Introduction to Integrated Mountain Watershed Management

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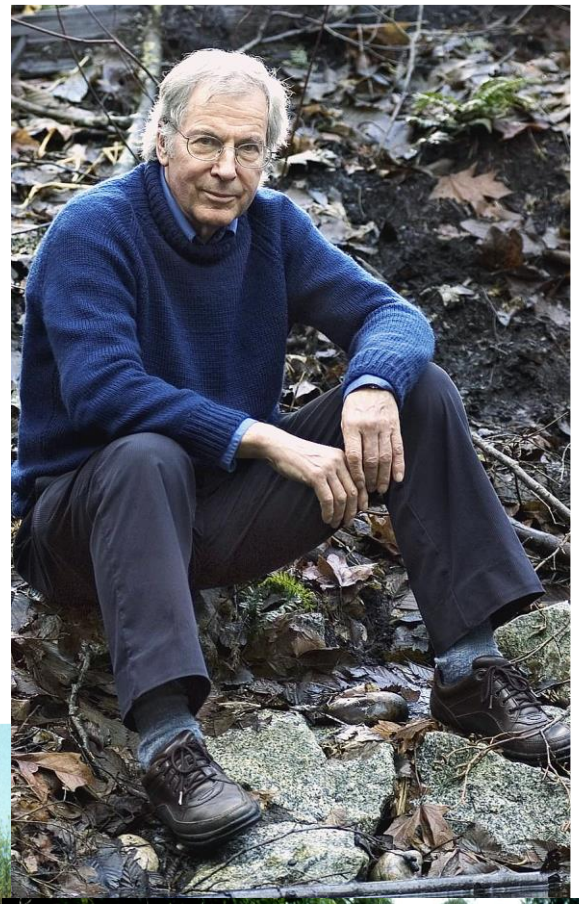
A Brief Introduction:
Hans Schreier works in the Land & Water Systems Program at the University of British Columbia in Vancouver, Canada

My research focuses on Water Resources Management in Mountains.
I was very fortunate to be able to work in the Himalayas, The Andes, The Rocky Mountains and the Alp in Europe & NZ



Welcome to Virtual IPROMO 2020

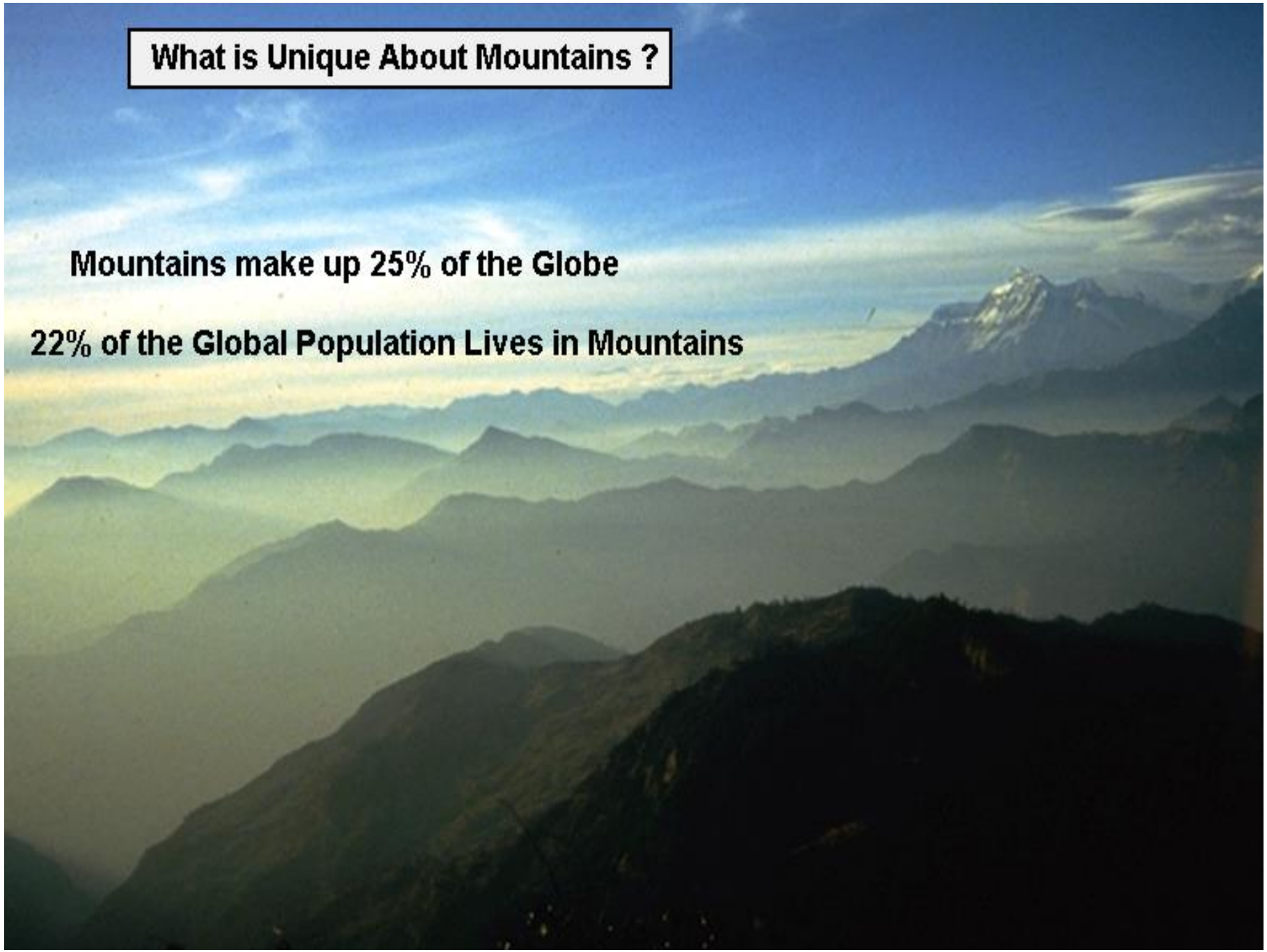
The Next 8 Sessions will cover the following Topics:

Day 2. Sept. 29, 2020

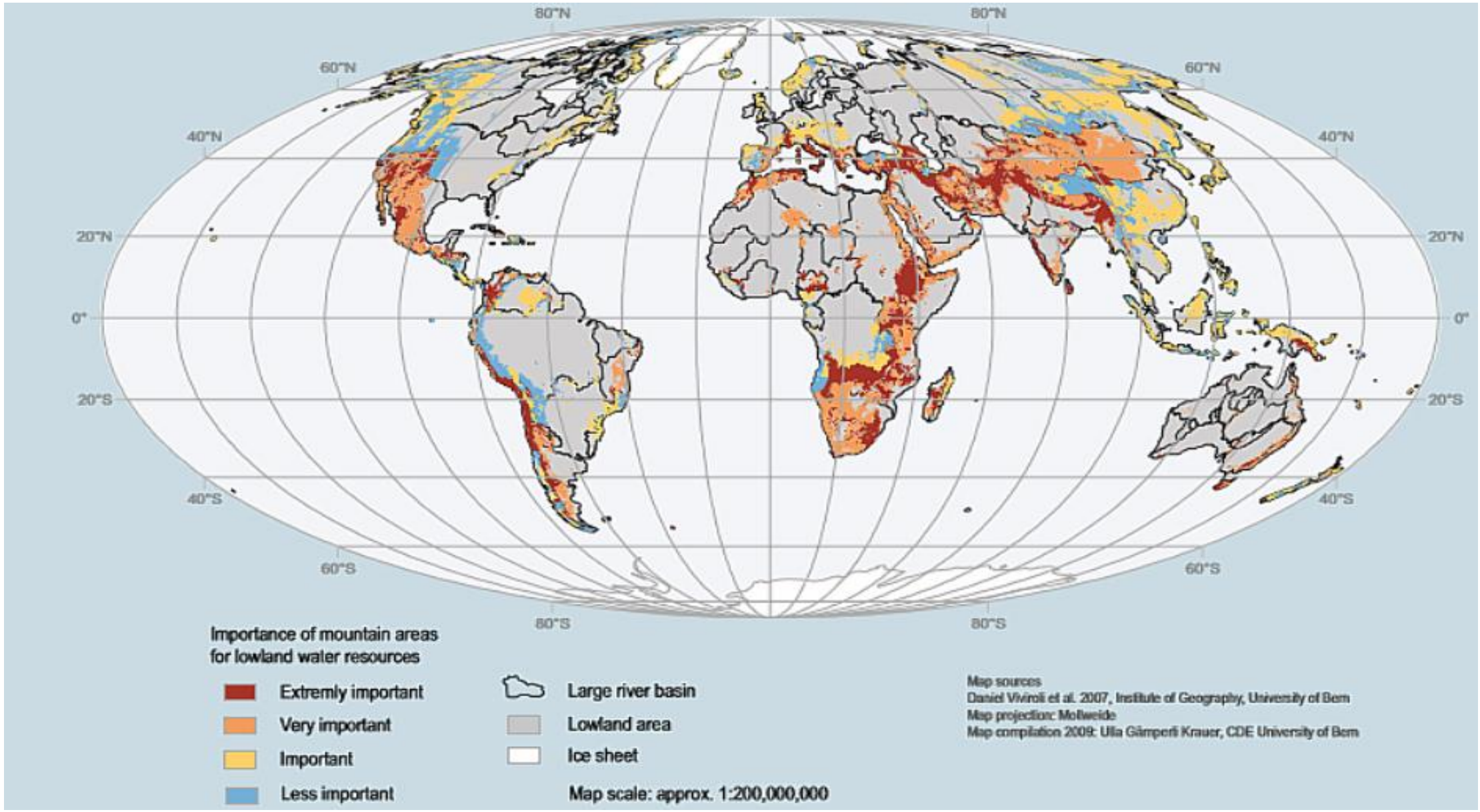
1. Introduction to Mountain Watershed Management
2. Recent Climate Changes in Mountains
3. Adaptation Methods to Climate Change.
4. Reducing Emissions and Sequester Carbon

Day 3. Sept. 30, 2020

5. Water and Mountain Tourism
6. Hydropower Issues & Himalayan-Andes Projects
7. Virtual Water & Food Security
8. Water Conservation & Source Water Protection


What is Unique About Mountains ?
Mountains make up 25% of the Globe
22% of the Global Population Lives in Mountains

Importance of Mountains for Lowland Water Resources



Advantages

Mountains are the Water Towers for Humanity

Mountains are Biodiversity Hotspot

Mountains as a Recreational Paradise

Mountains have Sacret and Spiritual Values

Constraints

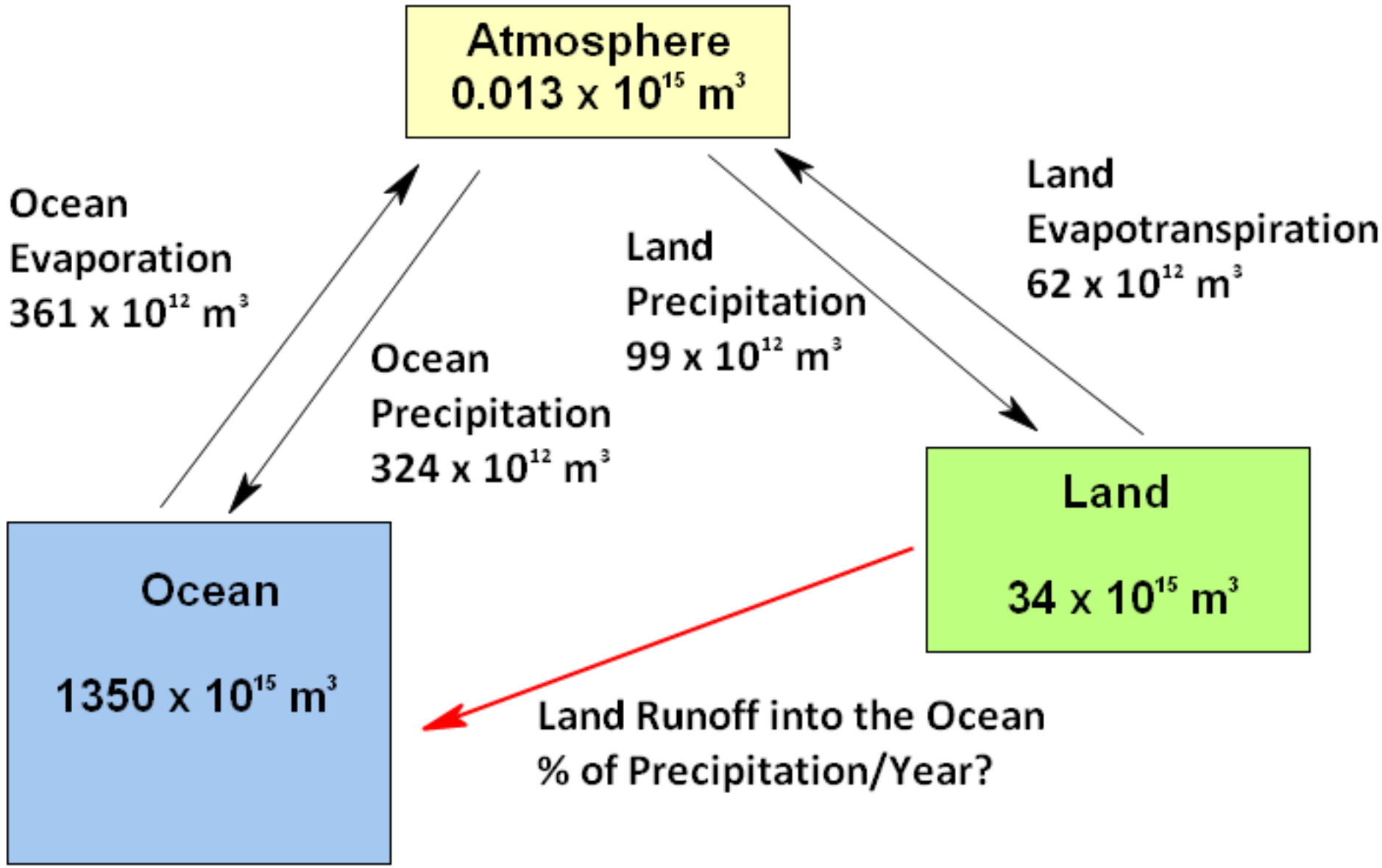
Mountains are Fragile, Hazardous and Have Low Resiliance

