastal Embankment Project)

Climate change impacts

- § Due to Climate change impacts with 1.5 m SLR about 17 million (15%) of people will be affected.
- § It has been estimated that 22,000 km² (16%) coastal land will go under water by 2050
- § Therefore almost 50 coastal towns are under threat in the Ganges delta



Climate change impacts (cont.)



Climate change impacts on Coastal Towns



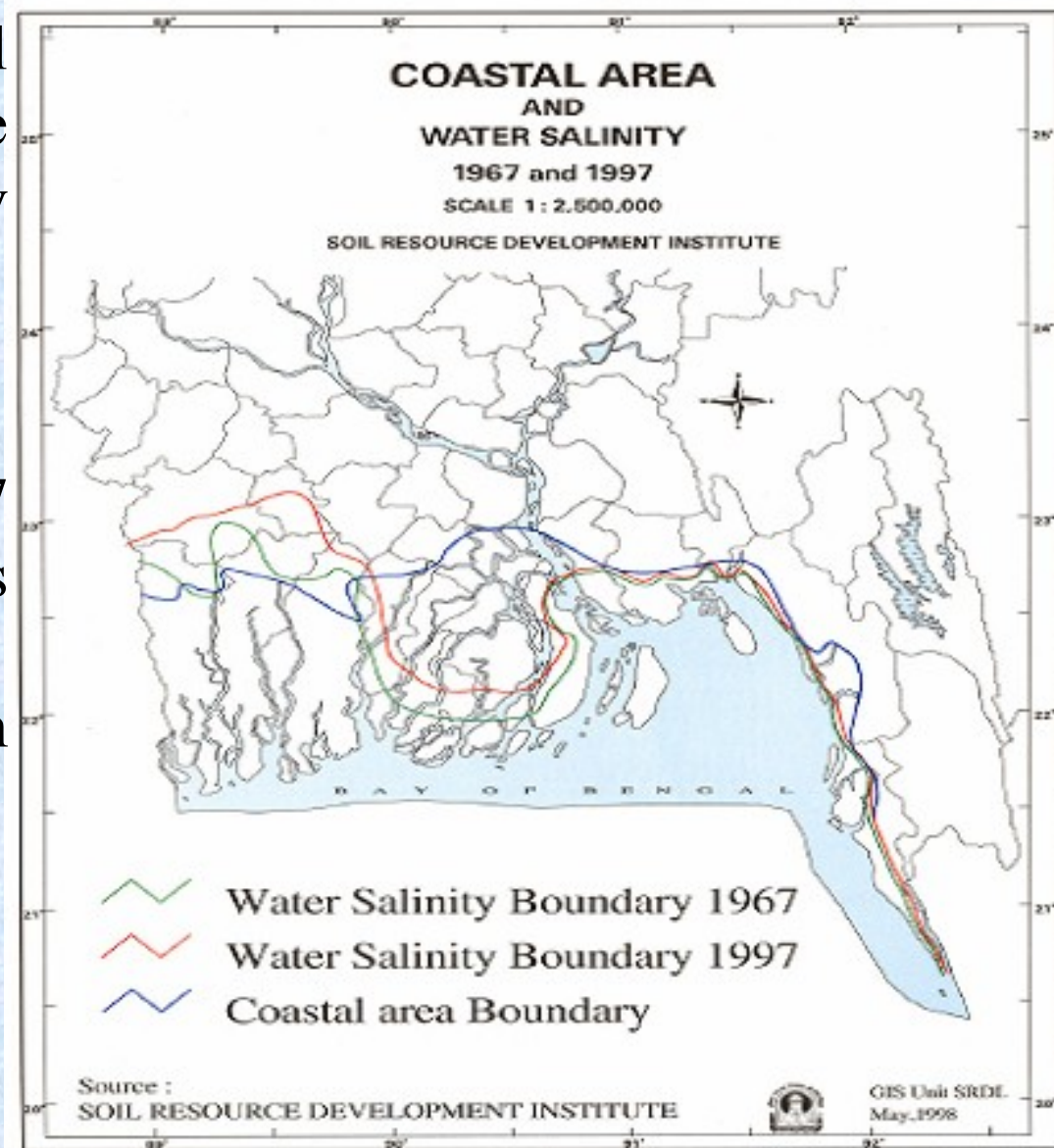
The three major rivers are carrying 100,000 to 140,000 m³/s upstream water and 1.8 to 2.4 billion tones of sediments loads are deposited on the bed of Bay of Bengal



Sea level rise

§ The main impacts of sea level rise on water resources are fresh water availability reduction by salinity intrusion.

