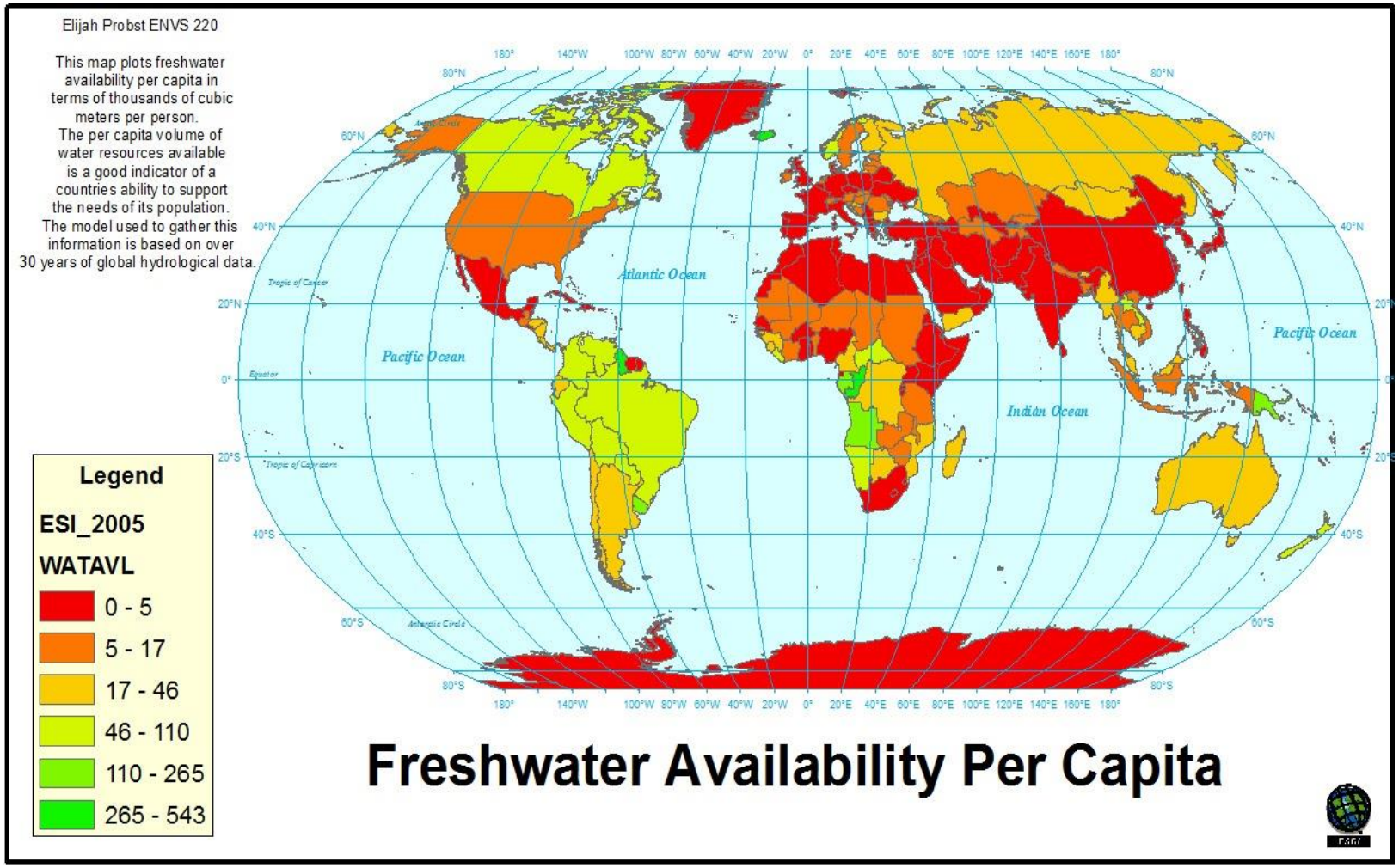
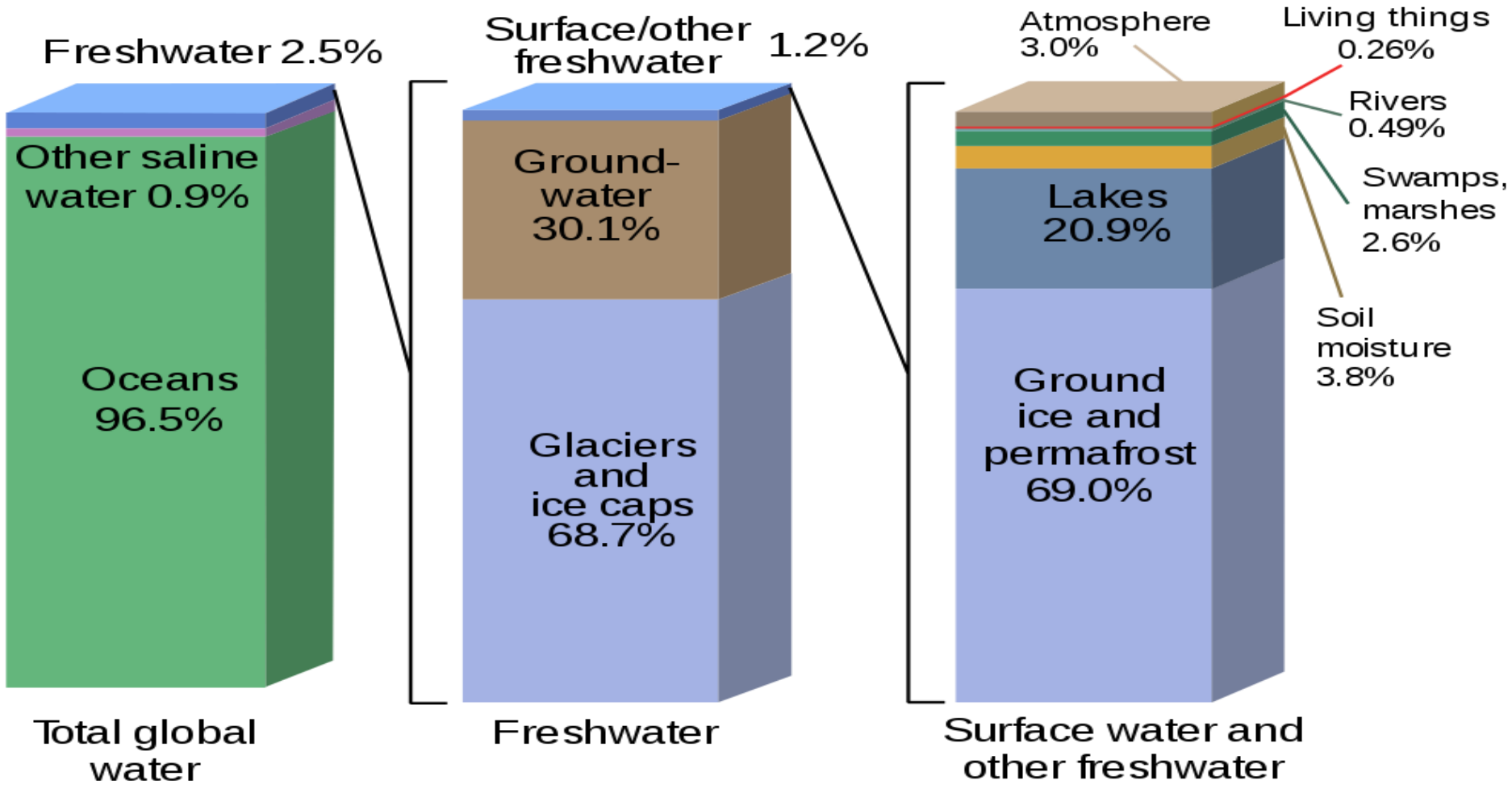
Water Security of India