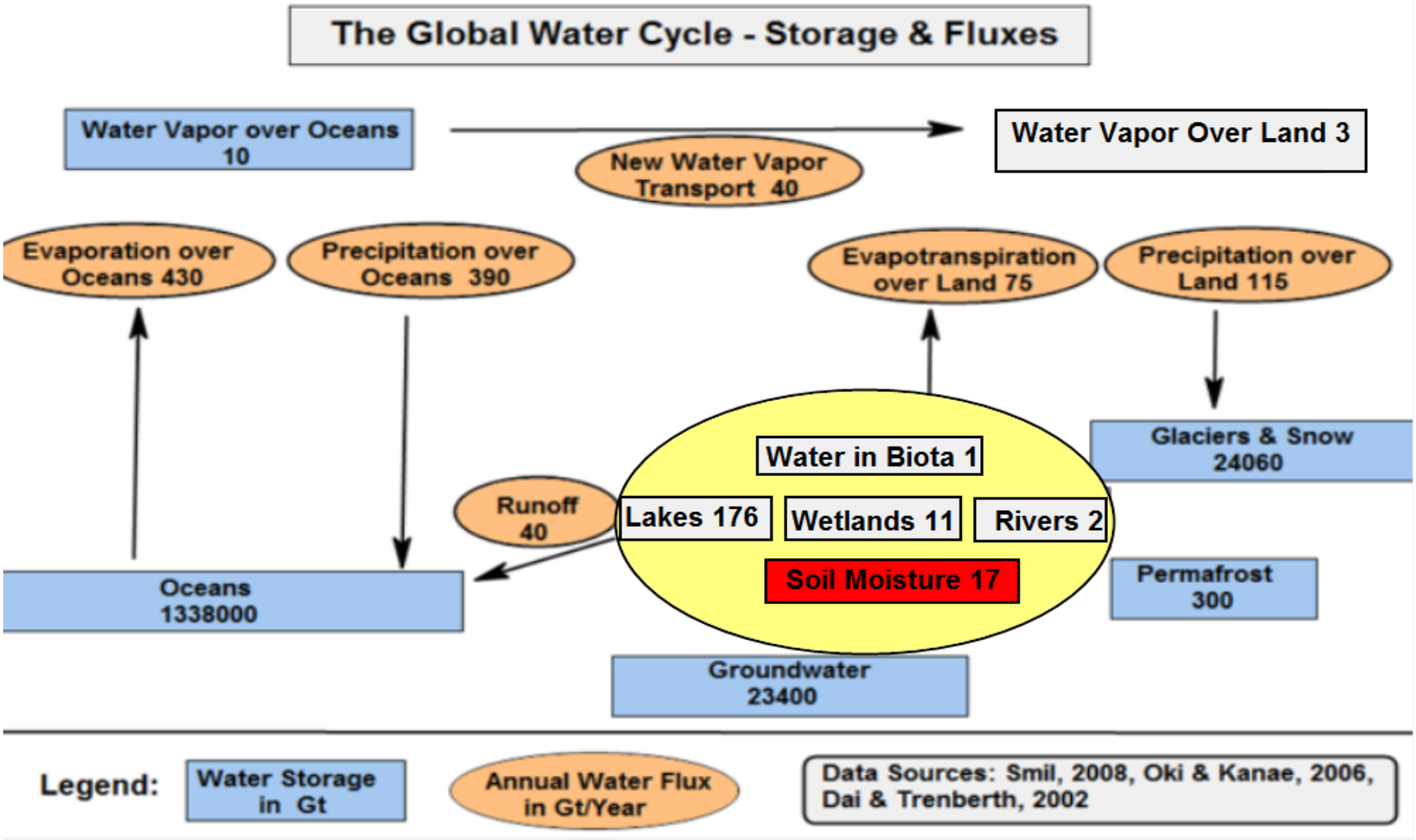
What Happens in Mountains can Have Very Large Impacts a Long Distance Downstream of Mountains

Mountain Areas Have Low Production Capacity and Transport in and out of Mountains is Difficult

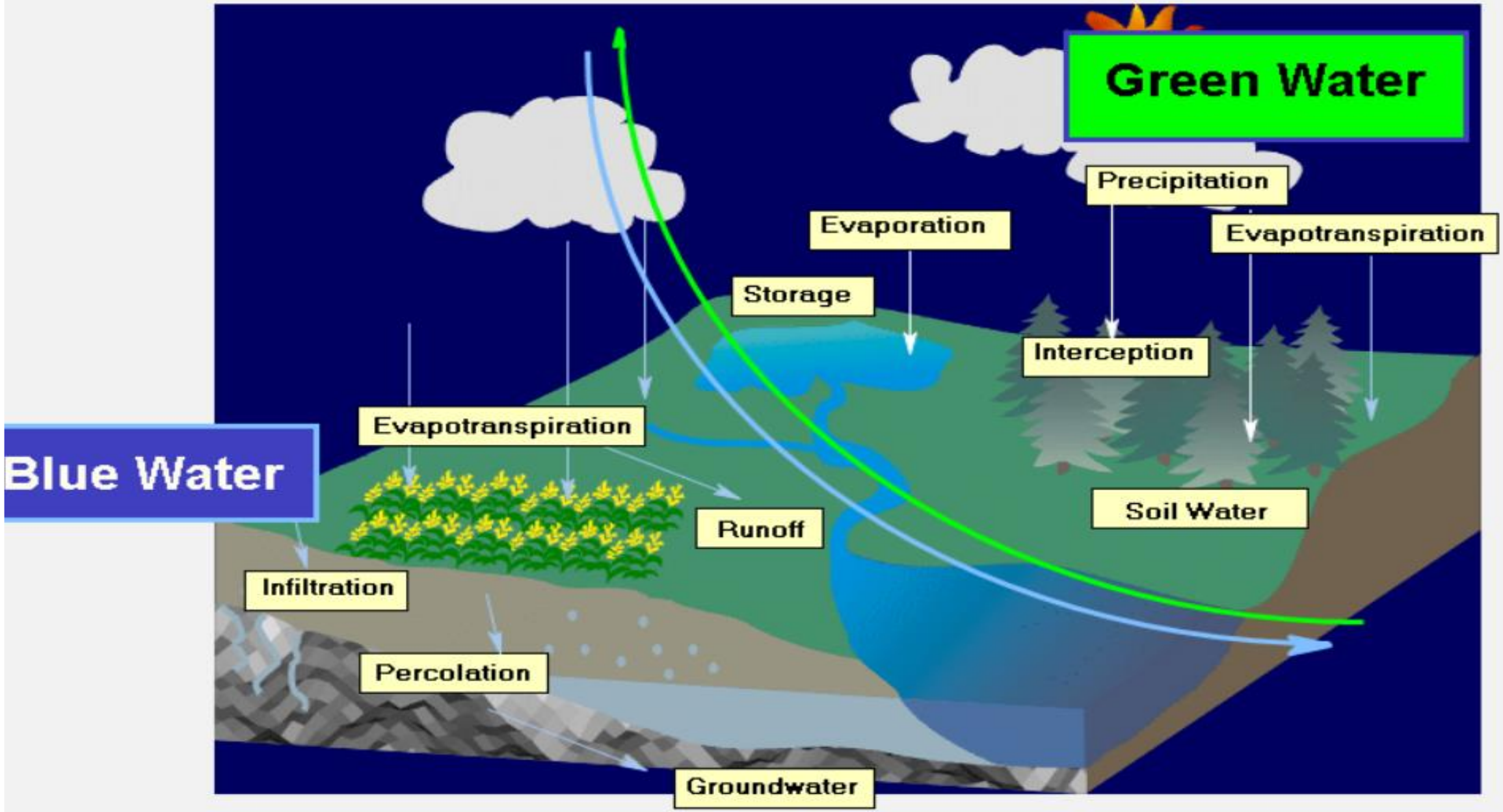
Many Conflicts Originate in Mountains (Poverty Issues)

Global Water Cycle

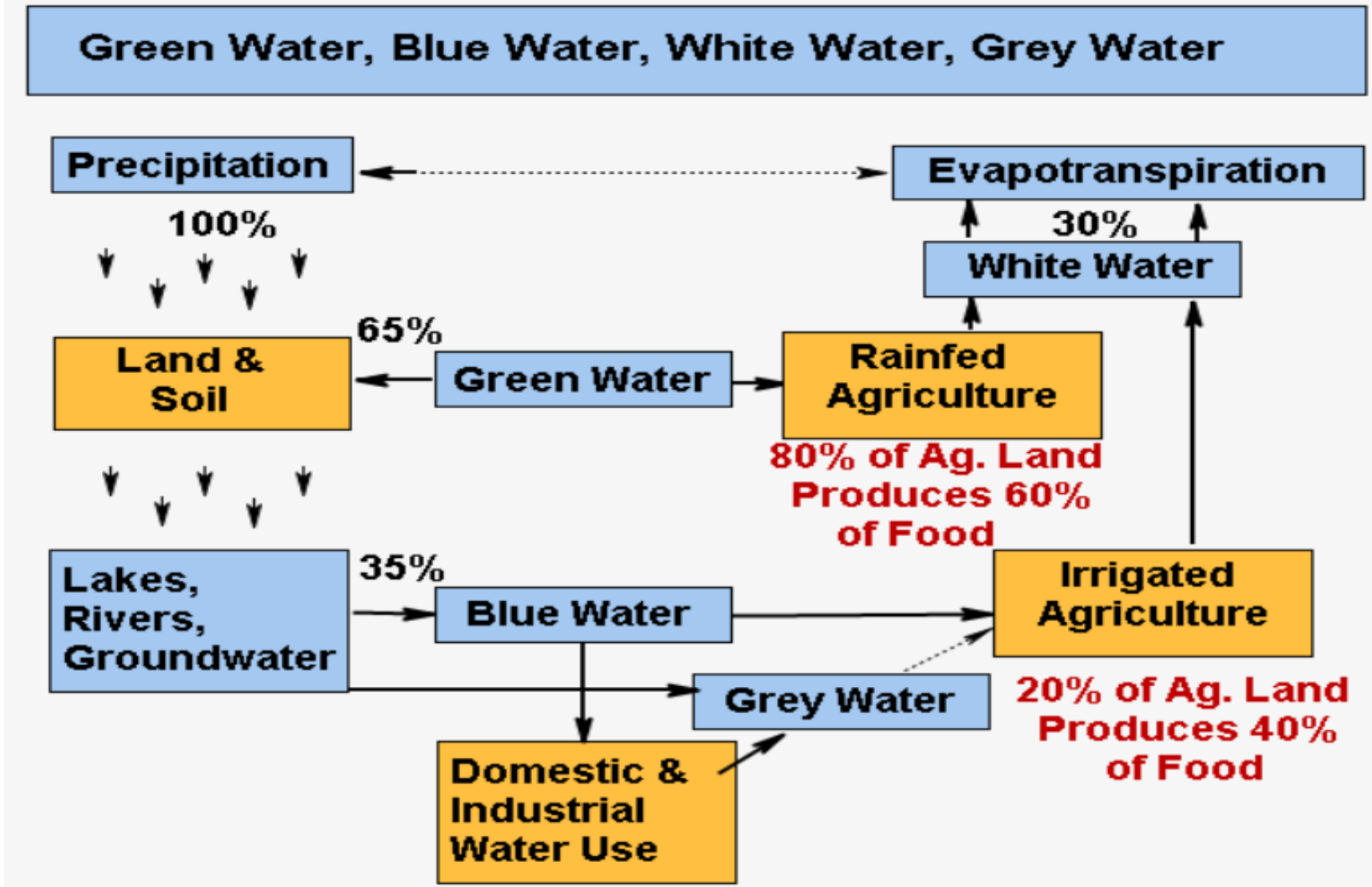



The Global Water Cycle - Storage & Fluxes
Water Vapor over Oceans 10
New Water Vapor Transport 40
Water Vapor Over Land 3
Evaporation over Oceans 430
Precipitation over Oceans 390
Evapotranspiration over Land 75
Precipitation over Land 115
Glaciers & Snow 24060
Water in Biota 1
Runoff 40
Lakes 176
Wetlands 11
Rivers 2
Soil Moisture 17
Permafrost 300
Oceans 1338000
Groundwater 23400
Legend:
Water Storage in Gt
Annual Water Flux in Gt/Year
Data Sources: Smil, 2008, Oki & Kanae, 2006, Dai & Trenberth, 2002

The Blue and Green Hydrological Cycle



The Proportion of Water Moving Through Different Cycles

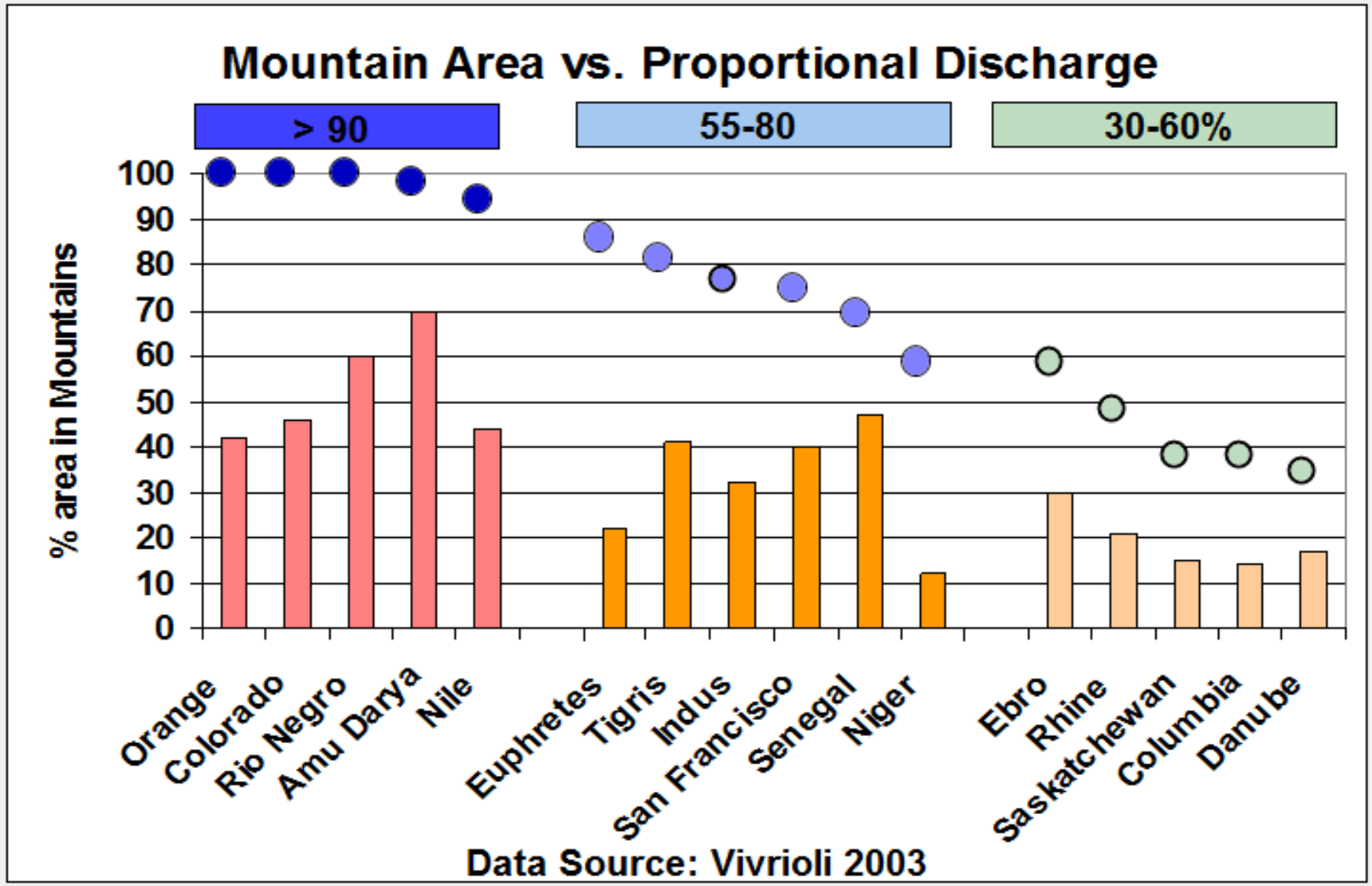


Mountains, the Water Towers of Humanity

The Mountains Portions in Different River Basins Provide Very Different Amounts of Water to the Lowland.