§ A water salinity map for the period of 1967 and 1997 produced by Soil Resources Development Institute (SRDI, 1998a) shows that the problem is already on the way.



Horizontal Expansion of shrimp farms

Shrimp farmers of Bangladesh mainly cultivate Indian Tiger Shrimp. Saline water is required for maximum growth of this species.

Shrimp farm area in Satkhira, Khulna and Bagerhat districts
(Ittefaq, 2004)

Year	Shrimp farm area (hectares)
1975	1,330
1987	67,650
2004	115,900

It is another indicator of salinity intrusion in the coastal zone.



Excessive pumping

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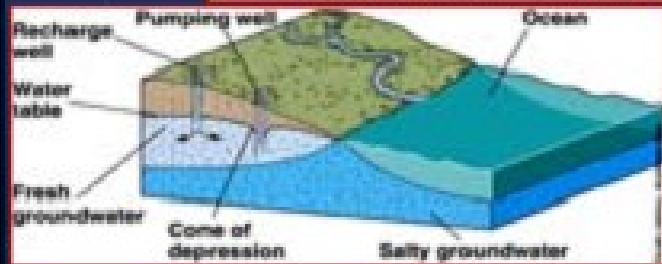
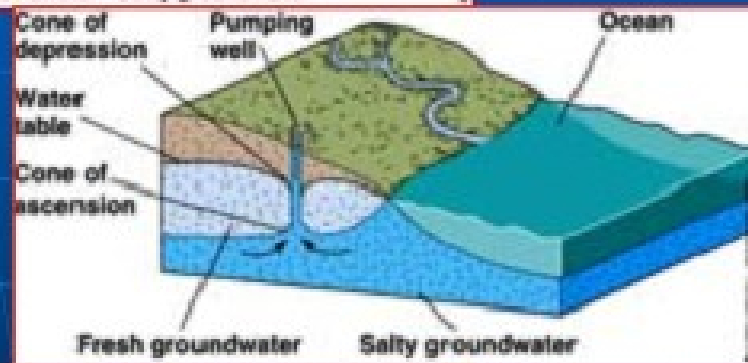
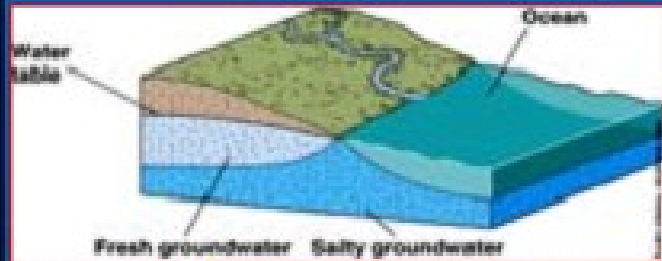
Second level

