

# **Water and Energy Systems in South Asia**

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# Plan of the presentation

- Hydrological regime of South Asia
- Water Resources in major river basins of the region : from an anthropocentric perspective
- Socio-economic features and major drivers of water demands
- Water Supply systems and agricultural water withdrawals
- Food and energy production and energy use in agriculture
- Water management issues in major basins of South Asia
- Management Challenges

# Hydrological regime of South Asian Countries

- The region experiences monsoons, which the quantum varies from country to country and region to region.
- The high altitude regions (Himalayan) also experience snow fall
- High spatial variation in rainfall & climate across the region and within countries and river basins
- Droughts and floods are common
- Year to year variation very high in regions of low rainfall and low in regions of high rainfall



# Water resources in major river basins

- 1/4<sup>th</sup> of the global population and 4.5 % of the renewable water
- Per capita renewable water is second lowest in Pakistan
- GBM, Indus and Helmand are the major trans-boundary river basins in terms of water resource availability
- Per capita renewable water is lowest in Indus basin
- Within India, Sabarmati has the lowest per capita renewable water resources
- Variability in water resources (as CV of precipitation) is high in lower and drier parts of Indus and Helmand ; and upper parts of GBM basin in India (UNEP, 2007)

# Effect of climate variables on stream flows

- Low rainfall regions experience very high variability in run-off, and vice versa
- In low rainfall regions, the stream flows have poor dependability
- This has significant negative implications for cost effectiveness of water harvesting/recharge systems

# Socio-economic factors driving water demand

- Most countries are agrarian, with large proportion of people dependent on agriculture and allied activities for livelihoods
  - **45.5 %** of labour force in India; **45%** in Pakistan; **78%** in Afghanistan
- Though structure of the economy changing over time, agriculture is still very significant in SA countries
- A large chunk of the population live in rural areas
  - **But, fast urbanization is happening in India and Pakistan**
- Indian has both the largest amount of arable land, and highest percentage area under cultivation
- Per capita arable land is highest in Afghanistan, followed by India.

# Water supply systems for agriculture and other sectors

- [Most countries use both surface water and groundwater for irrigation, while Sri Lanka uses only surface water](#)
- GBM has large diversion systems for irrigation , whereas Indus and Helmand have large surface reservoirs for irrigation
- Surface water systems in India include major to minor reservoirs & barrages; surface systems in Pakistan & Afghanistan are large reservoirs; in Sri Lanka, reservoirs and tanks are used; and in Bangladesh, mostly ponds
- [Per capita reservoir storage varies widely](#)
- India n metros mostly use water from major reservoirs



# Water supply systems for agriculture and other uses

- Great heterogeneity in geological formations in SA region
- India has different types of groundwater based water supply systems for irrigation, drinking and municipal uses
  - App. 25 m. wells , mostly low yielding (from 25 lpcd to 1 lpcd)
  - Millions of STWs in Gangetic alluvium for irrigation; hand pumps for rural drinking; river lift & DTWs for drinking in small towns
  - DTWs and STWs in the alluvium in Indus basin part of Punjab
  - Open wells and bore wells in western, south and eastern India
- Pakistan has STWs DTWs for irrigation; hand pumps for rural drinking
- STWs in Bangladesh, in the deltaic plains



# Agricultural water withdrawals

- Agricultural water withdrawal is highest in India (688 BCM), followed by Pakistan (172.4 BCM)
- [But, per capita water withdrawal for agriculture is highest in Pakistan, followed by Afghanistan](#)
- Agricultural water withdrawal in Pakistan is far higher than the internal renewable water resources, i.e., 52 BCM
- Most of the excess water comes from upper basin area of Indus basin
- Very low rainfall and high aridity increases water demand for agriculture in Pakistan

# Water resource problems in major river basins of South Asia

- Water resource stress is already high in Indus and Helmand basins
- Water development pressure is extremely high in Indus basin, with very high degree of exploitation of surface and groundwater
- Both Indus and Helmand have very poor ecological health, with situation in GBM being comparatively better
- Similar situation exists in many basins of India, in western, and southern parts with high environmental water stress
- Management capacity is poor in relation to water use efficiency, access to improved sanitation, and capacity for conflict resolution