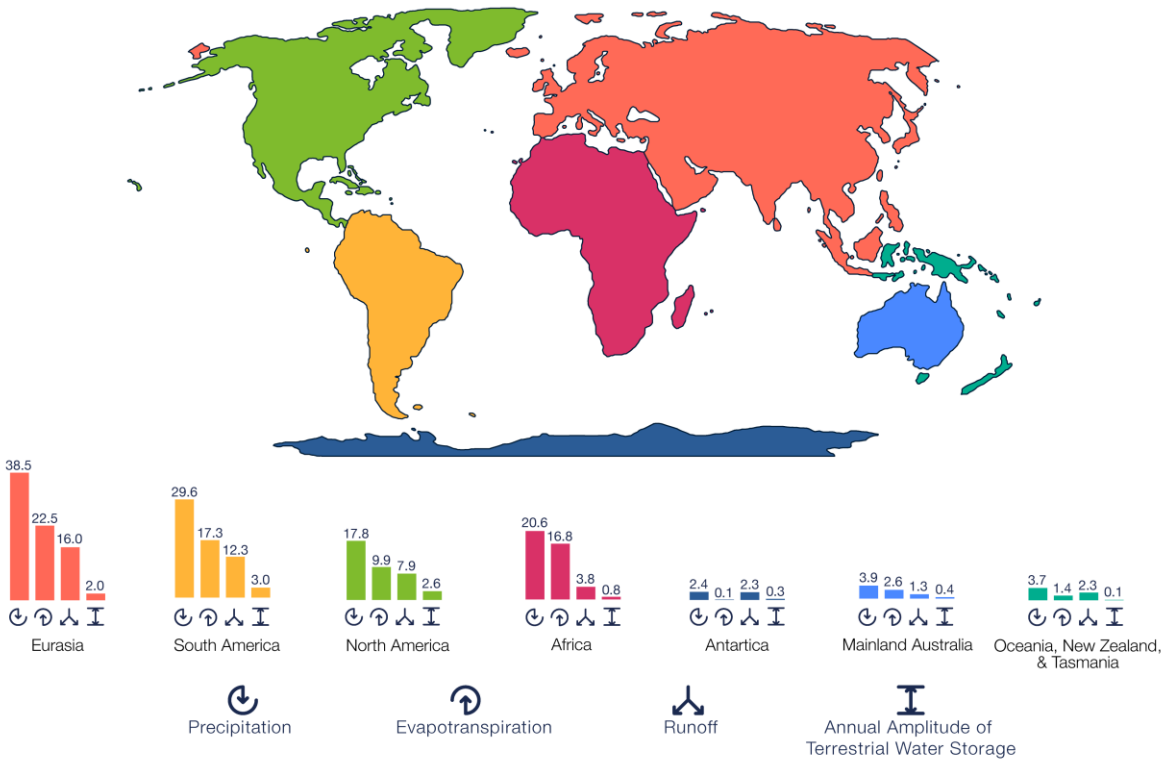
- Earth **“the water planet"**
- A world with plentiful water



Where is Earth's Water?



Introduction



Water security is "the reliable availability of an acceptable quantity and quality of water for health, livelihoods and production, coupled with an acceptable level of water-related risks“ (https://iwaponline.com/wp/article/9/6/545/31241/Sink-or-Swim-Water-security-for-growth-and)

Precipitation → Evapotranspiration, Runoff, Storages

The amount of water per year that precipitates, evaporates, runs off into streams and rivers, or soaks into groundwater storage for each of seven main land masses. The amounts listed are in units of thousand cubic kilometers. Credits: NASA Goddard/Conceptual Image Lab

Source: https://www.nasa.gov/feature/goddard/nasa-balances-water-budget-with-new-sestimates-of-liquid-asset

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Water Security of India

- More than 600 million people are facing acute water shortages
- India's 70% of the people depend on agricultural profession for their livelihood
- Fresh water availability is important for assessing climate adaptation to ensure water and food security, agricultural water management and socioeconomic development.
- Understanding the water balance components at global and continental is of important for a sustainable water resources management (Vörösmarty et al., 2015)

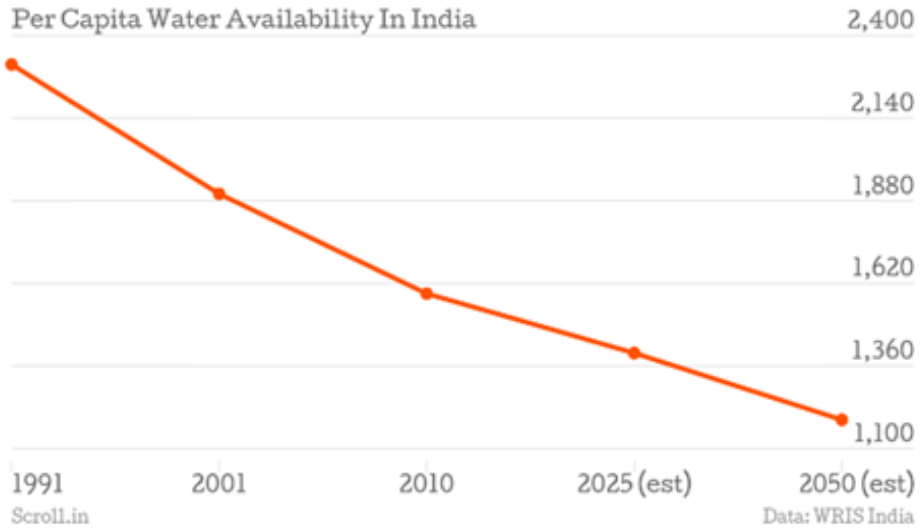

Figure 1: Per Capita Water Availibilty in India (Source: WRIS)