This Depends on Elevation, Climate Regime, Topographic Setting, Vegetation Cover and Land Use Activities

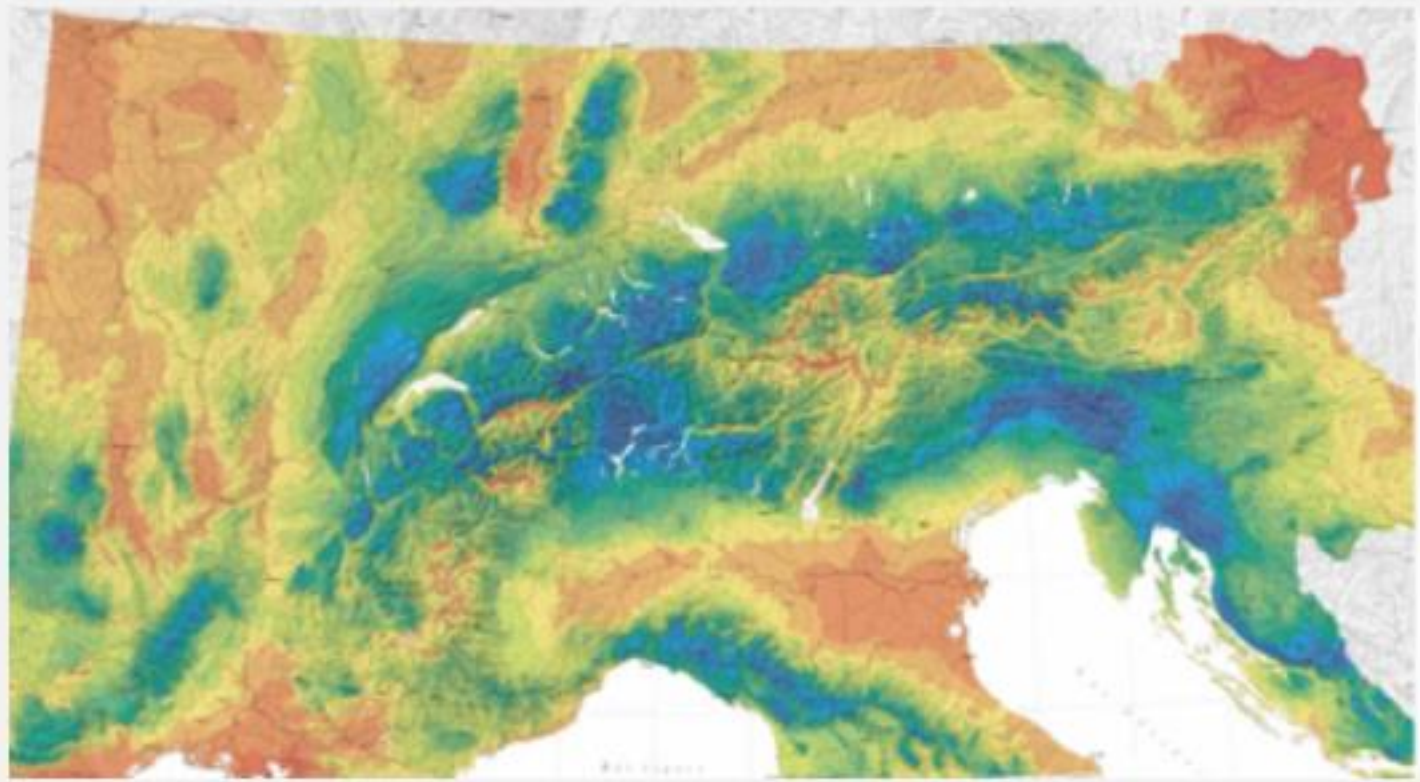
Proportional Discharge Contribution from Mountains in Major River Basins

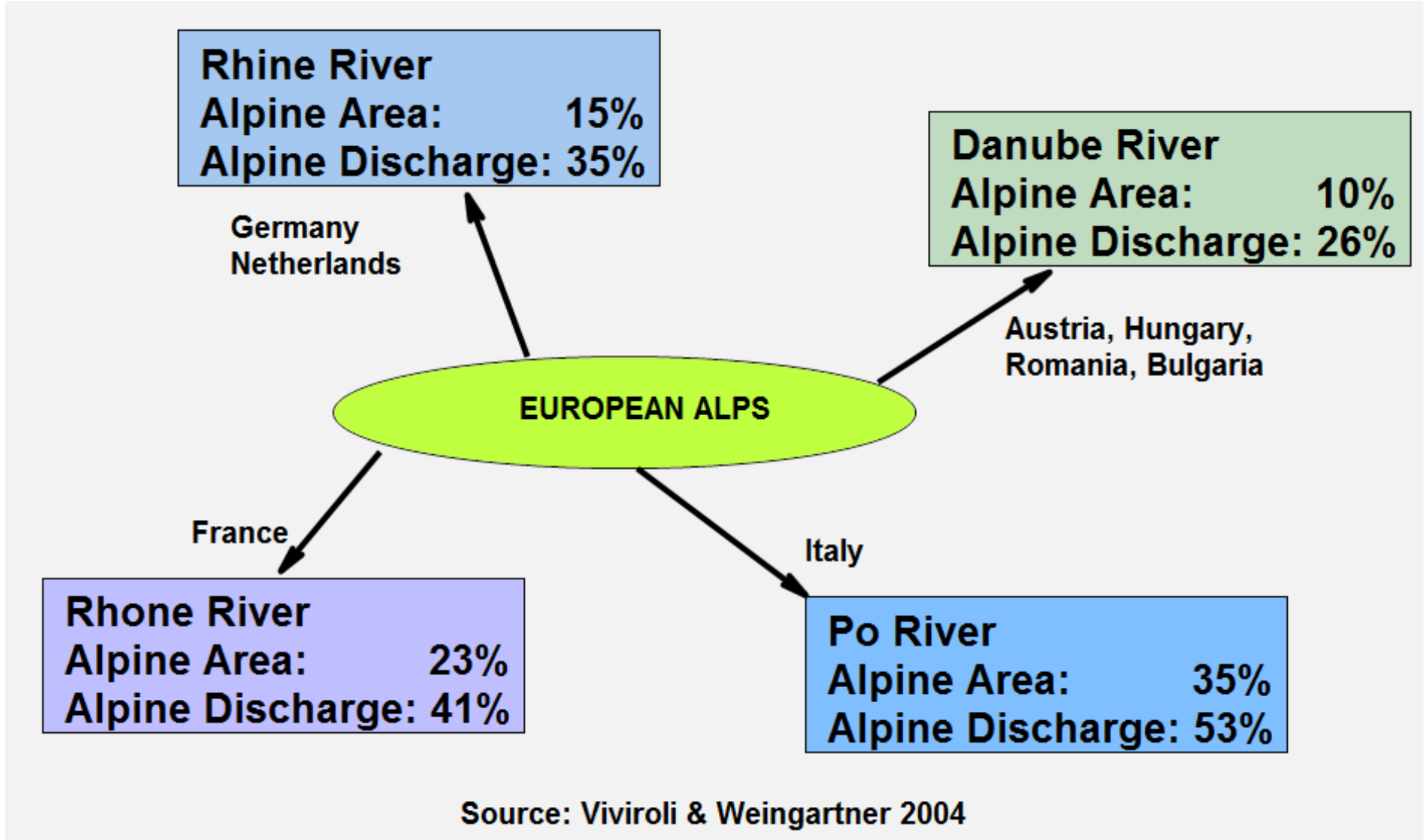


Runoff Surplus & Seasonal Supply

- Higher Rainfall and Lower Evapotranspiration than in Lowland
- Seasonal Redistribution: Accummulation & Melting of Snow
- Balancing Summer Effects in Lowland: Melting Snow & Ice

Annual Precipitation in Central Europe





Source: Viviroli & Weingartner 2004

Seasonal Impact

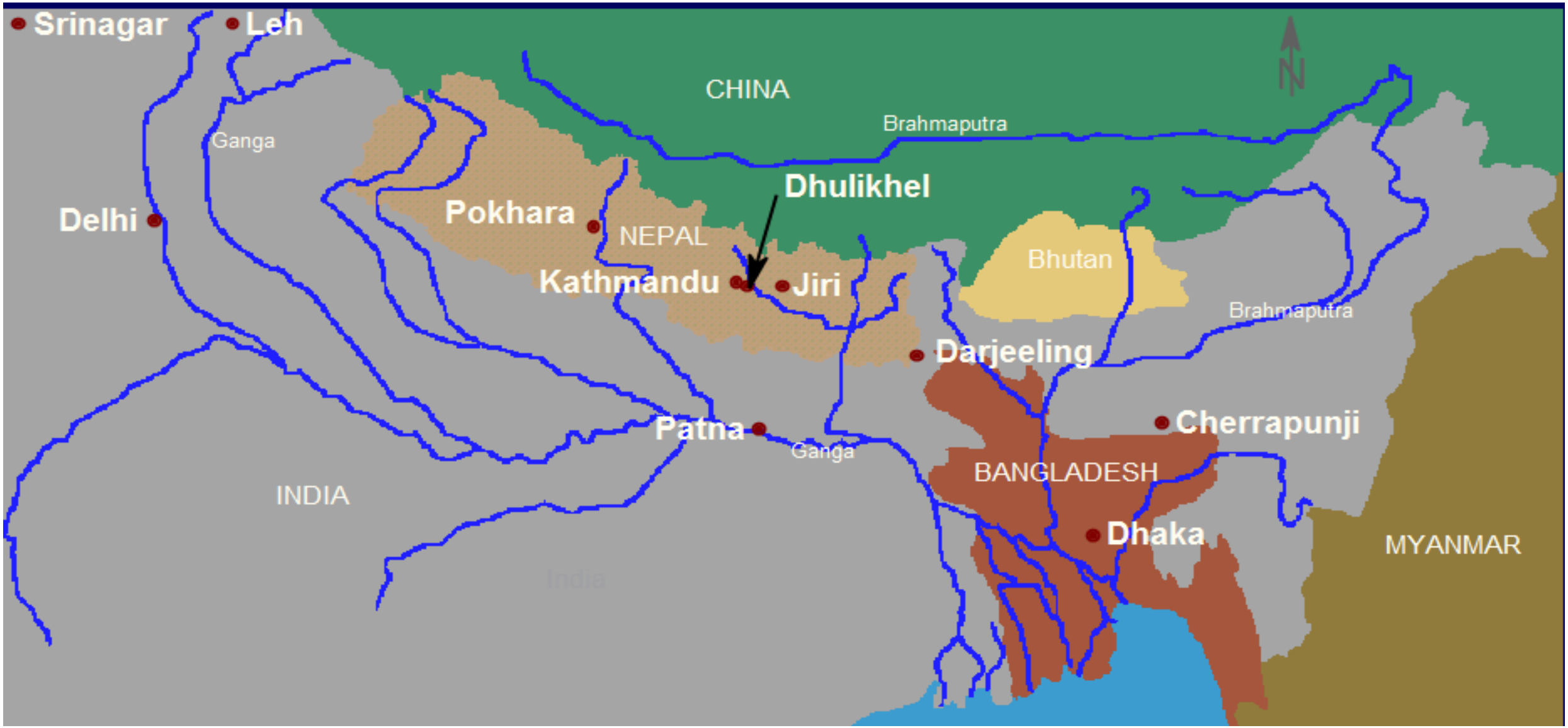
River Basins	Mountain Portion in Basin	Annual Contribution to Flow	Summer Contribution to Flow
Danube	10%	26%	36%
Po	35%	53%	80%
Rhine	15%	34%	52%
Rhone	23%	41%	69%

River Basins	Est. Basin Population Million	% in Mtn.	% Water from Mts	Monthly Discharge Billion m3/month		
				Lowest	Highest	Mean
Ganges	500	33%	65%	10.9	128.5	43.1
Nile	450	44%	93%	2.3	80.5	29.6
Yellow	190	41%	50%	0.6	10.3	5.7
Indus	160	31%	75%	6.7	40.7	19.9
Niger	110	11%	58%	0.1	90.7	28.2
Mekong	60	48%	34%	0.4	107.9	41.1

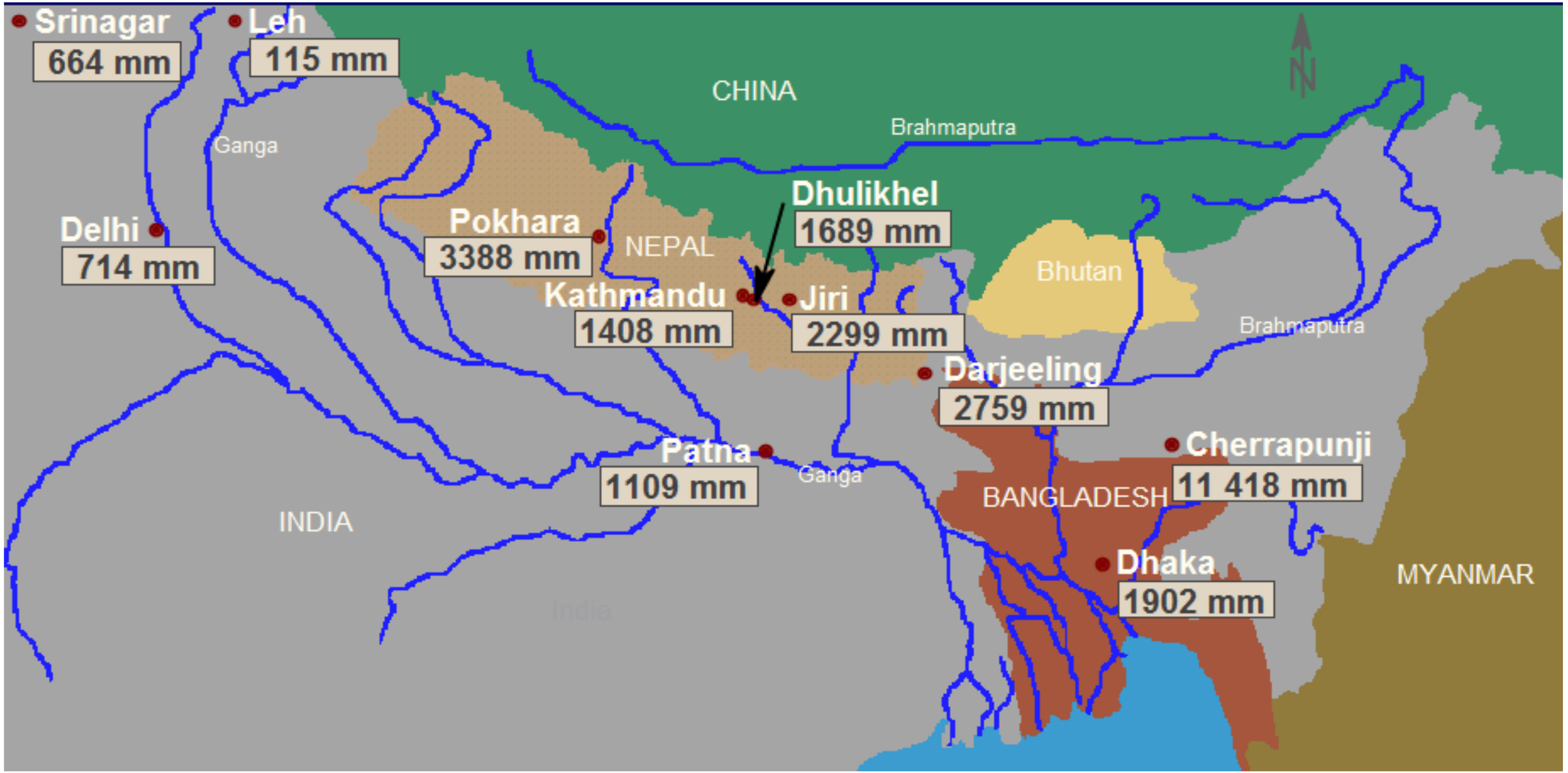
Categories Class	Water Availability Class	Average per Region
Absolute Water Scarcity	500 m3/person/year	MENA Countries
Water Scarcity	1000 m3/person/year	Sub-Saharan Africa
Water Stress	1700 m3/person/year	
Seasonal Stress	2500 m3/person/year	Caribbean

Risk of Water Shortages by River Basins	
Huang He, China	361 m3/person/year
Indus (India)	890 m3/person/year
Orange (South Africa)	1050 m3/person/year
Euphrates & Tigris (ME)	2189 m3/person/year
Nile (Egypt, Ethiopia)	2207 m3/person/year
Yangtze (China)	2265 m3/person/year