• Third level

• Fourth level

• Fifth level

Saltwater Incursion



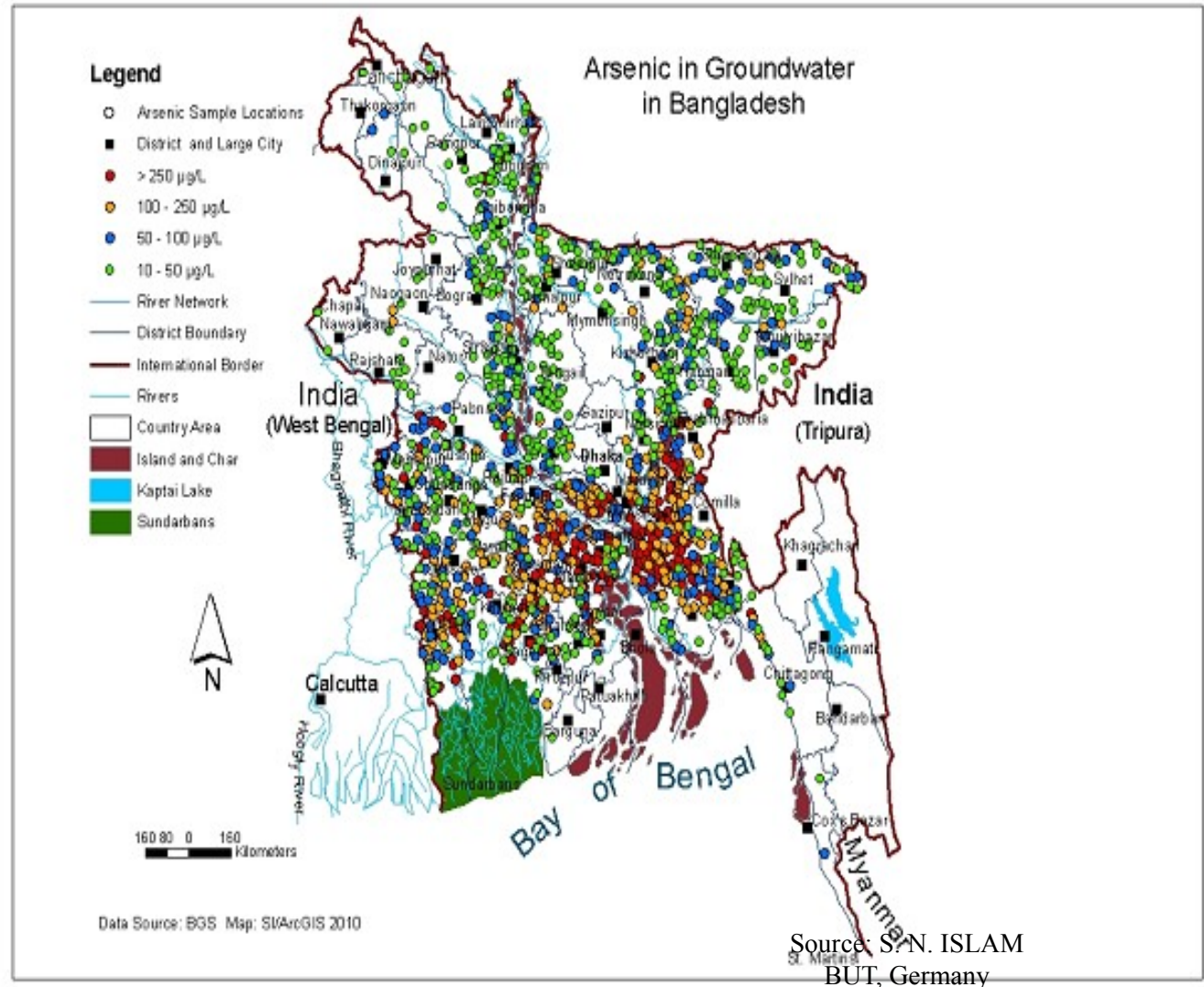
Excessive pumping in coastal areas can result in salt water being drawn into wells

- major problem in rapidly growing coastal communities
- recharge wells are often used to pump water back into the system

Arsenic in Groundwater in Bangladesh

Sources:

Arsenic and arsenical compounds are found in effluents and leaches from metallurgical industries, glassware and ceramic industry, dye and pesticide and fertilizer manufacturing industries



southern coastal towns are contaminated by Arsenic in ground water

Arsenic Removal technologies

- Coprecipitation

- Alum coagulation
 - Lime softening

- Sorption technique

- Activated alumina
 - Iron coated sand

- Membrane technique

- Reverse osmosis
 - Electrodialysis

- Microbial process

- Microbial oxidation
 - Microbial removal

Pollution of Ground Water

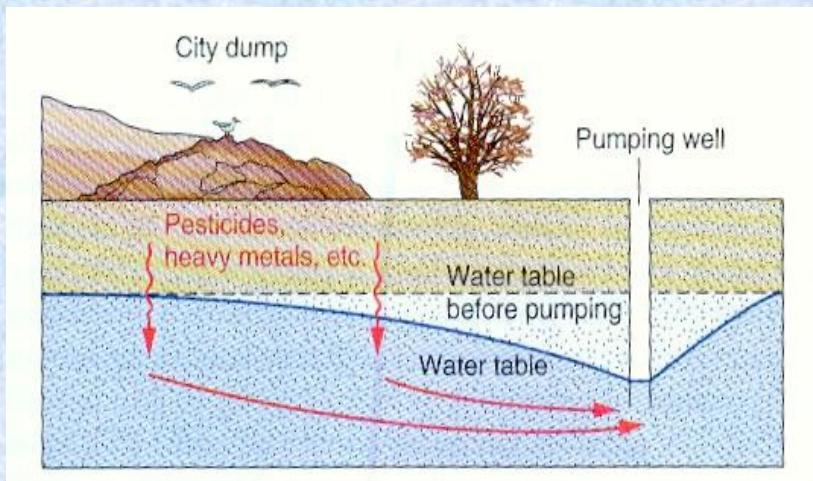
- Pesticides, herbicides, fertilizers: chemicals that are applied to agricultural crops that can find their way into ground water when rain or irrigation water leaches the poisons downward into the soil
- Rain can also leach pollutants from city dumps into ground-water supplies
- Heavy metals such as mercury, lead, chromium, copper, and cadmium, together with household chemicals and poisons, can all be concentrated in ground-water supplies beneath dumps

Pollution of Ground Water (cont.)

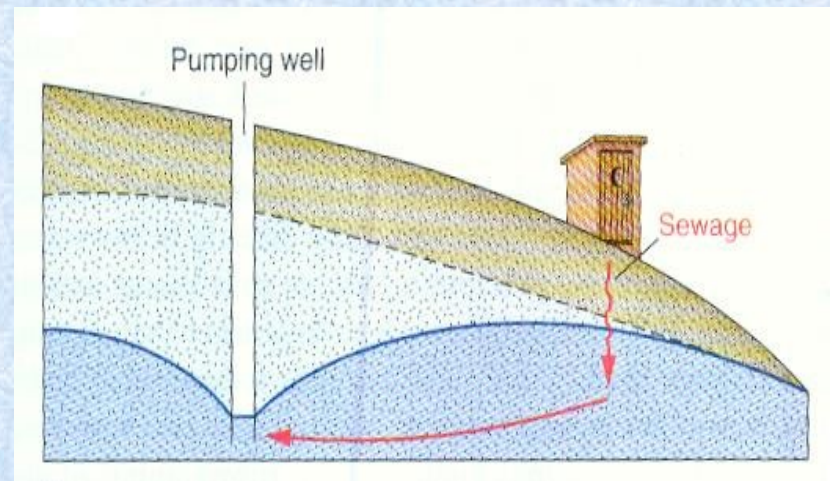
- liquid and solid wastes from septic tanks, sewage plants, and animal feedlots and slaughterhouses may contain bacteria, viruses, and parasites that can contaminate ground water
- acid mine drainage from coal and metal mines can contaminate both surface and ground water
- radioactive waste can cause the pollution of ground water due to the shallow burial of low-level solid and liquid radioactive wastes from the nuclear power industry

Pollution of Ground Water

- pumping wells can cause or aggravate ground-water pollution



Water table steepens near a dump, increasing the velocity of ground-water flow and drawing pollutants into a well