A population becomes "water stressed" when water levels fall to 1,700 cubic metres per capita, and "water scarce" when water levels fall to less than 1,000 cubic metres per capita. Source: http://www.futuredirections.org.au/publication/drought-water-security-india/

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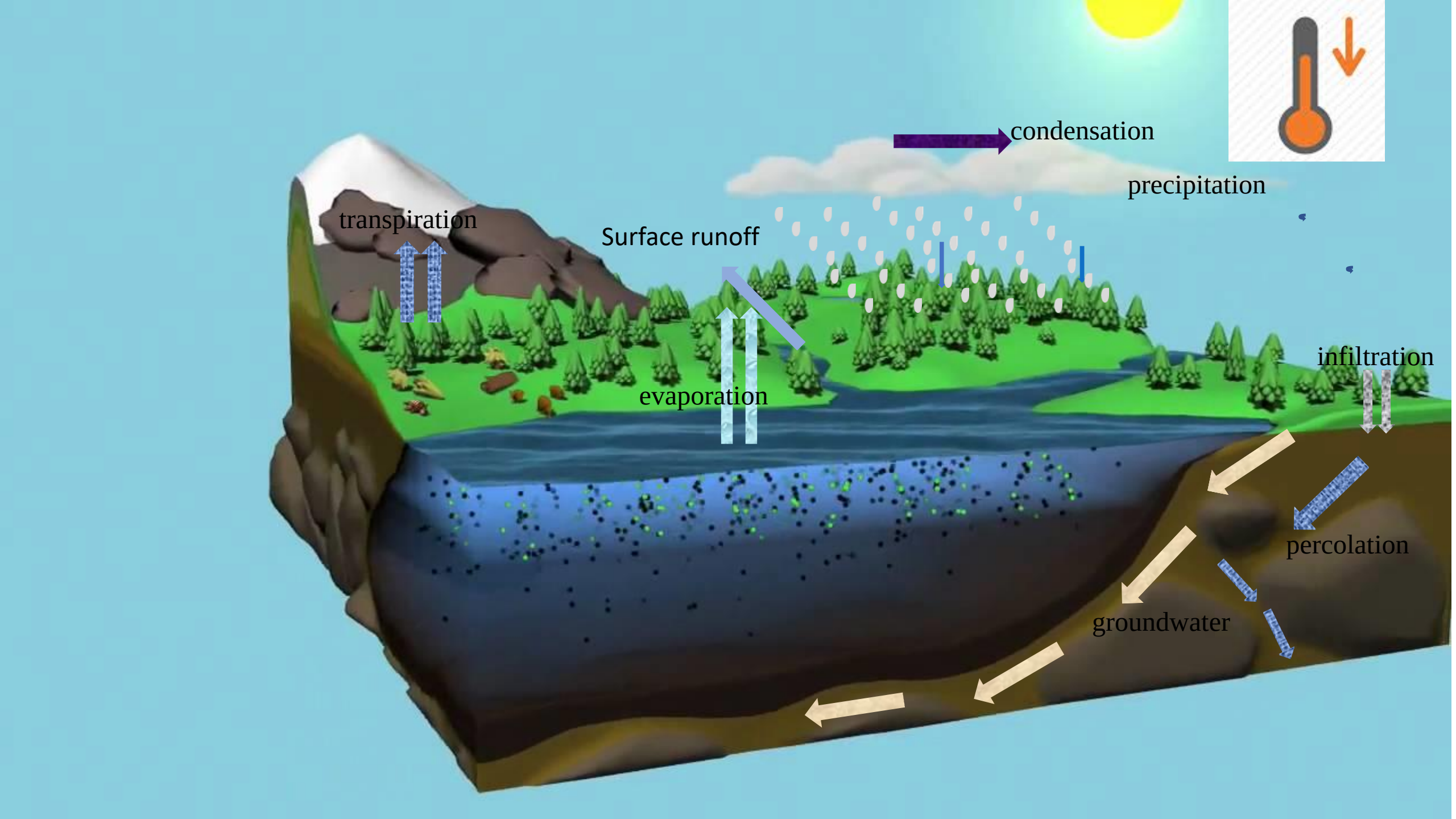
Introduction

- Understanding of fresh water availability is very important
- To assess
  - socio-economic and environmental impacts
  - Demographic change
  - Energy
  - Food security
  - Agricultural water management
  - Drinking water suppy

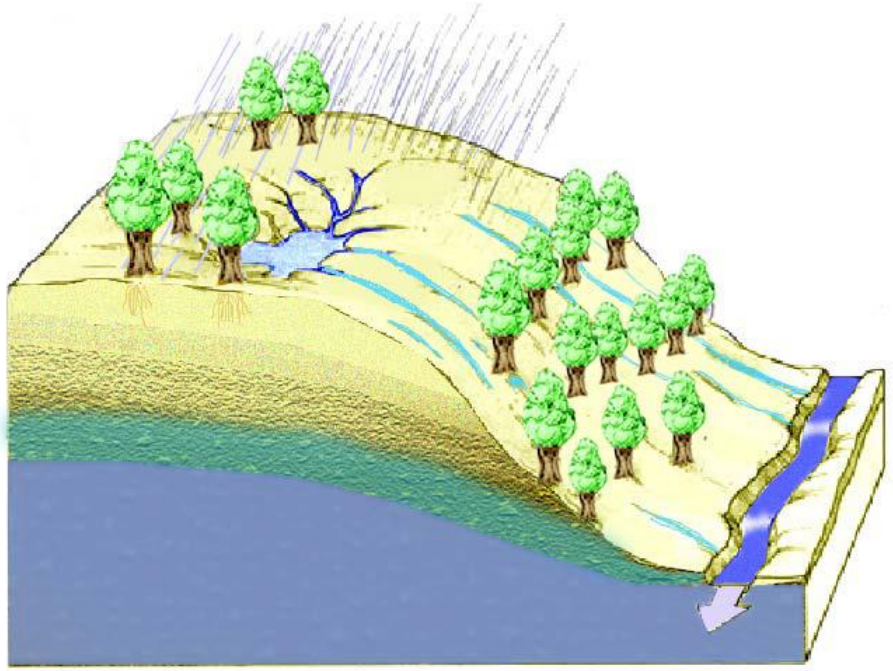
- Run-off from a river basin is the integrated outcome of climatic inputs (precipitation, temperature, etc.) and basin topography, land use/cover, and water management infrastructure.