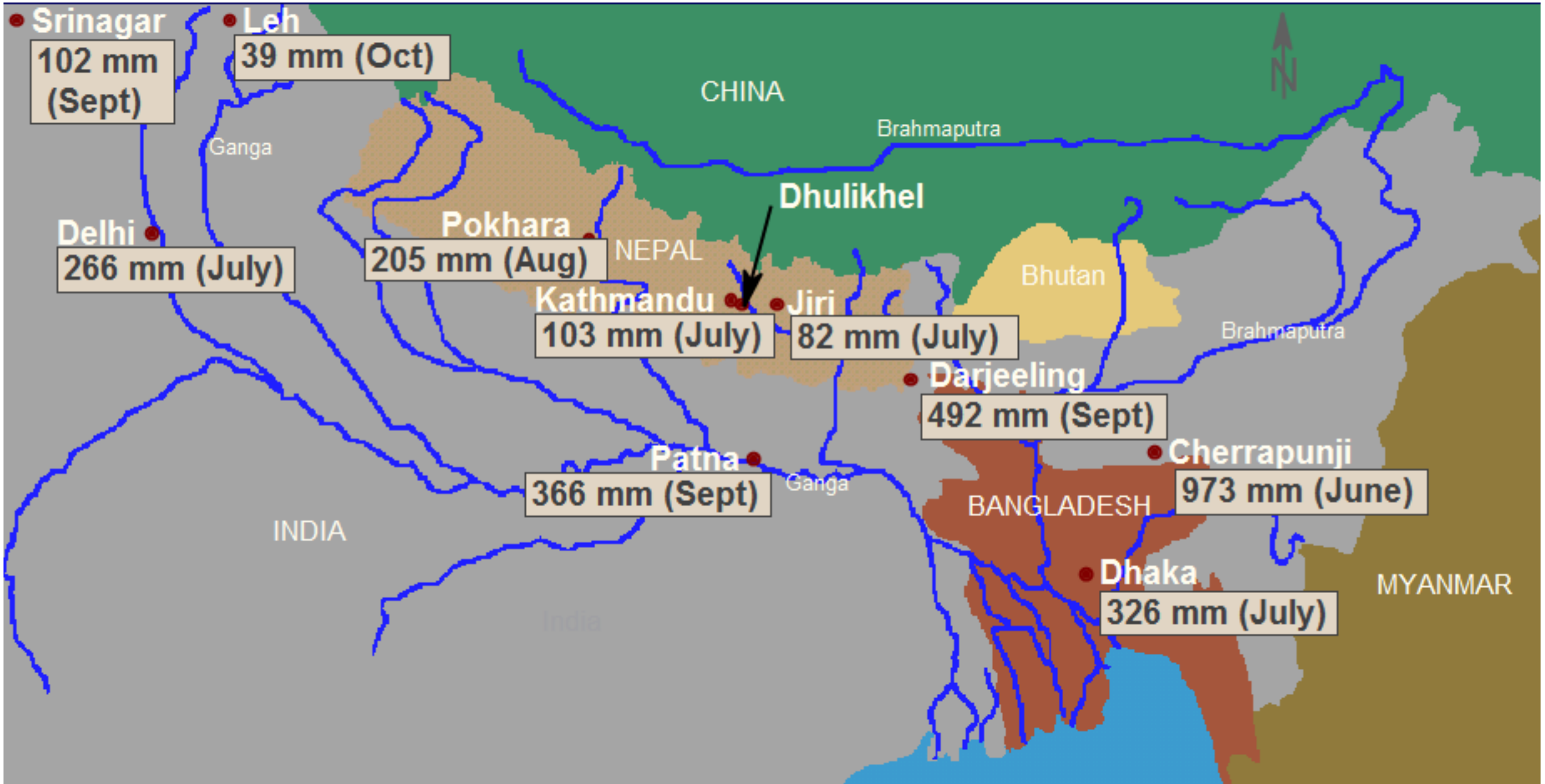
Himalayan **Mountain** Range



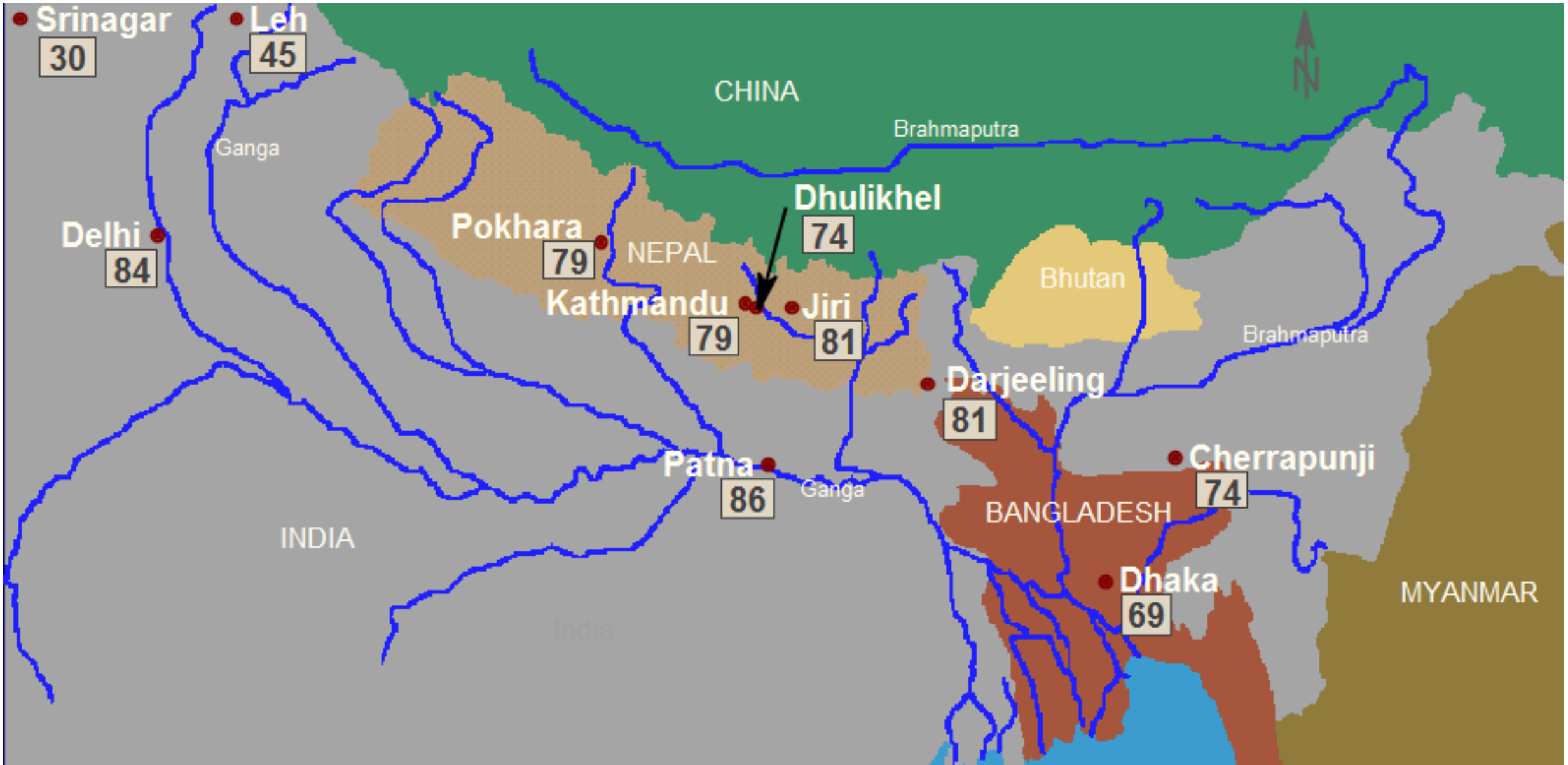
Variation in Annual **Precipitation** (in mm/Year)



Variation in 24 Hours Rainfall Intensity (mm/24 hrs)



% of annual Rainfall Between May-Aug (Monsoon)



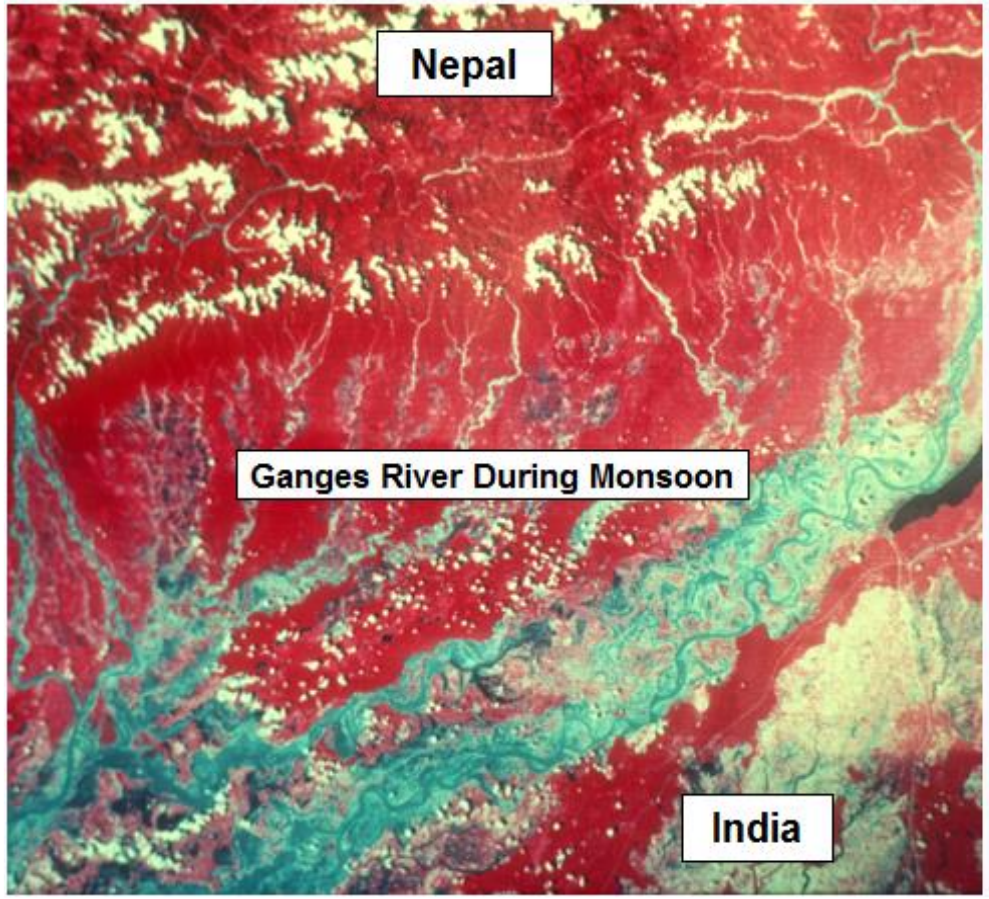
Variation in Annual Precipitation in Peru (mm/Year)

Great Variability in Peru's Climate

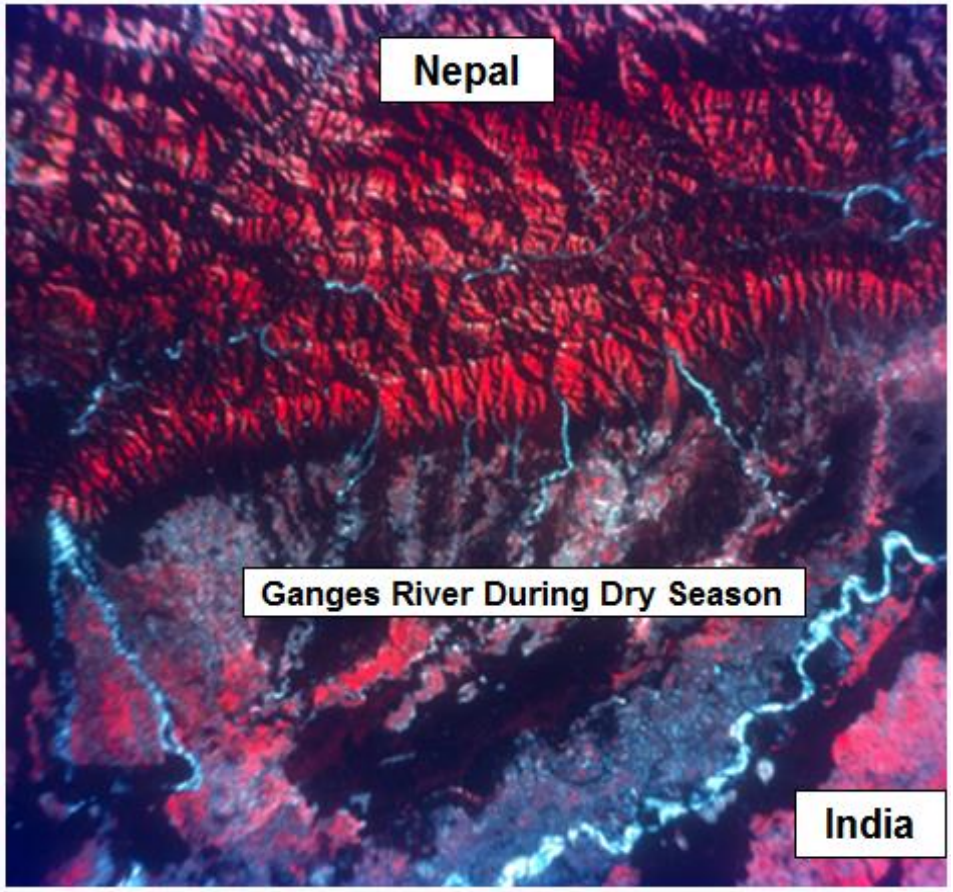
	Mean Temperatures	Annual Precipitation
Coast	21 °C	5-10 mm
Mountains	12 °C	400-700 mm
Tropics	32 °C	1900-3200 mm

More than 1/3 of the population lives in the coastal region (13 out of 35 Million)

Wet Season



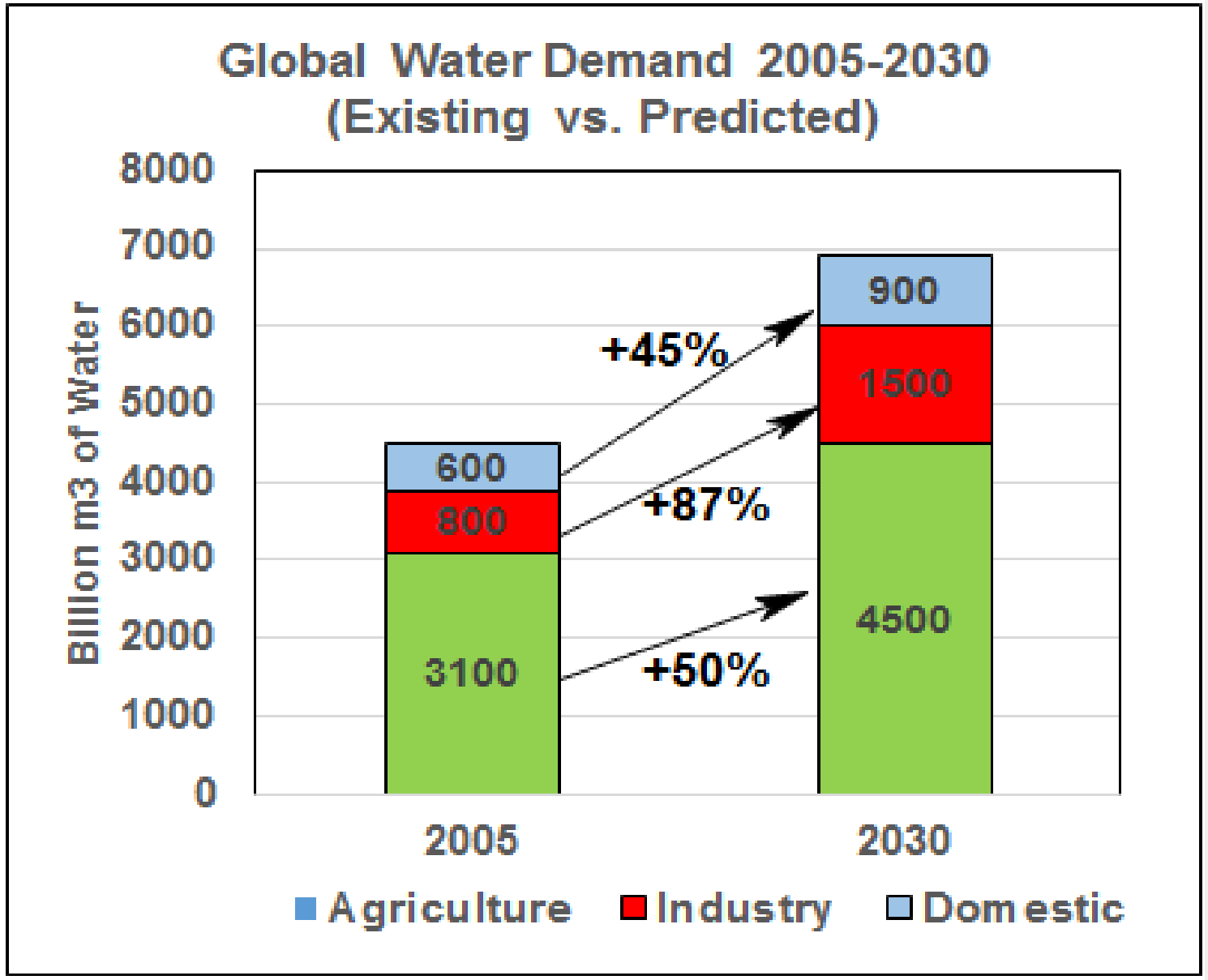
Dry Season



Why would the Runoff of Major Mountain Rivers Change?