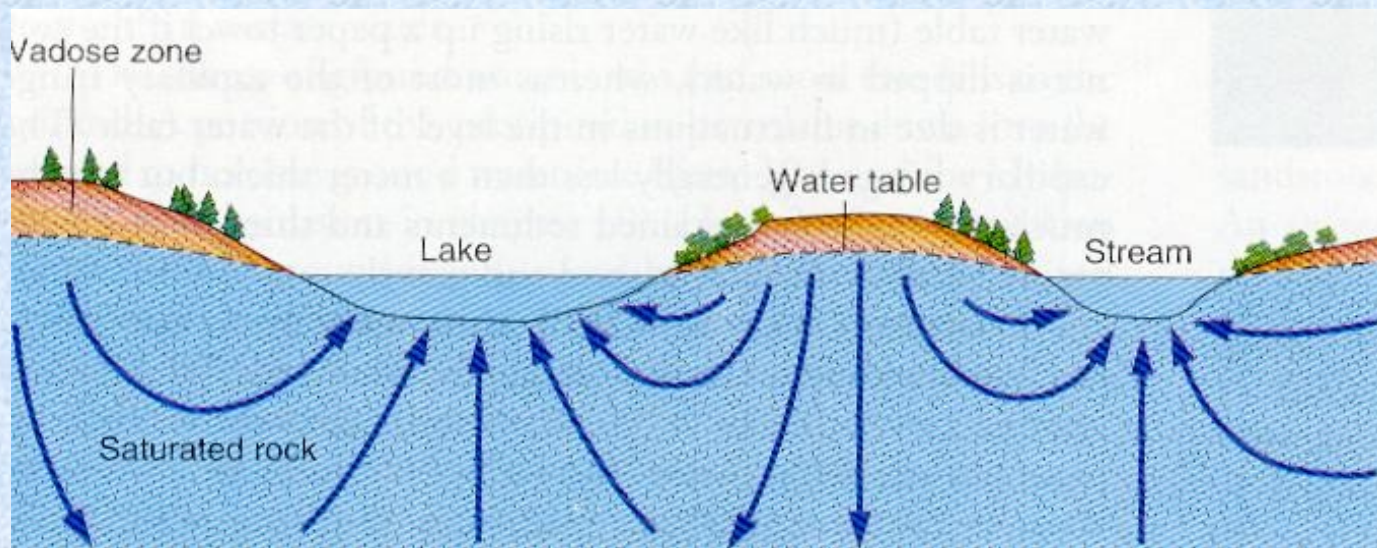


Water-table slope is reversed by pumping, changing direction of the ground-water flow, and polluting the well