- The summer monsoon accounts for more than 80% of the annual rainfall and primarily regulates the hydrology of the Indian subcontinent.

- A small change in the monsoon rainfall can have profound economic and environmental impacts, since a large population in India depends on agriculture and allied sectors that are climate-dependent.


condensation
precipitation
transpiration
Surface runoff
evaporation
infiltration
percolation
groundwater

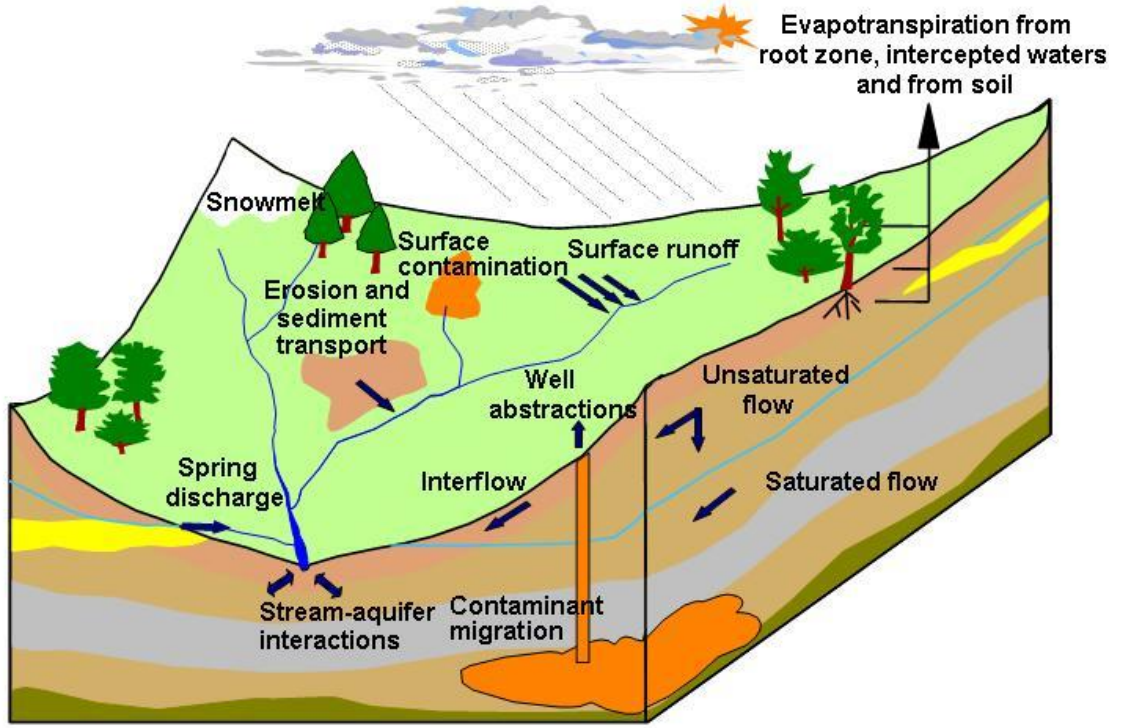
Estimation of Water Availability



Surface runoff is precipitation that does not infiltrate into the soil and runs across the land surface into surface waters (streams, rivers, lakes or other reservoirs)

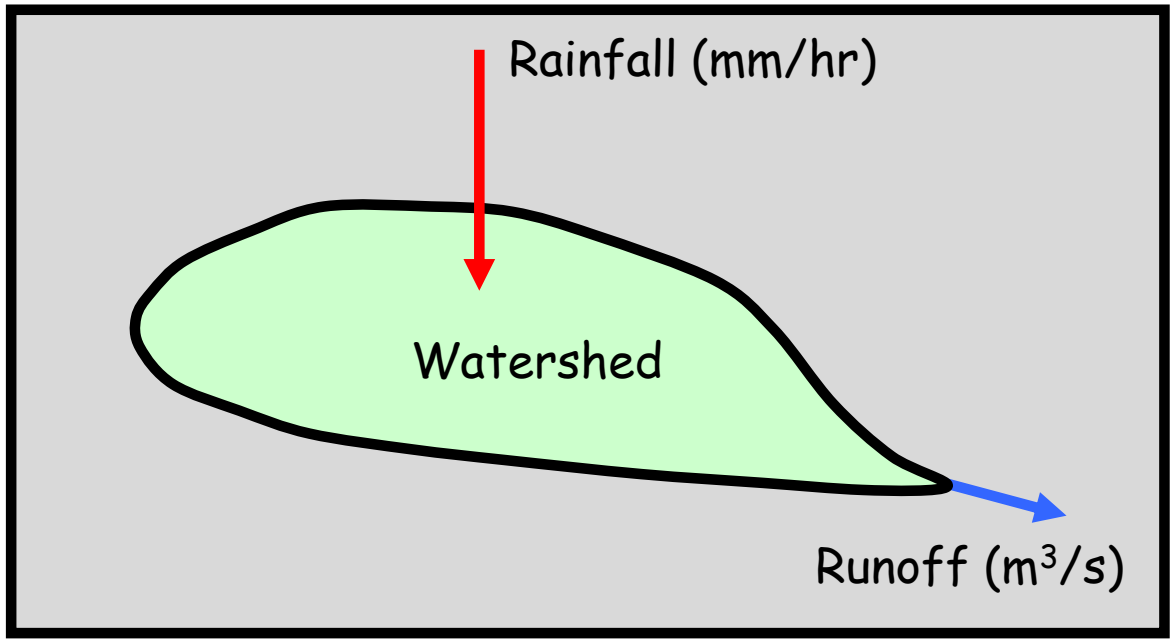
Introduction

- A rainfall-runoff model is a simplification of a real-world system (e.g., surface water, soil water, wetland, groundwater, estuary) that aids in understanding, predicting, and managing water resources. Both the flow and quality of water are commonly studied using hydrologic models (Rainfall-Runoff)