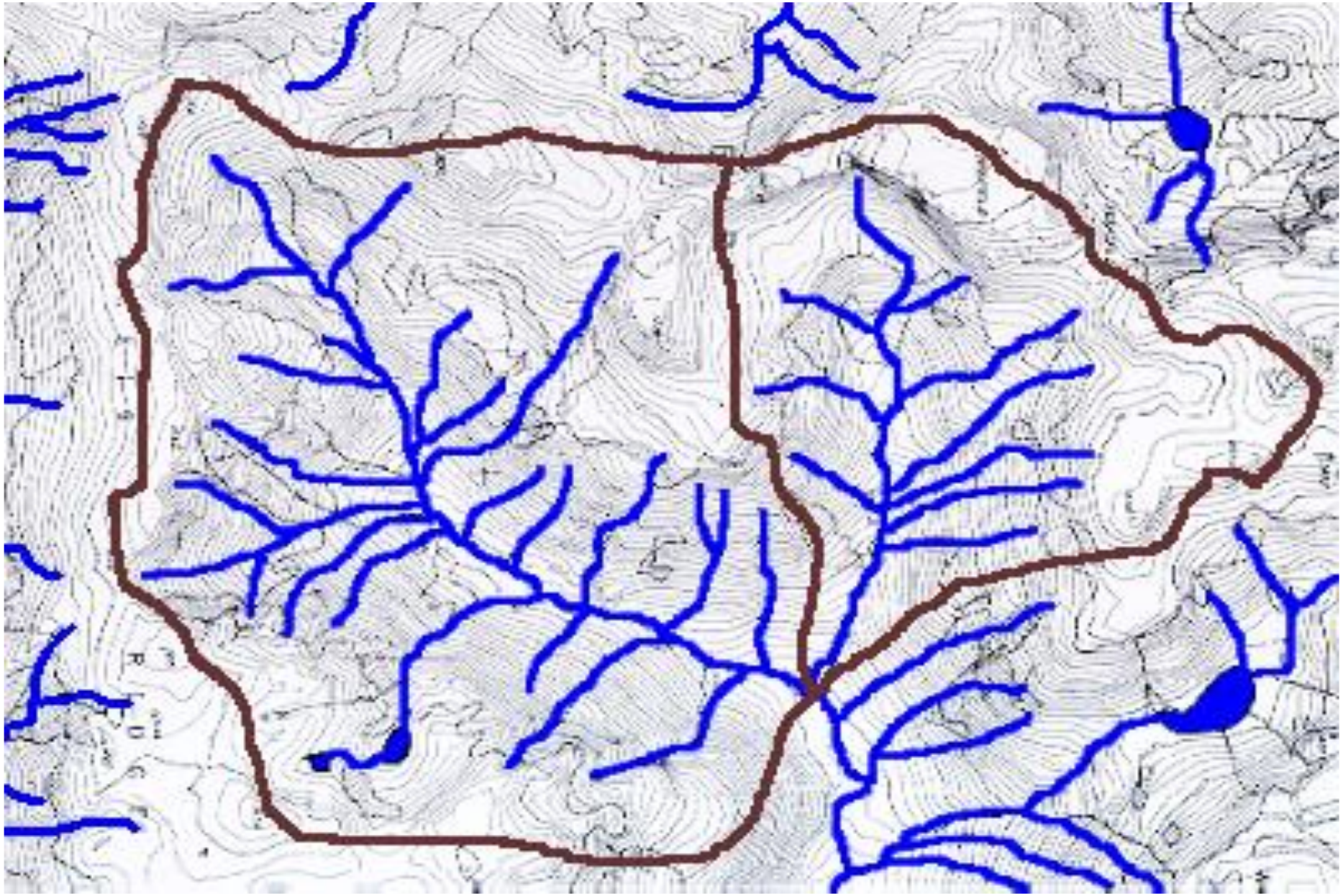
- Change in Precipitation
- Change in Snow Accumulation & Runoff
- Change in Glacial Melting
- Dams and Reservoirs
- Water Extraction & Use (Domestic, Irrigation)
- Changes in Vegetation Cover (Logging, Fires)
- Overuse of Groundwater Resources (Mining)
- Soil Compaction & Changes in Surface Cover

In 2010 69% of all Water was used for Agriculture

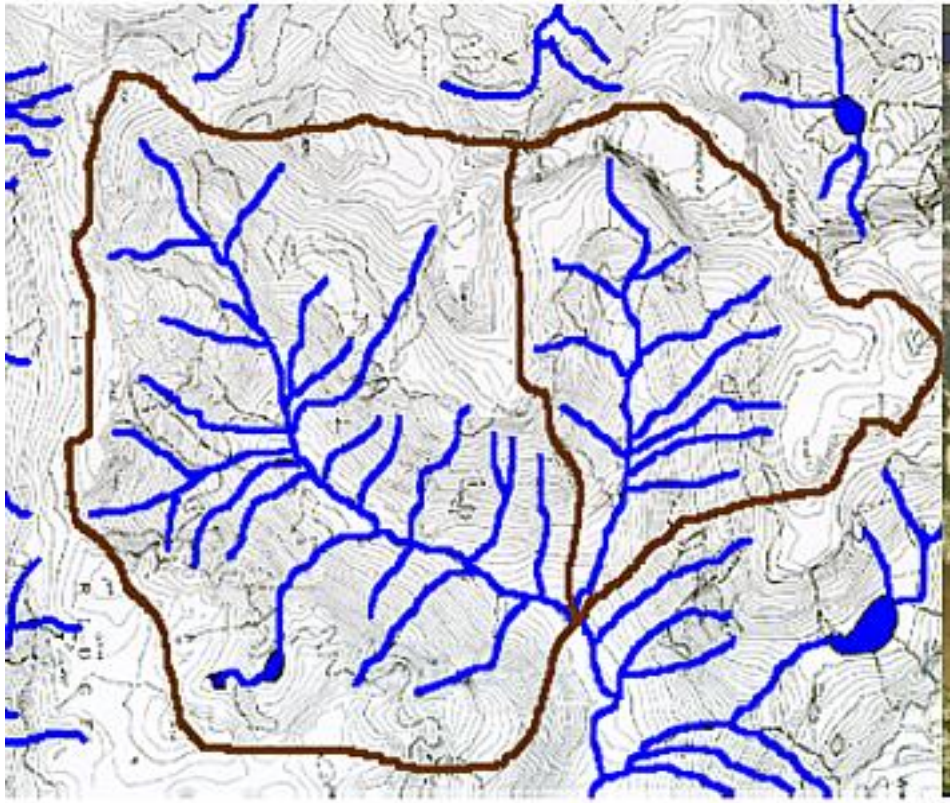


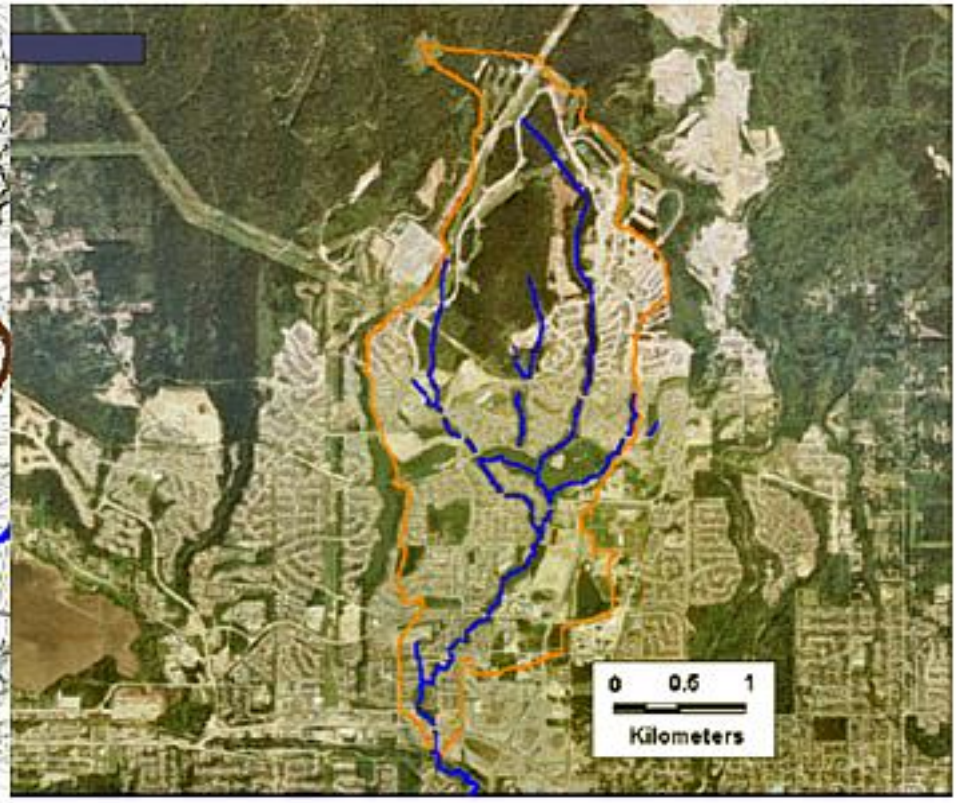
Data Source: McKinsey Corp. 2012

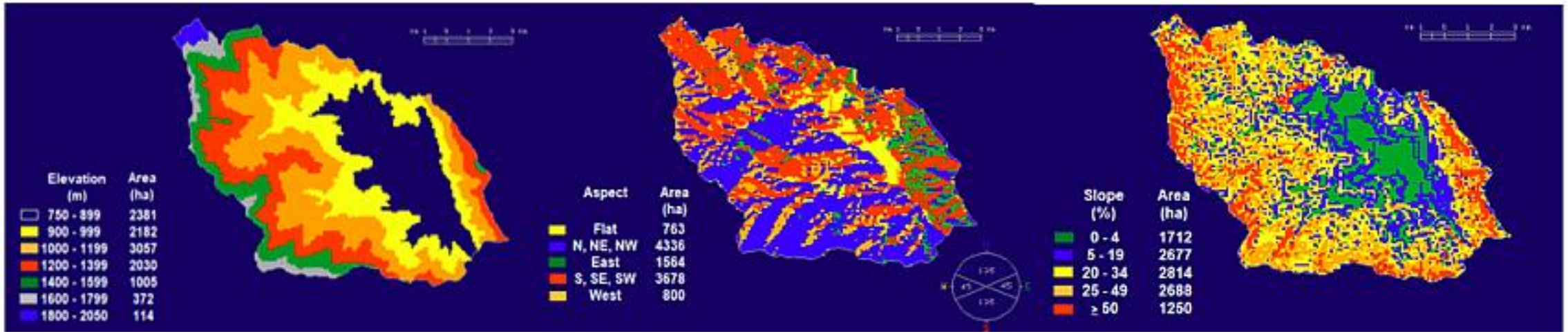
Why Integrated Watershed Management?



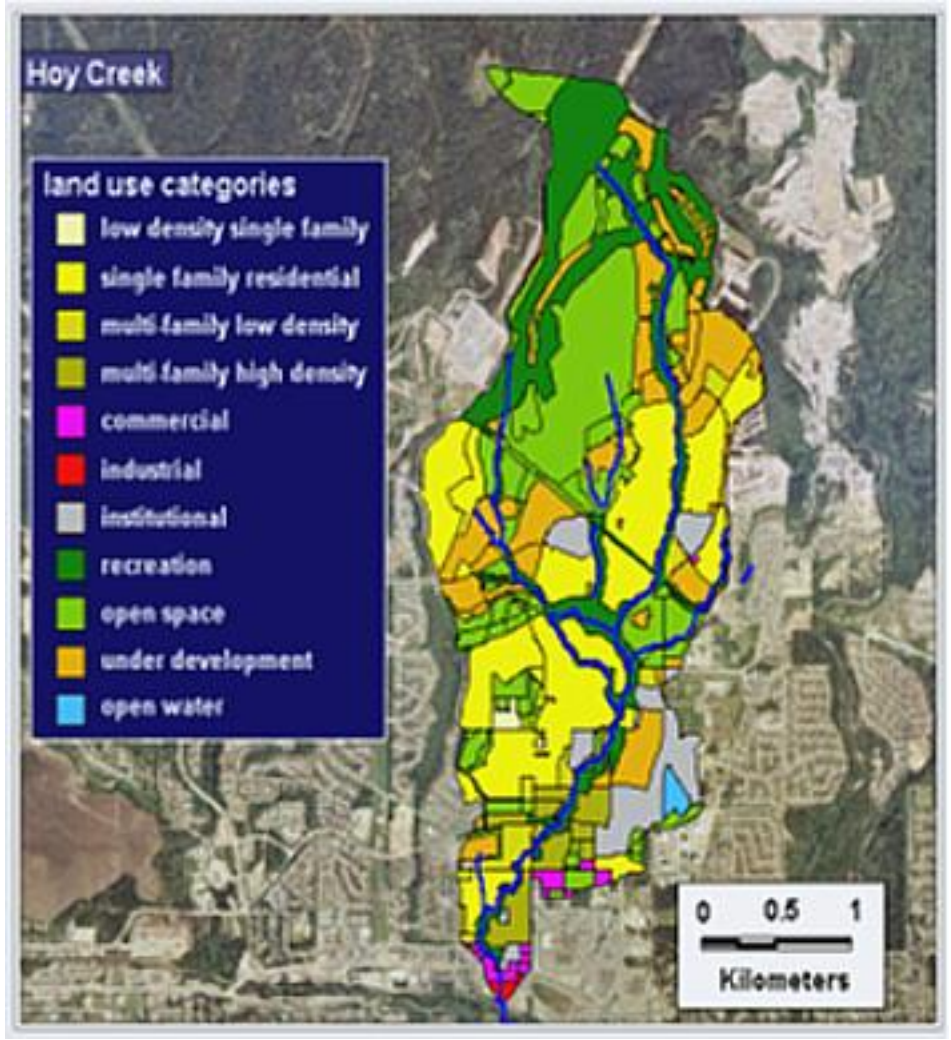
Building A Comprehensive Mountain Watershed Information System