# Per capita cereal production in South Asian countries

Country	Average dietary energy supply adequacy			Share of dietary energy supply derived from cereals, roots and tubers			Per capital cereal production		
	Percentage			Percentage			Kilograms		
	90-92	00-02	10-12	90-92	00-02	07-09	1990	2000	2011
<b>Bangladesh</b>	101	107	107	85	84	82	258.4	298.4	344.4
<b>Bhutan</b>	NA	NA	NA	NA	NA	NA	NA	NA	NA
<b>India</b>	104	101	105	66	62	60	223.2	225.4	233.8
<b>Nepal</b>	105	107	113	77	75	72	322.8	306.9	316.9
<b>Pakistan</b>	109	109	110	55	52	48	188.6	211.8	205.2
<b>Sri Lanka</b>	97	103	109	60	56	56	148.9	153.7	192.0

## Production, Utilization & Surplus of rice in South Asian countries during 2007-09 (million tons)

Country	Production	Domestic use	Surplus/deficit	S/D as % of production
India	94.29	87.96	6.32	6.71
Bangladesh	30.36	29.18	1.18	3.88
Pakistan	6.42	3.25	3.18	49.46
Srilanka	2.35	2.39	-0.04	-1.68
Maldives	0.00	0.01	-0.01	-
Nepal	2.76	3.13	-0.31	-13.56

## Production, Utilization & Surplus of Wheat in South Asian countries during 2007-09 (million tons)

<b>Country</b>	<b>Production</b>	<b>Domestic use</b>	<b>Surplus/deficit</b>	<b>S/D as % of production</b>
<b>India</b>	78.35	78.66	-0.31	-0.39
<b>Bangladesh</b>	0.81	2.72	-1.91	-235.55
<b>Pakistan</b>	22.76	20.18	2.58	11.32
<b>Srilanka</b>	0.00	0.89	-0.89	-
<b>Maldives'</b>	0.00	0.02	-0.02	-
<b>Nepal</b>	1.48	1.48	0.00	0.00

## Production, Utilization & Surplus of Pulses in South Asian countries during 2007-09 (million tons)

<b>Country</b>	<b>Production</b>	<b>Domestic use</b>	<b>Surplus/deficit</b>	<b>S/D as % of production</b>
<b>India</b>	14.44	17.09	-2.66	-18.41
<b>Bangladesh</b>	0.22	0.67	-0.45	-199.62
<b>Pakistan</b>	1.06	1.48	-0.43	-40.21
<b>Srilanka</b>	0.02	0.18	-0.16	-765.00
<b>Maldives'</b>	0.00	0.00	0.00	--
<b>Nepal</b>	0.24	0.25	-0.01	-2.38

## Per capita supply of various food items in South Asian countries (2009)

Item	India	Bangladesh	Pakistan	Srilanka	Nepal
Cereals excl.beer	152.6	180.9	129.8	143.5	171.3
Rice (Milled Equivalent)	70.9	159.7	14.5	97.3	78.0
Wheat	60.2	14.7	106.1	44.1	37.9
Pulses + (Total)	12.9	4.8	8.1	8.0	8.4

# Milk production (in million ton, 2007-2009)

<b>Country</b>	<b>Production</b>	<b>Domestic use</b>	<b>Surplus/deficit</b>	<b>S/D as % of production</b>
<b>India</b>	107.59	106.56	1.03	0.96
<b>Bangladesh</b>	3.06	3.43	-0.37	-11.94
<b>Pakistan</b>	33.28	33.40	-0.12	-0.36
<b>Srilanka</b>	0.19	0.77	-0.58	-313.64
<b>Maldives</b>	0.00	0.02	-0.02	-
<b>Nepal</b>	1.48	1.50	-0.02	-1.40



# Comparison of electricity profiles of South Asian countries (1990-2008)

Country	Electricity Installed Capacity		Electricity Generation (000'Gwh)		Distribution Losses (%)		Per capita Consumption (Kwh)	
	1990	2008	1990	2008	1990	2008	1990	2008
<b>India</b>	74.69	177.38	275.49	785.53	20.52	24.66	276	566
<b>Pakistan</b>	7.74	19.77	87.44	87.74	21.48	21.87	277	436
<b>Bangladesh</b>	2.52	5.45	32.93	32.93	34.08	13.17	44	149
<b>Nepal</b>	0.27	0.72	3.05	3.05	18.40	19.56	35	89
<b>Srilanka</b>	1.29	2.64	8.89	8.89	16.86	11.33	149	414

# Hydro-power potential & % of exploitation in South Asian countries (2010)

<b>Country</b>	<b>Estimated Hydro-power potential (in GW)</b>	<b>Currently exploited Hydro-power (in GW)</b>	<b>Currently exploited % of Hydro-power</b>
<b>India</b>	149	37.5	25
<b>Nepal</b>	83	0.83	1
<b>Pakistan</b>	50	6.45	12.9
<b>Bhutan</b>	30	0.45	1.5
<b>Bangladesh</b>	0.8	0.224	28
<b>Srilanka</b>	2	1.2	60
<b>Total</b>	305.8	18.95	6.2