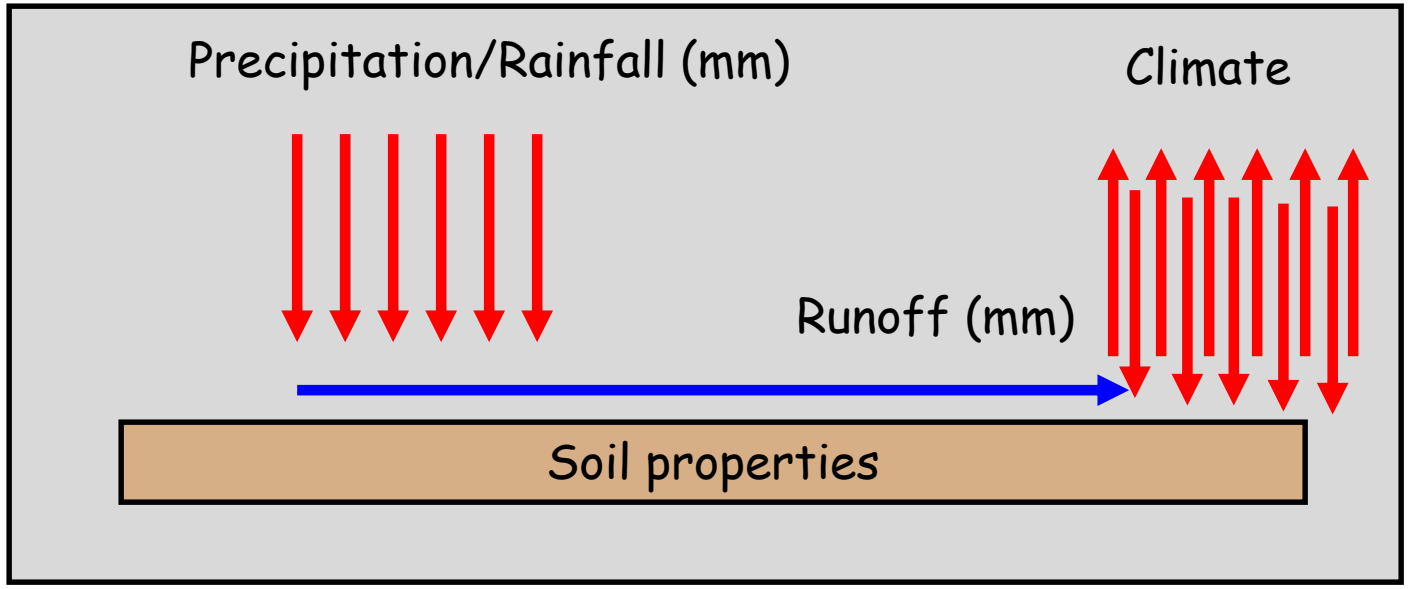
River basin

- River Basin is an extent or an area of land where all surface water from rain, melting snow, or ice converges to a single point at a lower elevation, usually the exit of the basin, where the waters join a river.



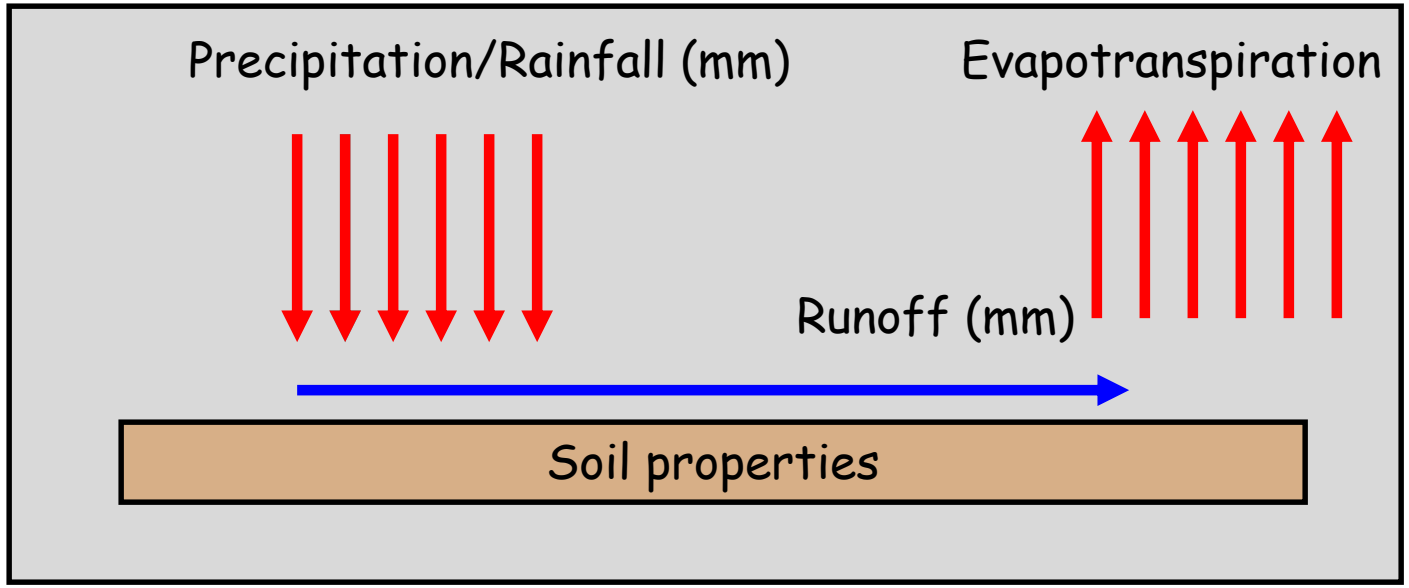
Flow = f(Runoff, Watershed hydrologic properties)

Rainfall – Runoff Modelling



Flow/Discharge/Runoff = f(Precipitation, soil properties, climate)

Simplified Form of Hydrological Cycle



Flow/Discharge/Runoff = Precipitation - Evapotranspiration

Estimation of Fresh Water Availabilities

- Traditional assessment of available water is based on runoff, which necessitates rigorous hydrological models, simulations and observed measurements of streamflows.

- Poor monitoring network at a larger spatial extent is the limitation to understand the water availability at larger spatial extent (Indian sub continent)

- Simplistic and proxy to estimate the atmospheric budget or water availability: Precipitation (P) – Evapotranspiration (E)