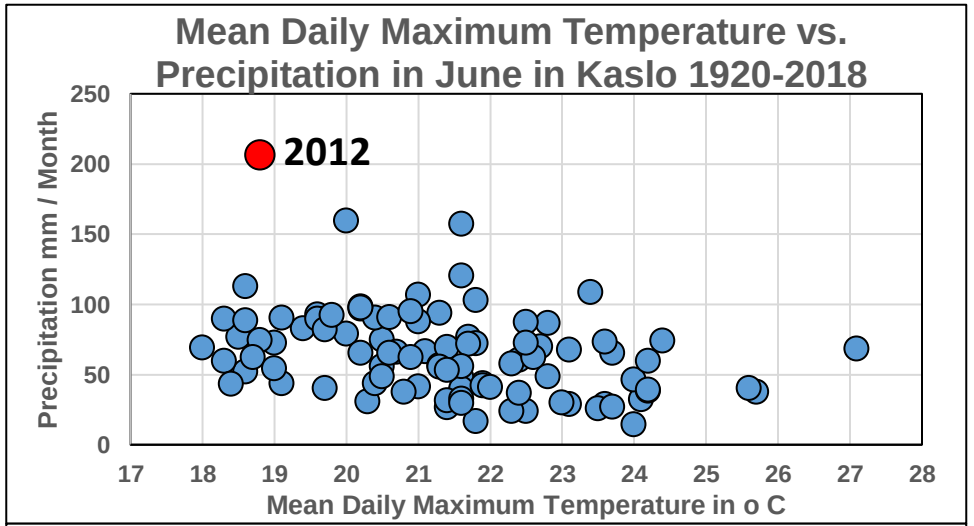


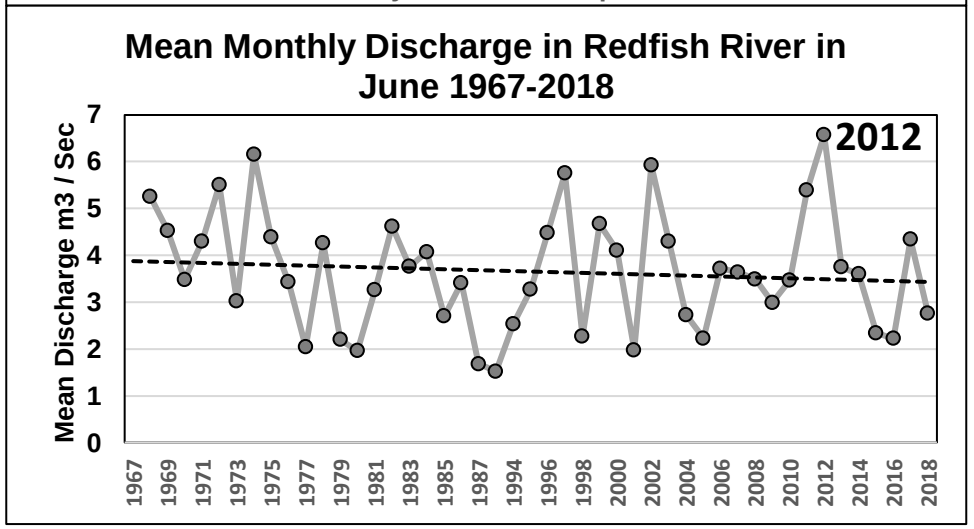


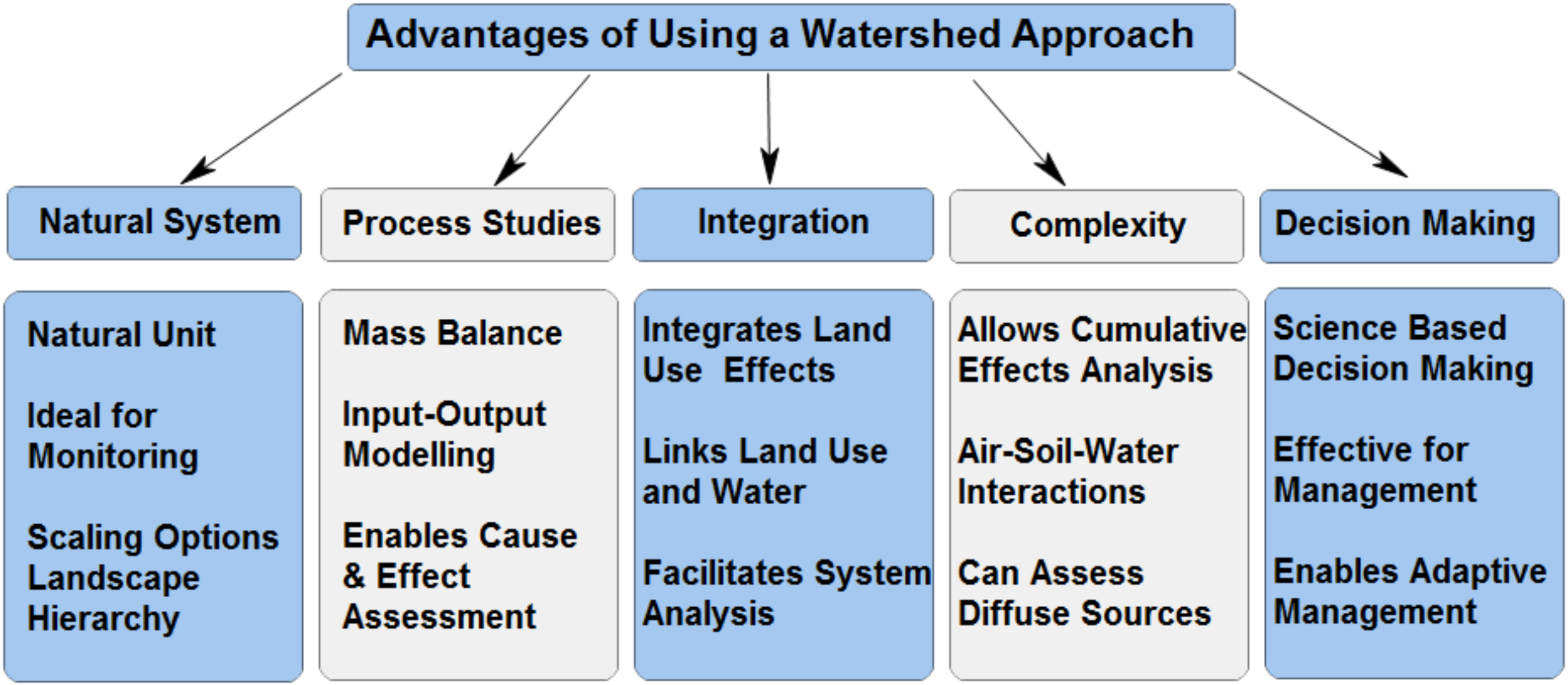
Land Use Map

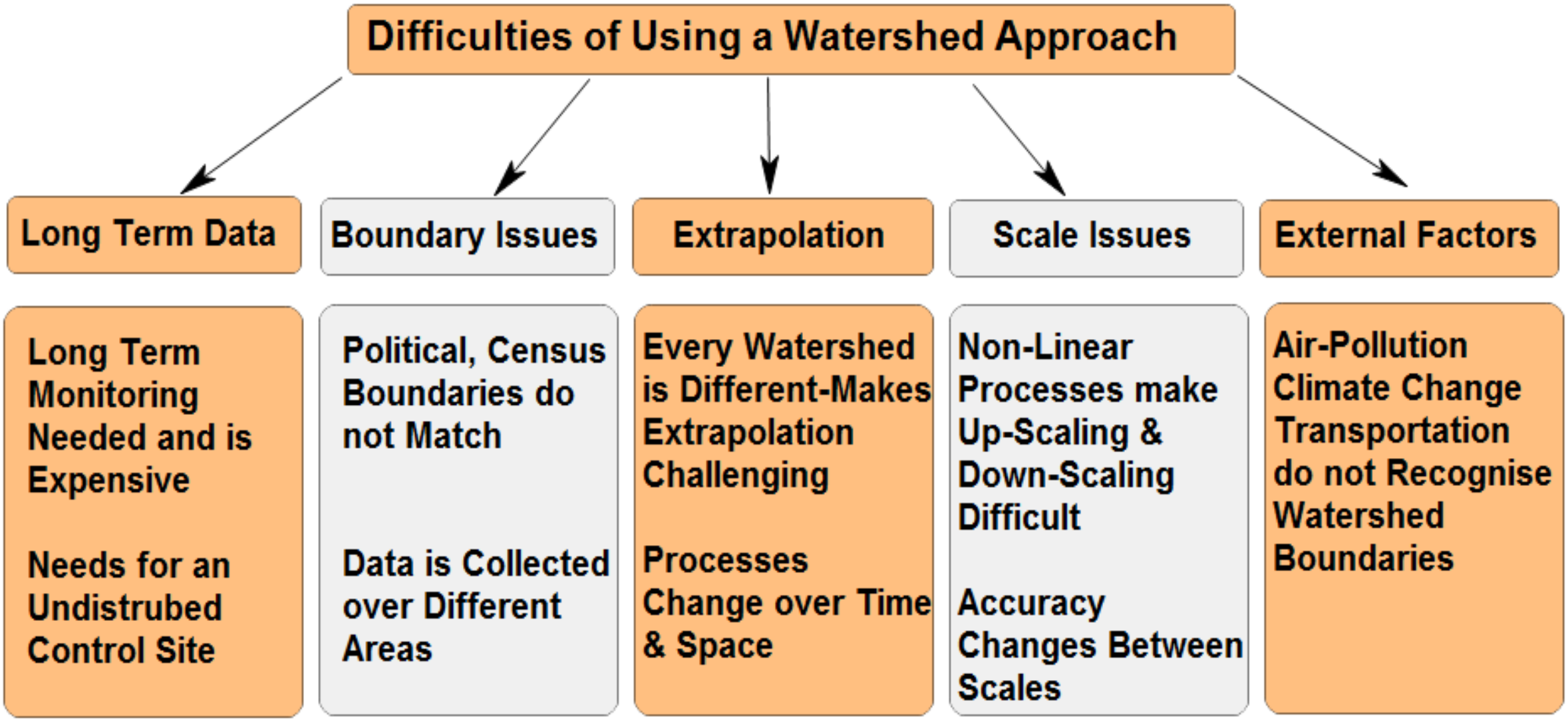


Climate and Hydrometric Information






Advantages of Using a Watershed Approach
Natural System
Process Studies
Integration
Complexity
Decision Making
Natural Unit
Ideal for Monitoring
Scaling Options Landscape Hierarchy
Mass Balance
Input-Output Modelling
Enables Cause & Effect Assessment
Integrates Land Use Effects
Links Land Use and Water
Facilitates System Analysis
Allows Cumulative Effects Analysis
Air-Soil-Water Interactions
Can Assess Diffuse Sources
Science Based Decision Making
Effective for Management
Enables Adaptive Management


Difficulties of Using a Watershed Approach
Long Term Data
Boundary Issues
Extrapolation
Scale Issues
External Factors
Long Term Monitoring Needed and is Expensive
Needs for an Undistrubed Control Site
Political, Census Boundaries do not Match
Data is Collected over Different Areas
Every Watershed is Different-Makes Extrapolation Challenging
Processes Change over Time & Space
Non-Linear Processes make Up-Scaling & Down-Scaling Difficult
Accuracy Changes Between Scales
Air-Pollution Climate Change Transportation do not Recognise Watershed Boundaries