Pollution of Ground Water

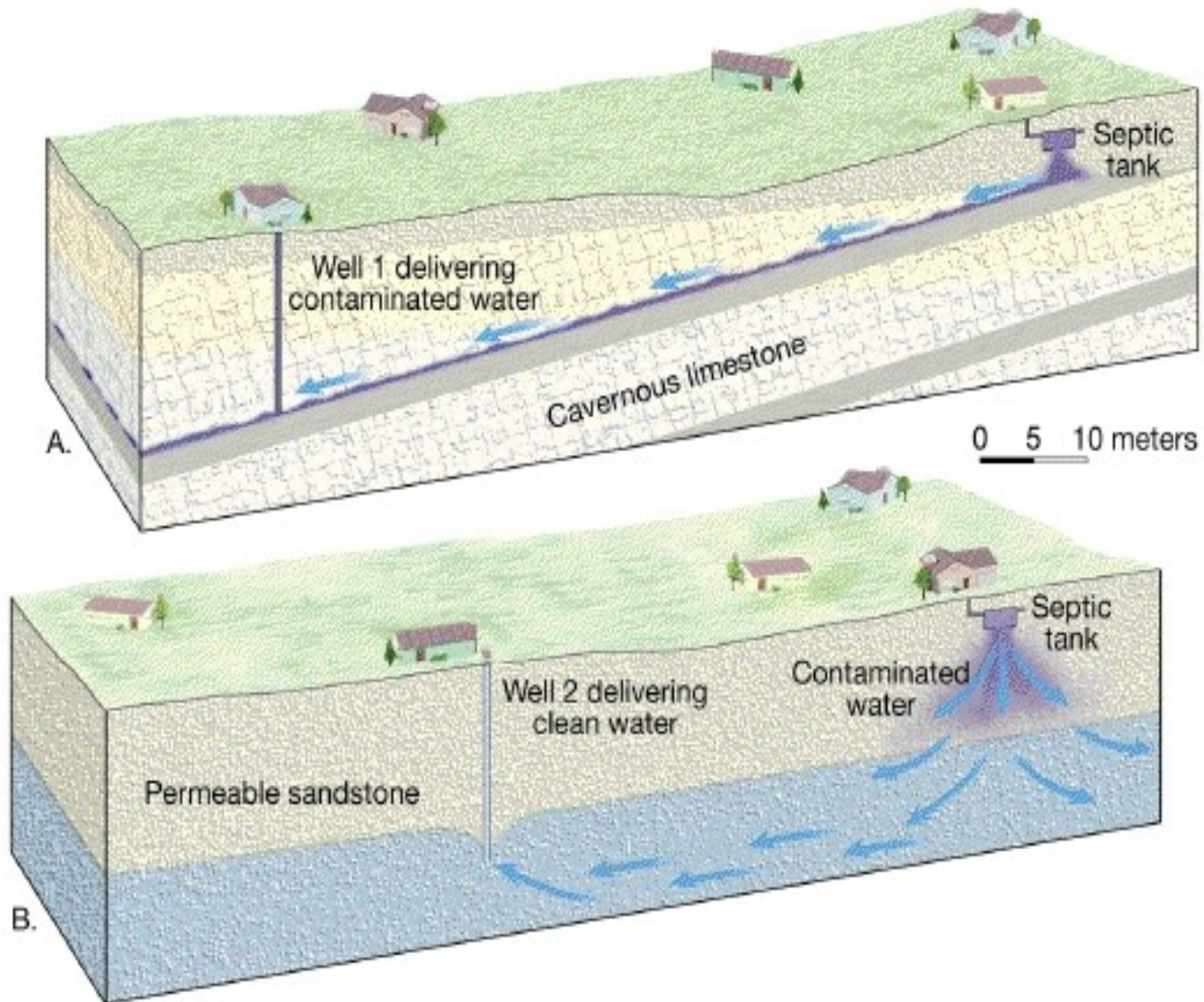
Movement of ground water

Darcy' found that the velocity of water flow through porous media is proportional to the hydraulic gradient