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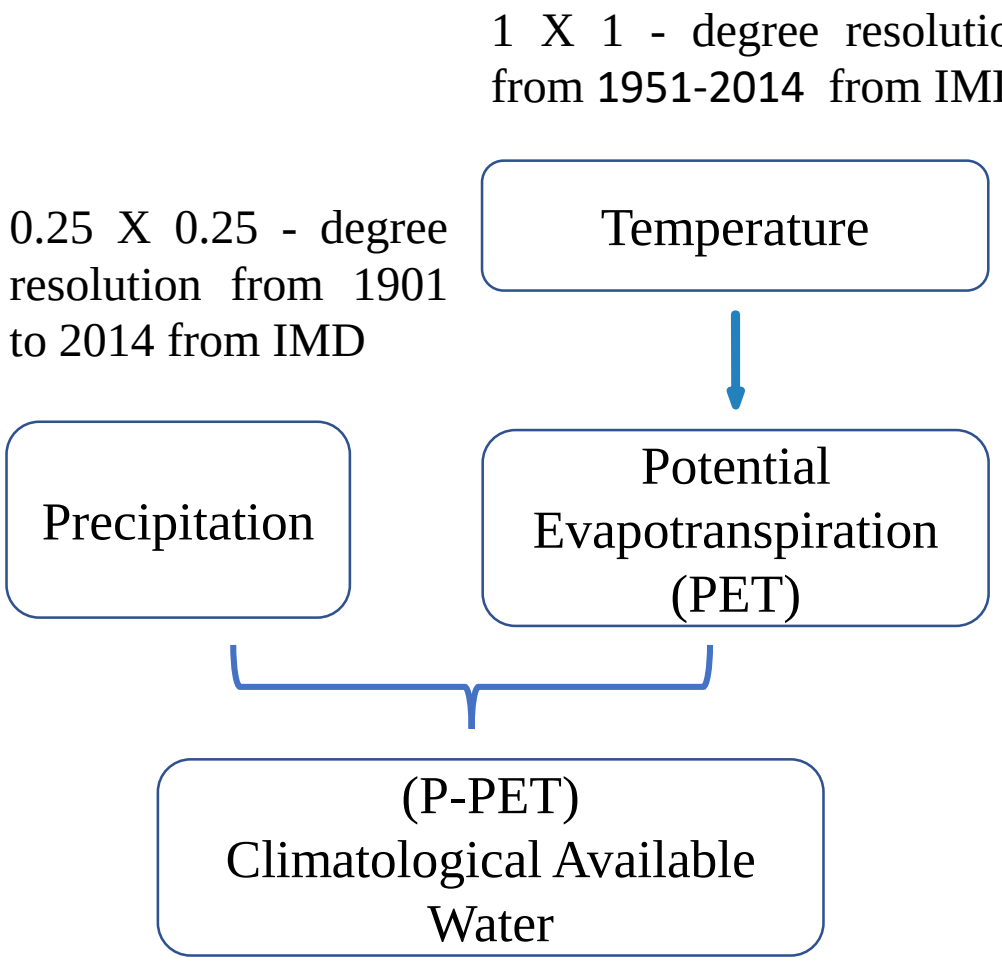
Estimation of Fresh Water Availabilities



$$PET = 0.0023 * (T_{max} - T_{min})^{1/2} * (T_{mean} + 17.8) * R_a$$

T_{max} = Maximum air temperature

T_{min} = Minimum air temperature

T_{mean} = Average air temperature

R_a = Extra-terrestrial radiation expressed in equivalent evaporation units and calculated using the latitude of the location and time of the year.

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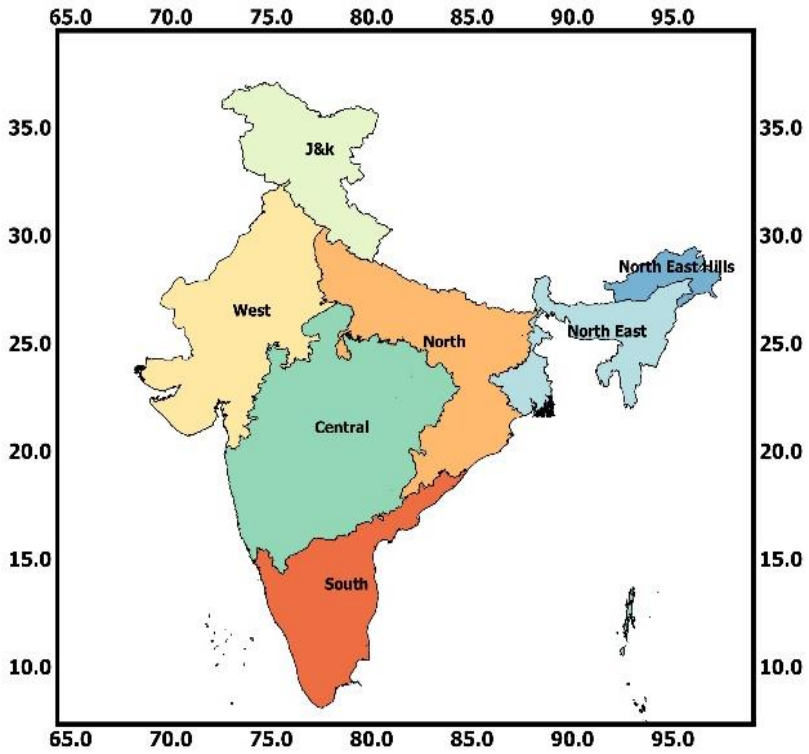
Case Study



Meteorological homogeneous zones of India

Zone	Precipitation (mm)	PET (mm)	Water/Energy Limited Zone
South	1248	1695	Water Limited
West	545	1768	Water Limited
North	1180	1688	Water Limited
Central	1084	1800	Water Limited
J&K	1025	1343	Water Limited
North-East	2118	1473	Energy Limited
North-East Hills	2715	1434	Energy Limited