Land Use Change and Climate Change Interaction

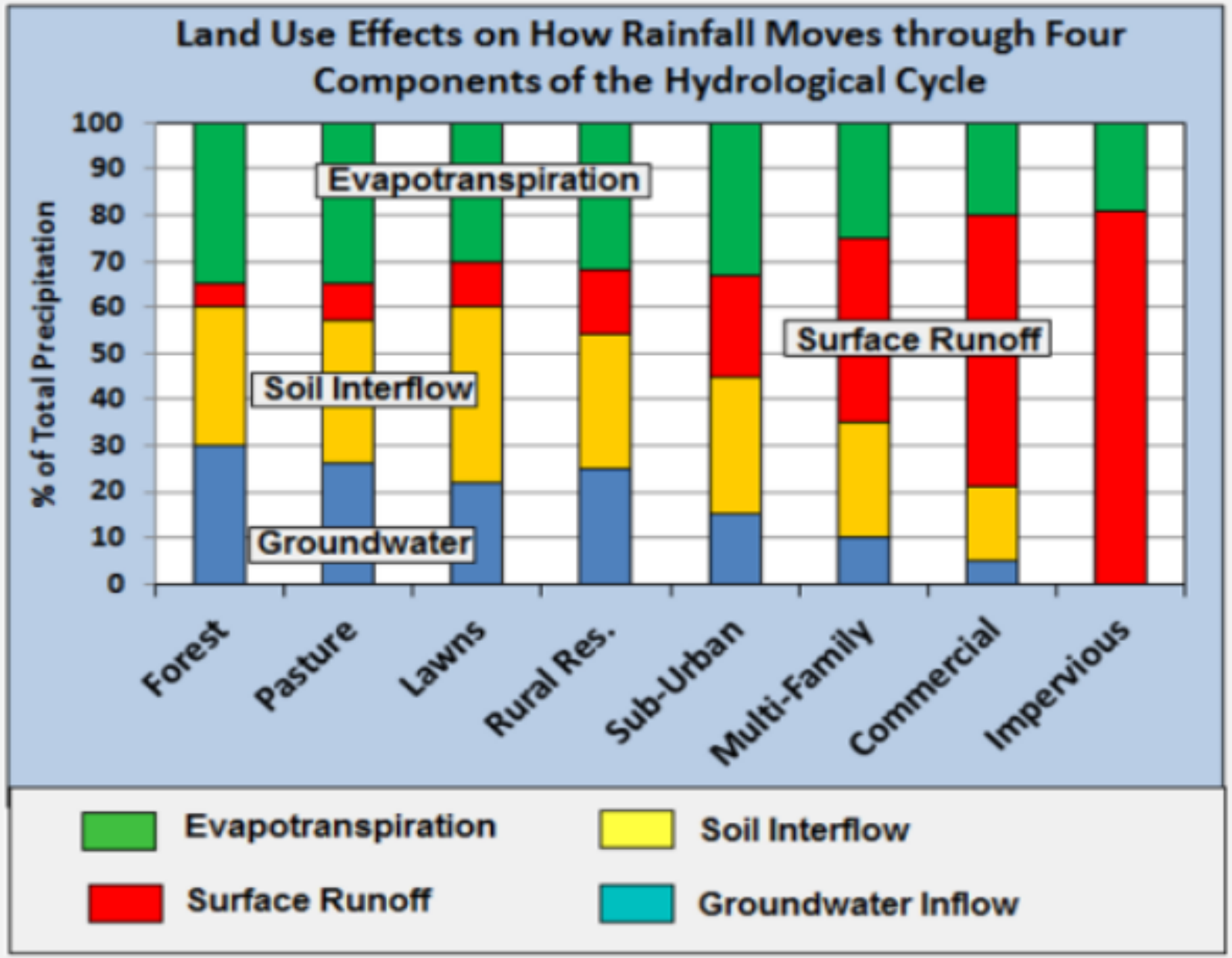
Evidence of increased Variability

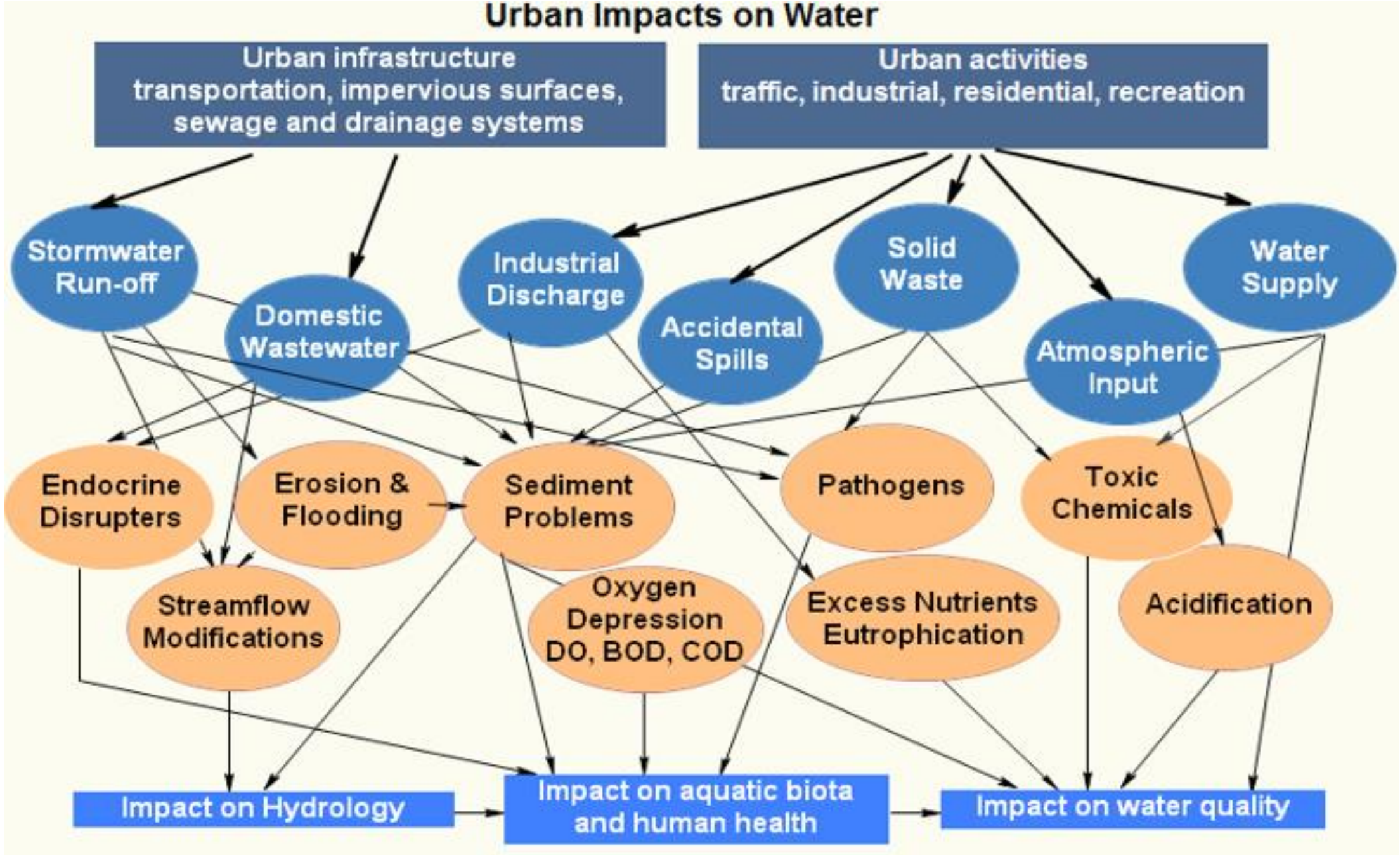
Increased Climatic Variability

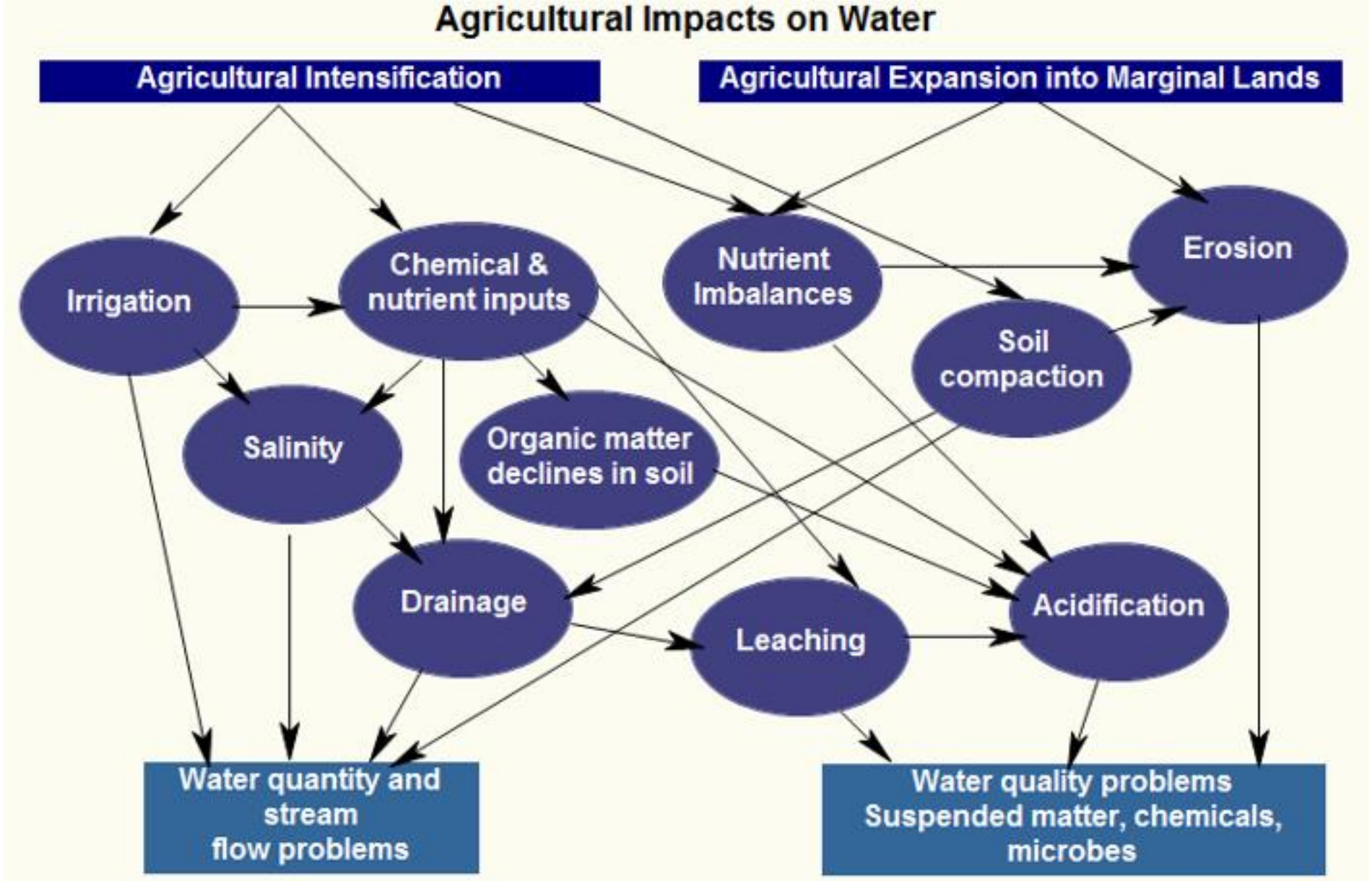
Increased Land Use Changes & Intensity

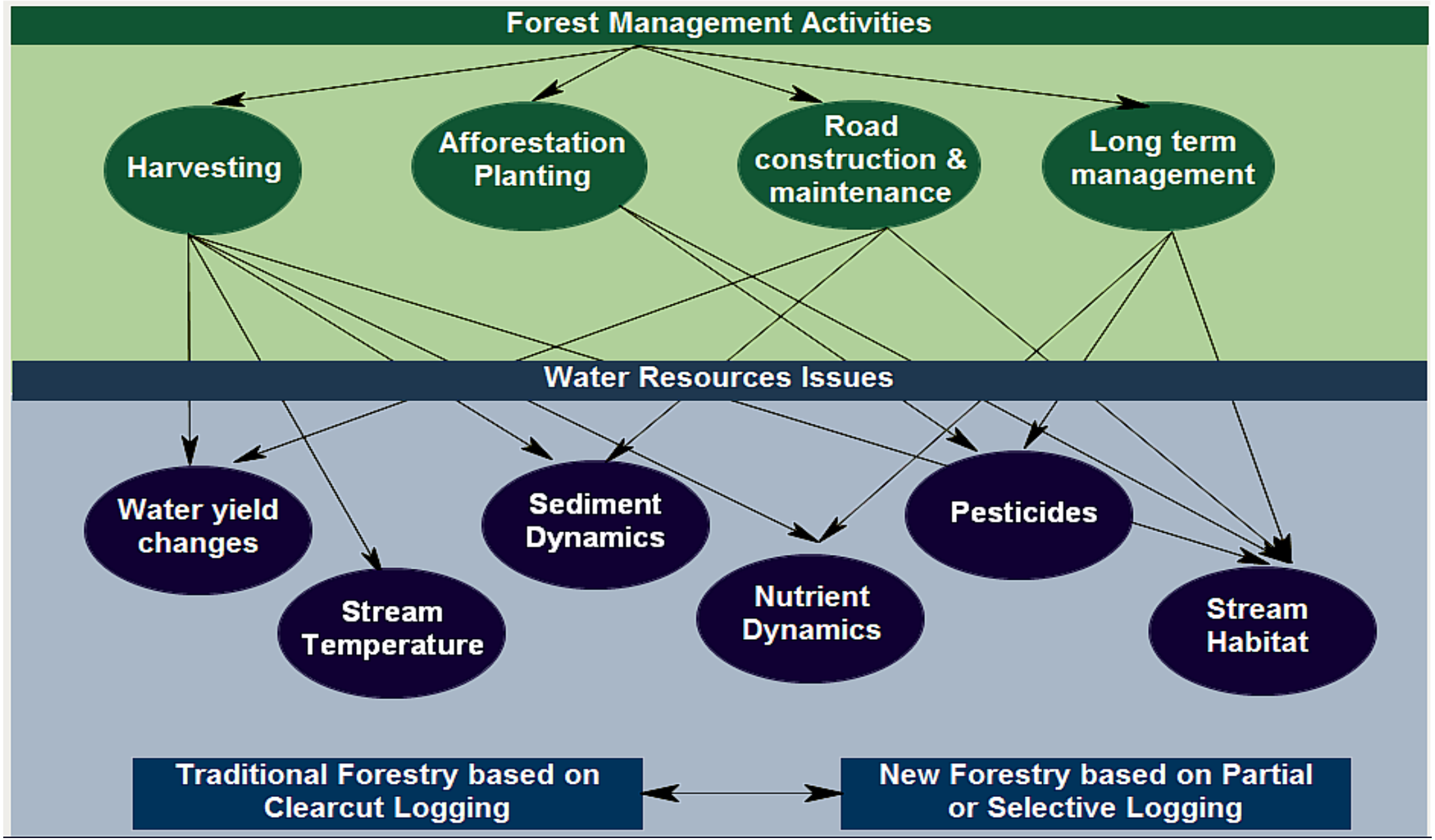
Rainfall Redistribution by Land Use

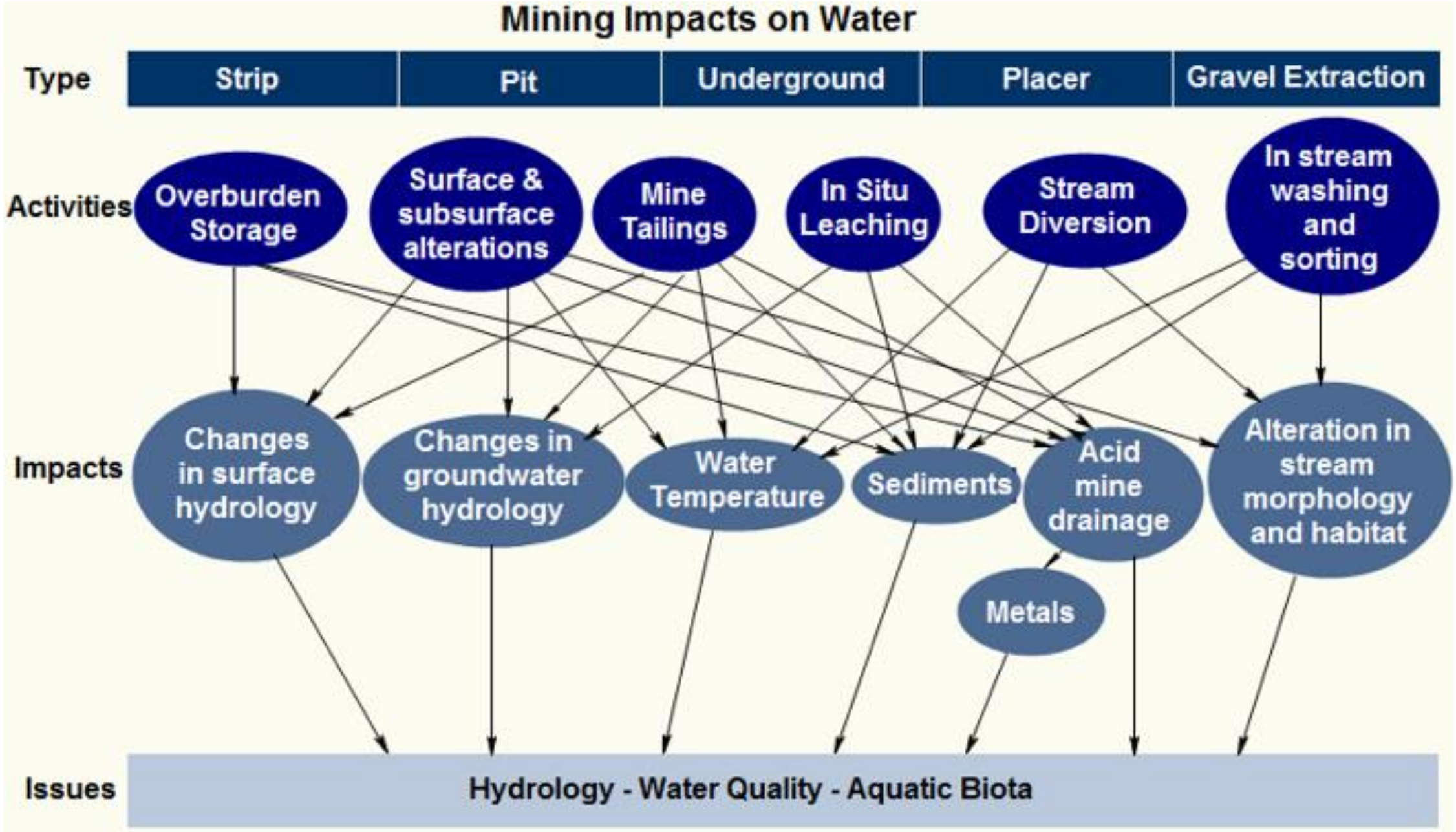
Note: Change in Surface Runoff as a result of land use changes (in Red)