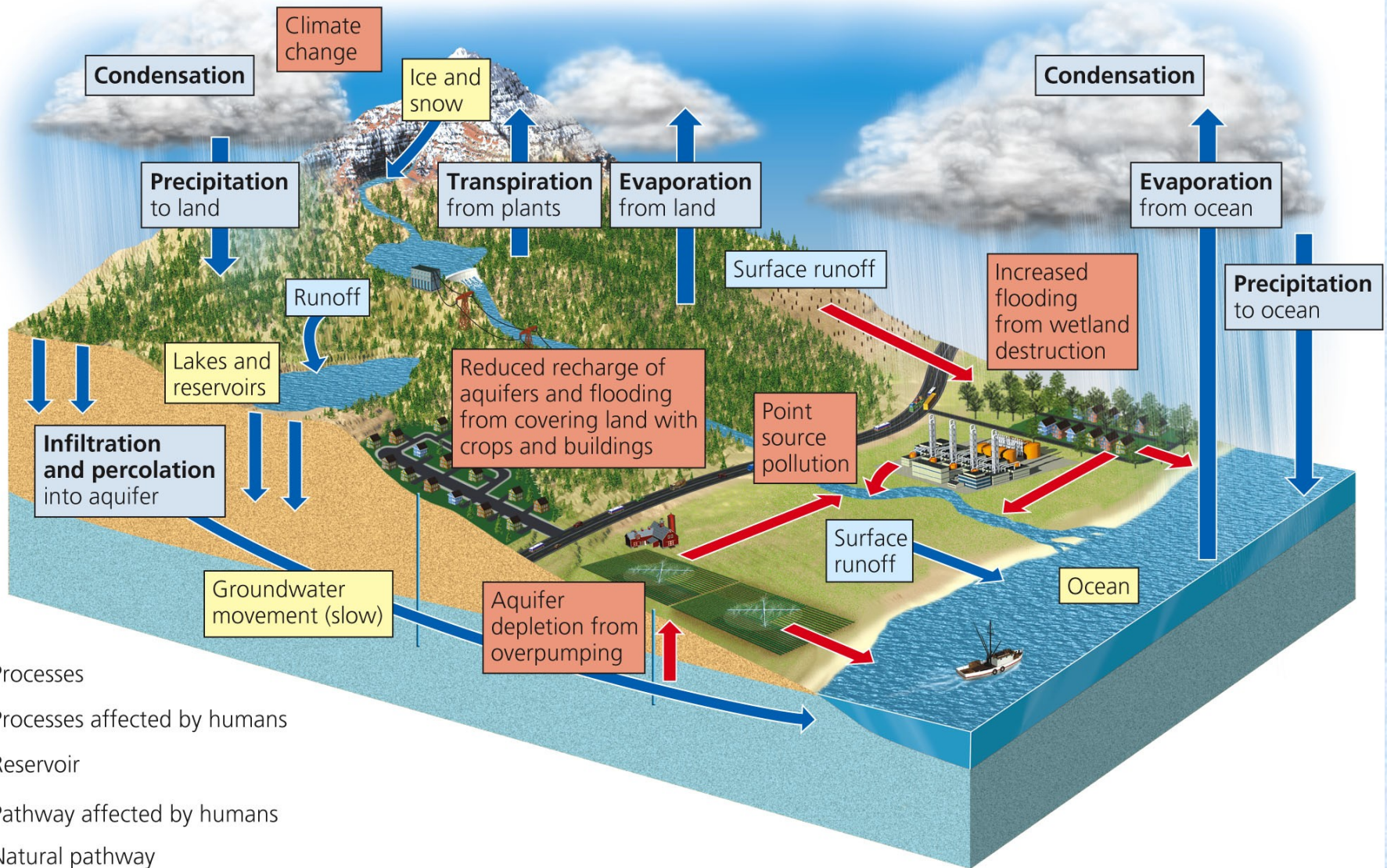


- Ground water moves relatively slowly through rock underground in response to differences in water pressure and elevation, water within the upper part of the saturated zone tends to move downward following the slope of the water table

Pollution of Ground Water



Present state of problems



regulatory measures for sustainability

- § Rainwater harvesting
- § Solar desalination
- § Shallow shrouded tubewell (15 to 20 m depth)
- § Pond sand filter
- § Water management
- § Balancing withdrawal and recharge
- § Optimizing water use for domestic and industrial purposes
- § Using efficient irrigation techniques

Balancing Withdrawal and Recharge

- A local supply of groundwater will last indefinitely if it is withdrawn for use at a rate equal to or less than the rate of recharge to the aquifer
- If ground water is withdrawn faster than it is being recharged, however, the supply is being reduced and will one day be gone

Balancing Withdrawal and Recharge (cont.)

- To avoid the problems of falling water tables, subsidence, and compaction, artificial recharge can be done;
- Natural floodwaters or treated industrial or domestic wastewaters are stored in infiltration ponds in the surface to increase the rate of water percolation into the ground
- Rain water harvesting can be helpful for artificial recharge

Conclusions

- The ground water is very much important for the costal urban inhabitants, living in the coastal cities in Bangladesh.
- The upstream fresh water scarcity and tidal inundation due to SLR is a severe problem for maintaining quality of urban drinking water in the coastal region.
- Therefore ensure upstream freshwater supply, desalination technology and rain water harvesting could solve the drinking quality management in the coastal towns.
- Peoples participation, awareness education and applied research is necessary and it should be included in national urban water development program to maintain drinking water quality, supply and management in the coastal cities in Bangladesh.

Thank you for kind attention