P < PET – Water Limited
P>PET – Energy Limited

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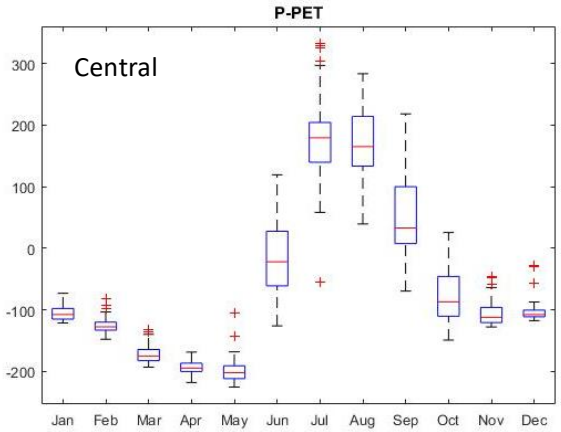
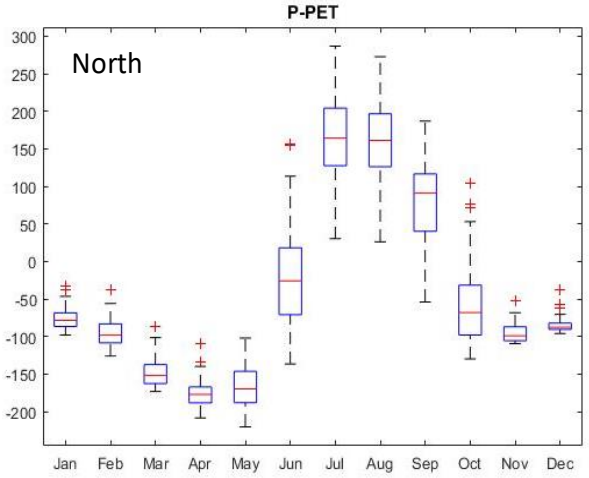
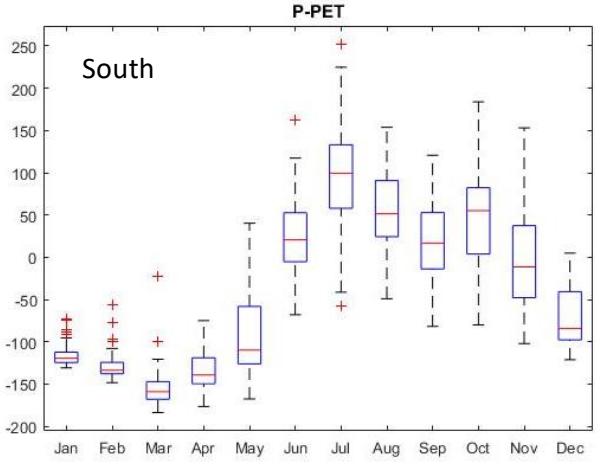
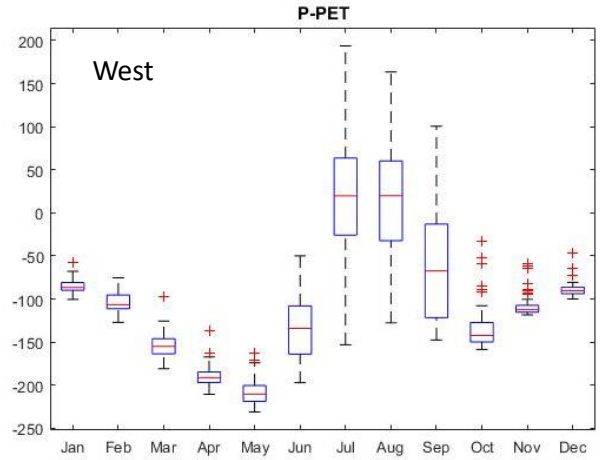
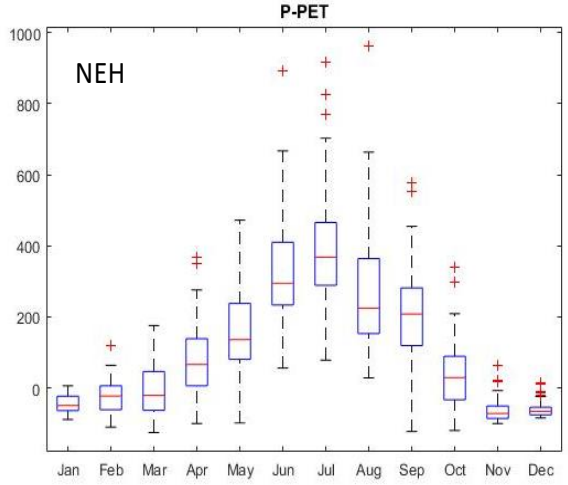
Temporal Variation of Water Availability Over India