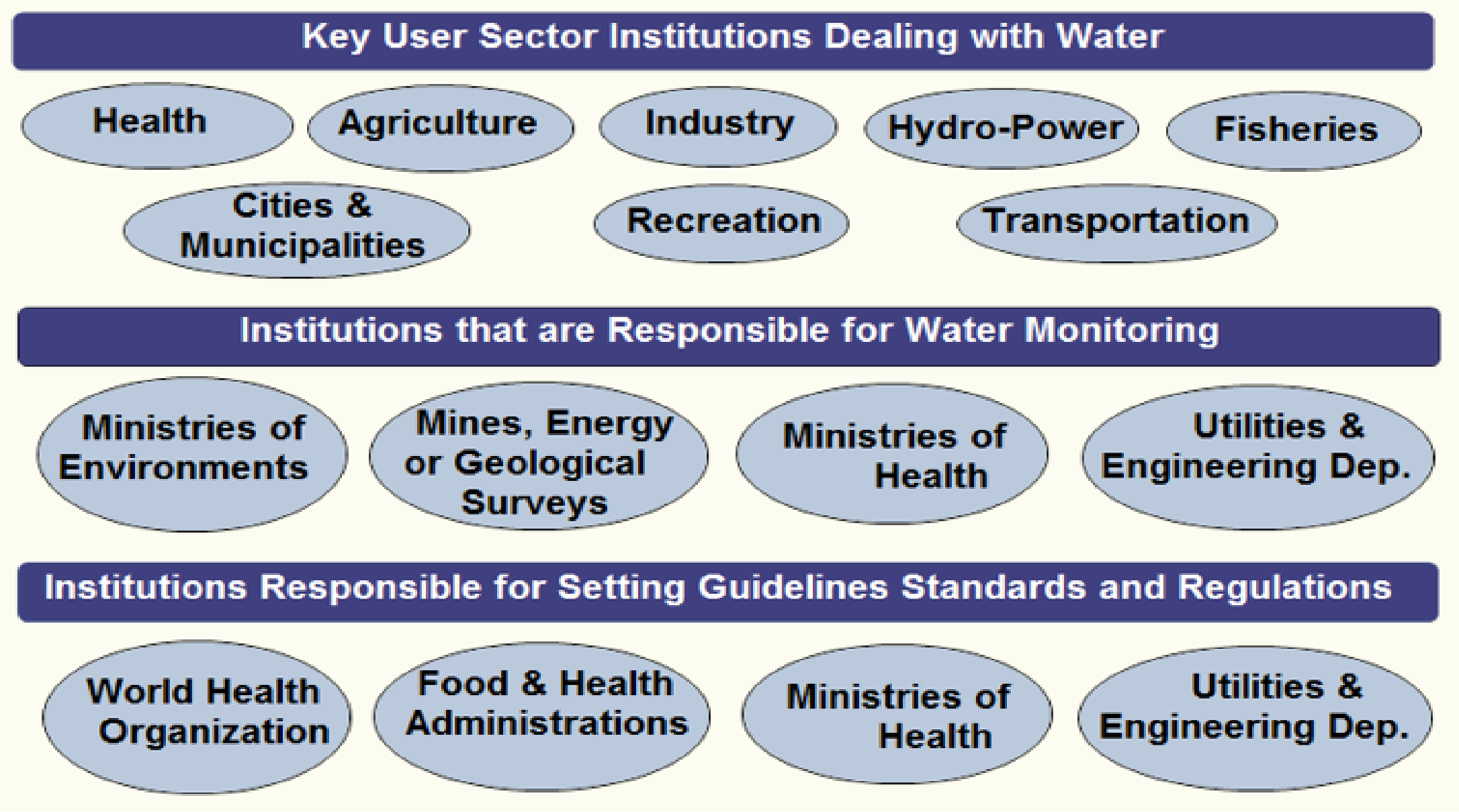

Urban Impacts on Water
Urban infrastructure
transportation, impervious surfaces,
sewage and drainage systems
Urban activities
traffic, industrial, residential, recreation
Stormwater
Run-off
Domestic
Wastewater
Industrial
Discharge
Accidental
Spills
Solid
Waste
Atmospheric
Input
Water
Supply
Endocrine
Disrupters
Erosion &
Flooding
Sediment
Problems
Pathogens
Toxic
Chemicals
Streamflow
Modifications
Oxygen
Depression
DO, BOD, COD
Excess Nutrients
Eutrophication
Acidification
Impact on Hydrology
Impact on aquatic biota
and human health
Impact on water quality

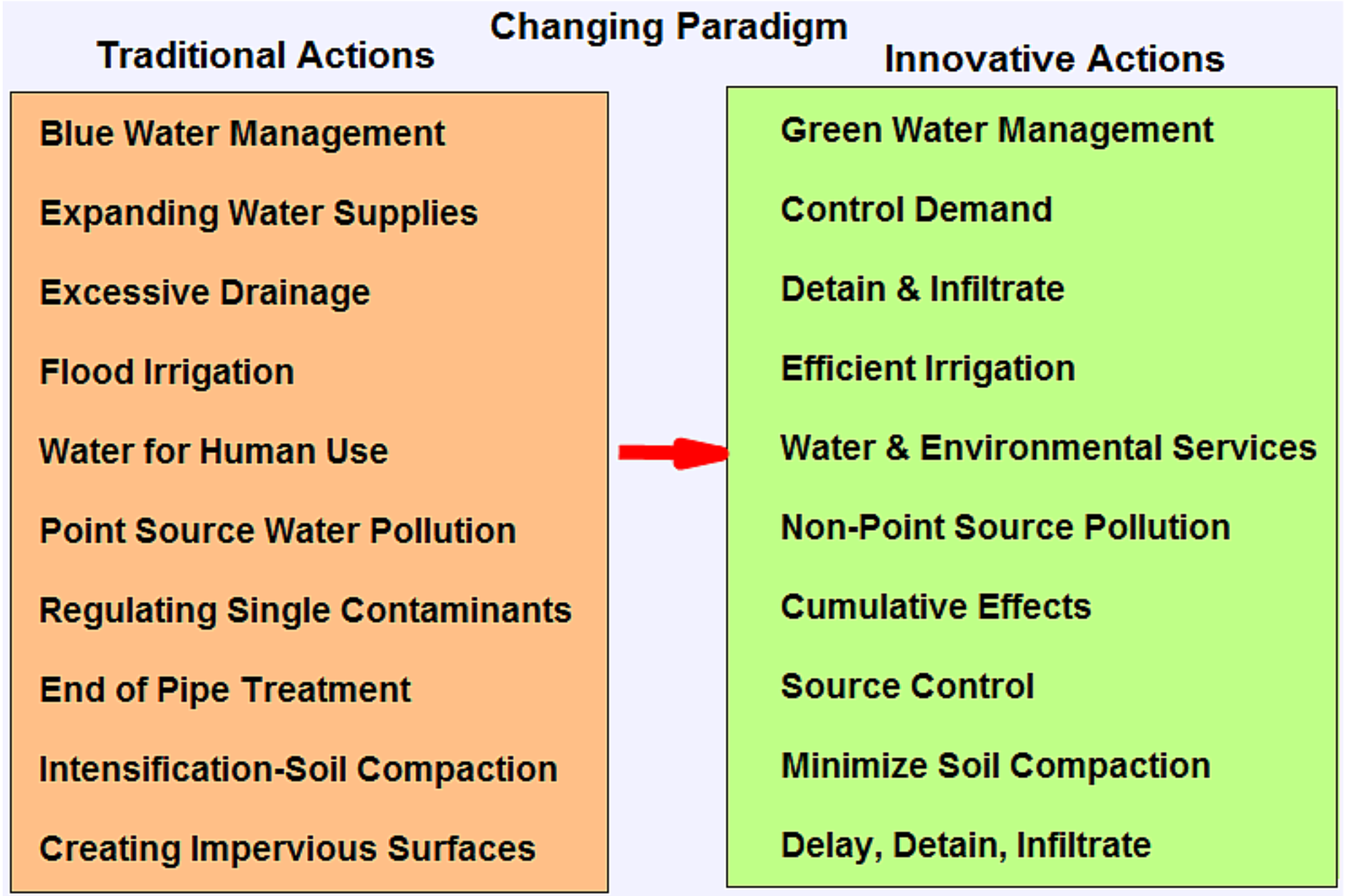

Agricultural Impacts on Water
Agricultural Intensification
Agricultural Expansion into Marginal Lands
Irrigation
Chemical & nutrient inputs
Nutrient Imbalances
Erosion
Soil compaction
Salinity
Organic matter declines in soil
Drainage
Leaching
Acidification
Water quantity and stream flow problems
Water quality problems Suspended matter, chemicals, microbes


Forest Management Activities
Harvesting
Afforestation Planting
Road construction & maintenance
Long term management
Water Resources Issues
Water yield changes
Stream Temperature
Sediment Dynamics
Nutrient Dynamics
Pesticides
Stream Habitat
Traditional Forestry based on Clearcut Logging
New Forestry based on Partial or Selective Logging

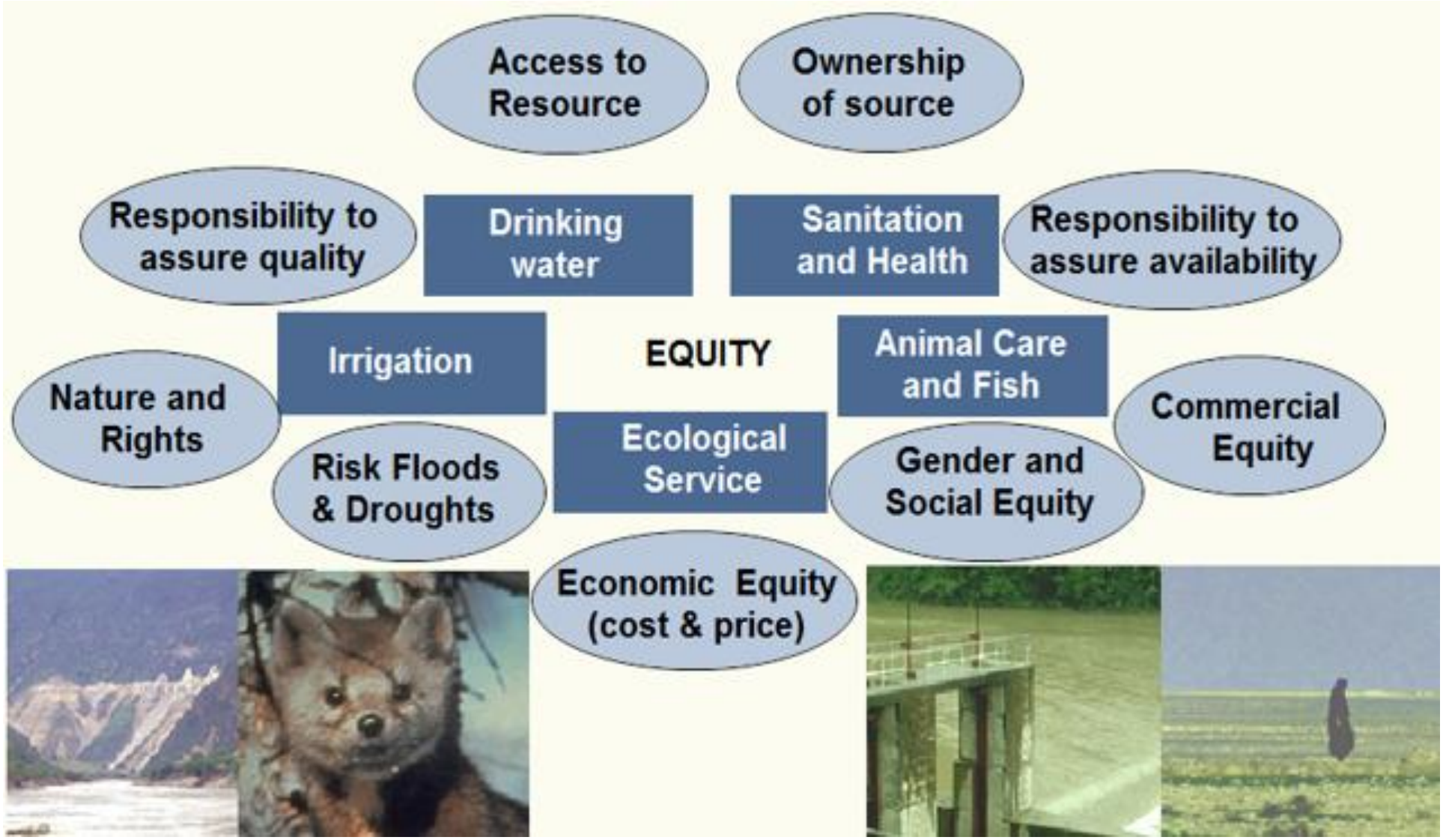

Mining Impacts on Water
Type
Strip
Pit
Underground
Placer
Gravel Extraction
Activities
Overburden Storage
Surface & subsurface alterations
Mine Tailings
In Situ Leaching
Stream Diversion
In stream washing and sorting
Impacts
Changes in surface hydrology
Changes in groundwater hydrology
Water Temperature
Sediments
Acid mine drainage
Alteration in stream morphology and habitat
Metals
Issues
Hydrology - Water Quality - Aquatic Biota

Water Governance Issues

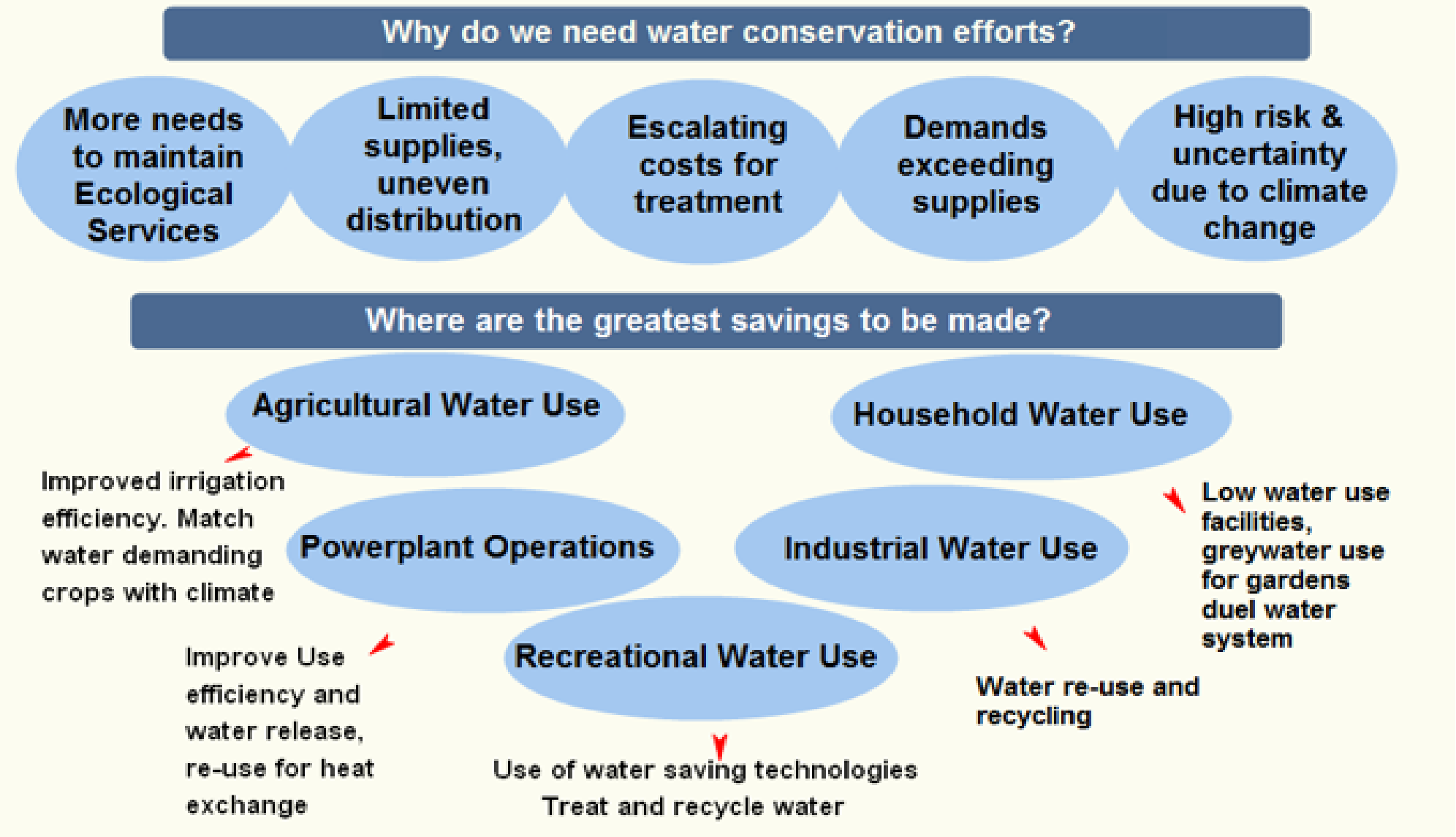



Changing Paradigm
Traditional Actions
Innovative Actions
Blue Water Management
Expanding Water Supplies
Excessive Drainage
Flood Irrigation
Water for Human Use
Point Source Water Pollution
Regulating Single Contaminants
End of Pipe Treatment
Intensification-Soil Compaction
Creating Impervious Surfaces
Green Water Management
Control Demand
Detain & Infiltrate
Efficient Irrigation
Water & Environmental Services
Non-Point Source Pollution
Cumulative Effects
Source Control
Minimize Soil Compaction
Delay, Detain, Infiltrate

Water Access & Equity Issues



Why We Need for Water Conservation



How to Cope with Climate Extremes and Land Use Intensification and its Impact on Water

Densification = More Imperviousness

Climate Change = Increased Variability

The next 3 Sessions Deal with:

1: Recent Climate Changes in Mountains
2: Reduce Emissions and Sequester Carbon
3: Adaptation Methods to Climate Change.