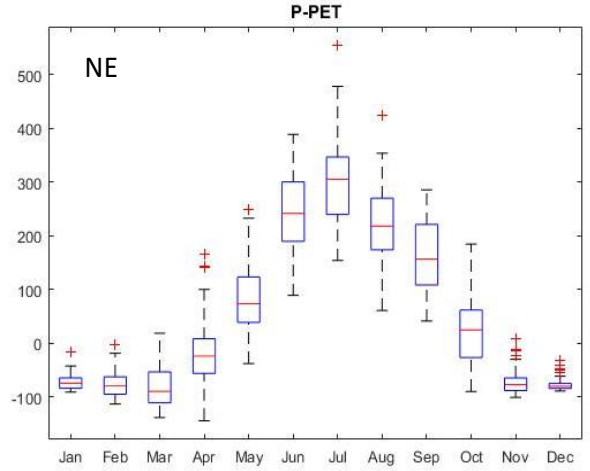


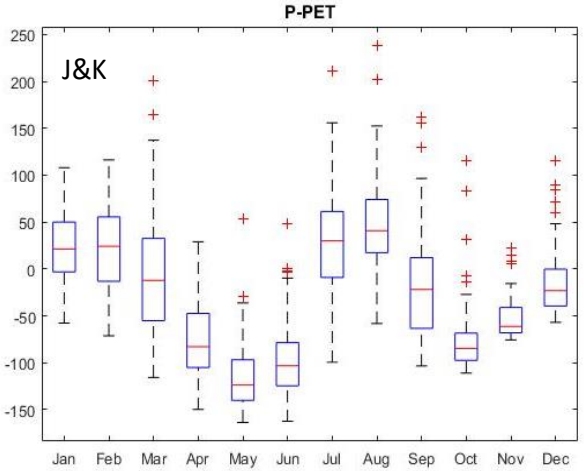


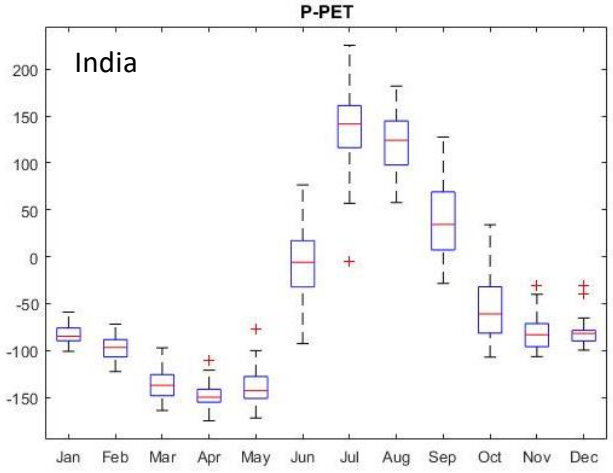












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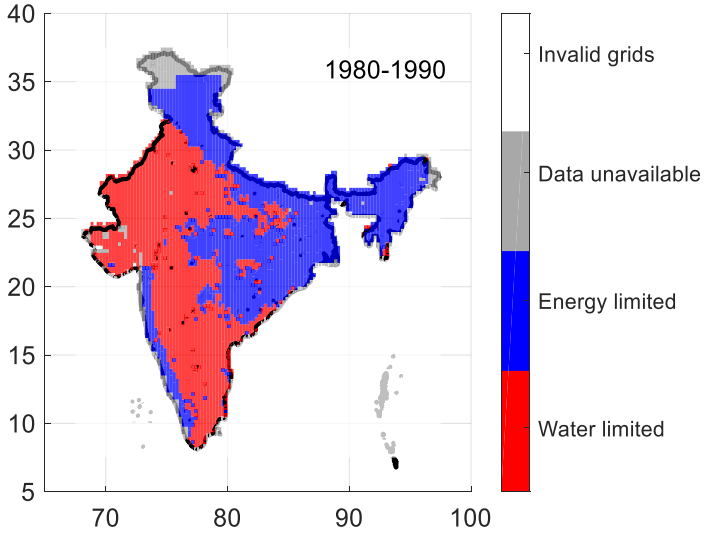
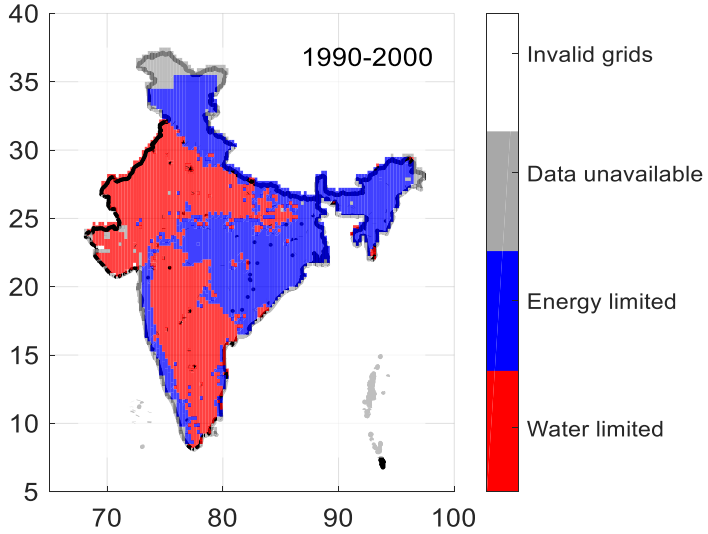
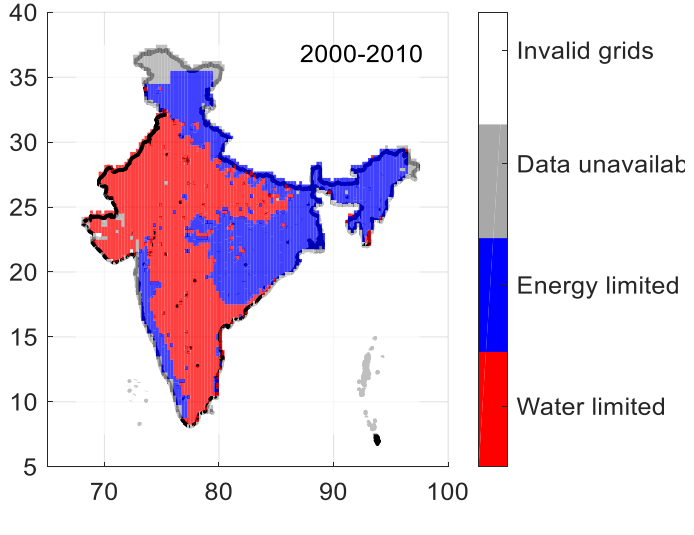
Results: Changes in Water and Energy Limited Zones over India Based on Remote Sensing PET







Global Land Evaporation Amsterdam Model (GLEAM) satellite-based ET data for the period of 1980 to 2018 at 0.25X0.25 degree resolution, https://www.gleam.eu/

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Assignment

The ratio of PET/P, commonly known as dryness index or aridity index, ϕ

The PET/P ratio (aridity index) will be used here as a way to differentiate between energy-limited and water-limited regions

Measure to study the extension of the deserts (extremely water-limited limited regions)

Regime	ϕ classification
Arid	$12>\phi\geq5$
Semi-arid	$5>\phi\geq2$
Sub-humid	$2>\phi\geq0.75$
Humid	$0.75>\phi\geq0.375$

Assignment

1. To classify water-energy limited zones of India
2. To study the variability of the landscape’s (India) aridity
3. To study the variability of water security of India
    1. Spatial variability
    2. Temporal variability

Assignment

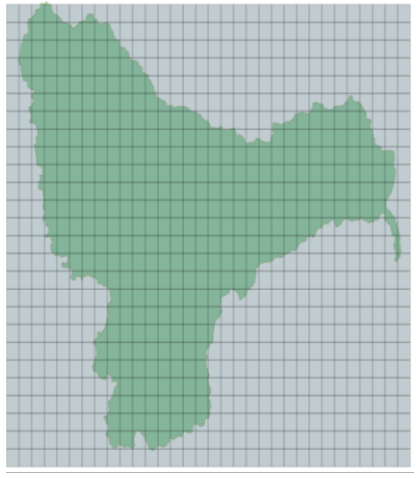
Spatial Resolution – 0.25X0.25 Degree
Temporal Resolution – Monthly data from 1951 to 2014 – 64 X12 = 768

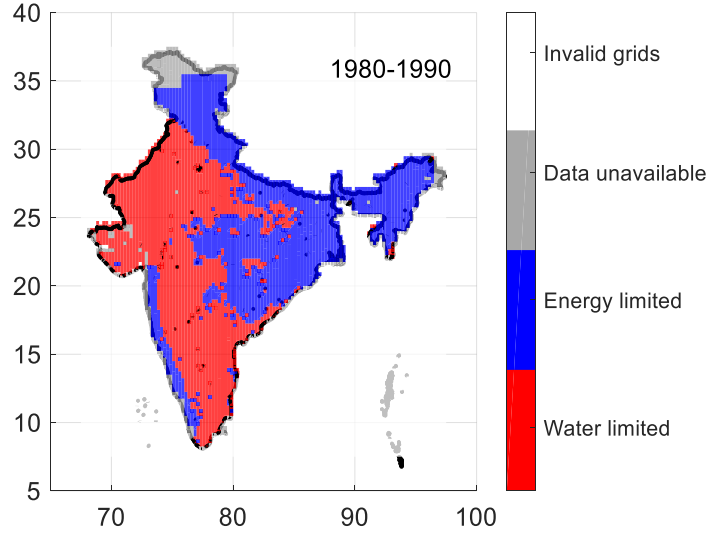
Longitude (longitude)

grid: /X (degree_east)
ordered (66.5E) to (100E) by
0.25 N= 135 pts :grid

Latitude (latitude)

grid: /Y (degree_north)
ordered (6.5N) to (38.5N) by
0.25 N= 129 pts :grid





Data : rain_India – 121X121X768
PET_India - 121X121X768

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