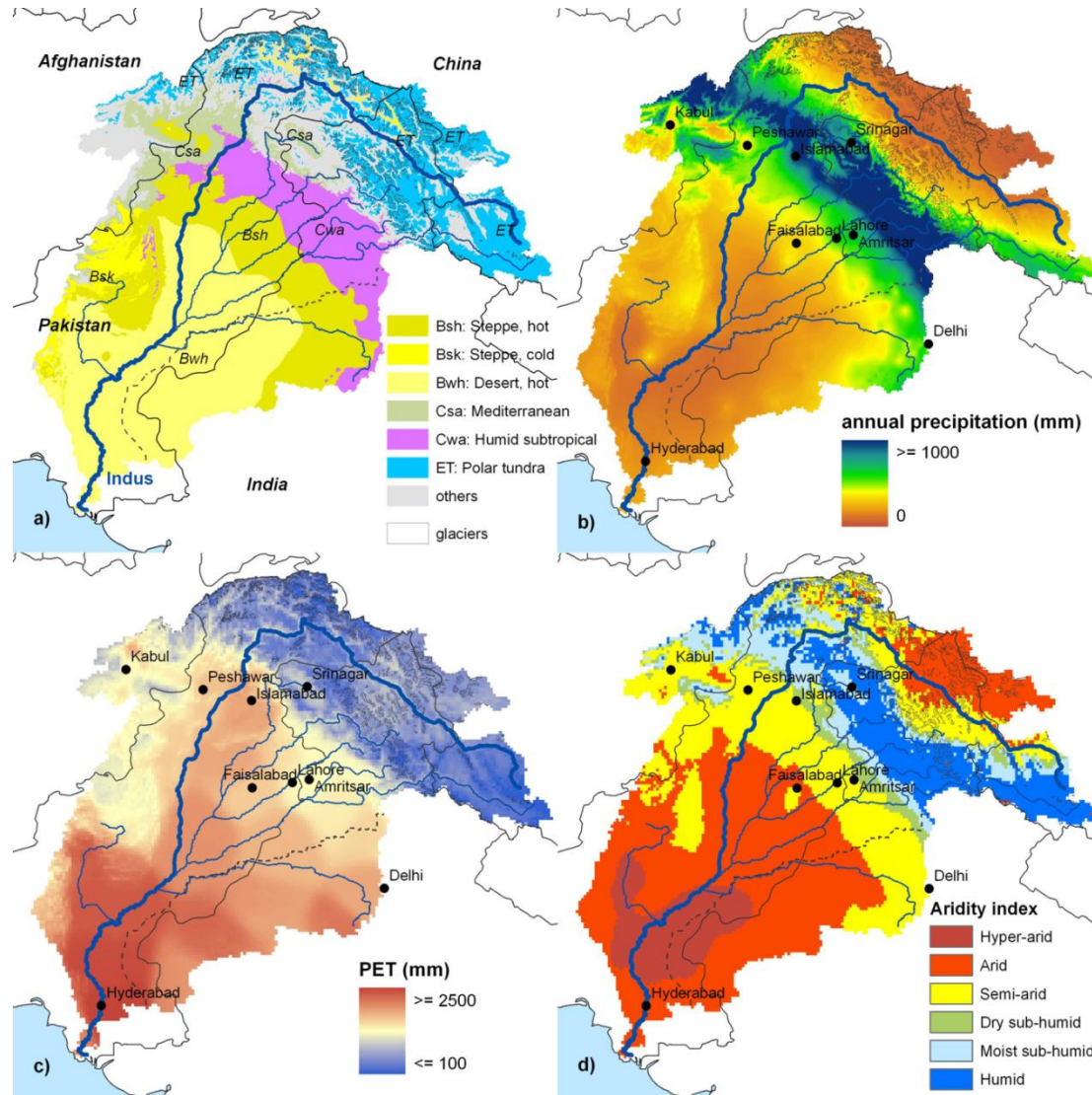
# Water management challenges

- No river basin organizations exist for trans-boundary river basins such as Indus, Ganges, Brahmaputra or Helmand
- Even within countries, there is no coordination of water resource development and management activities at the river basin level
  - Approach to water development is “**Sectoral**” and “**Segmented**”
  - **Catchments** form the unit for surface water development planning ; over-appropriation is rampant
  - Single agency performing multiple functions (planning, development, management, water quality monitoring)

# Water management challenges

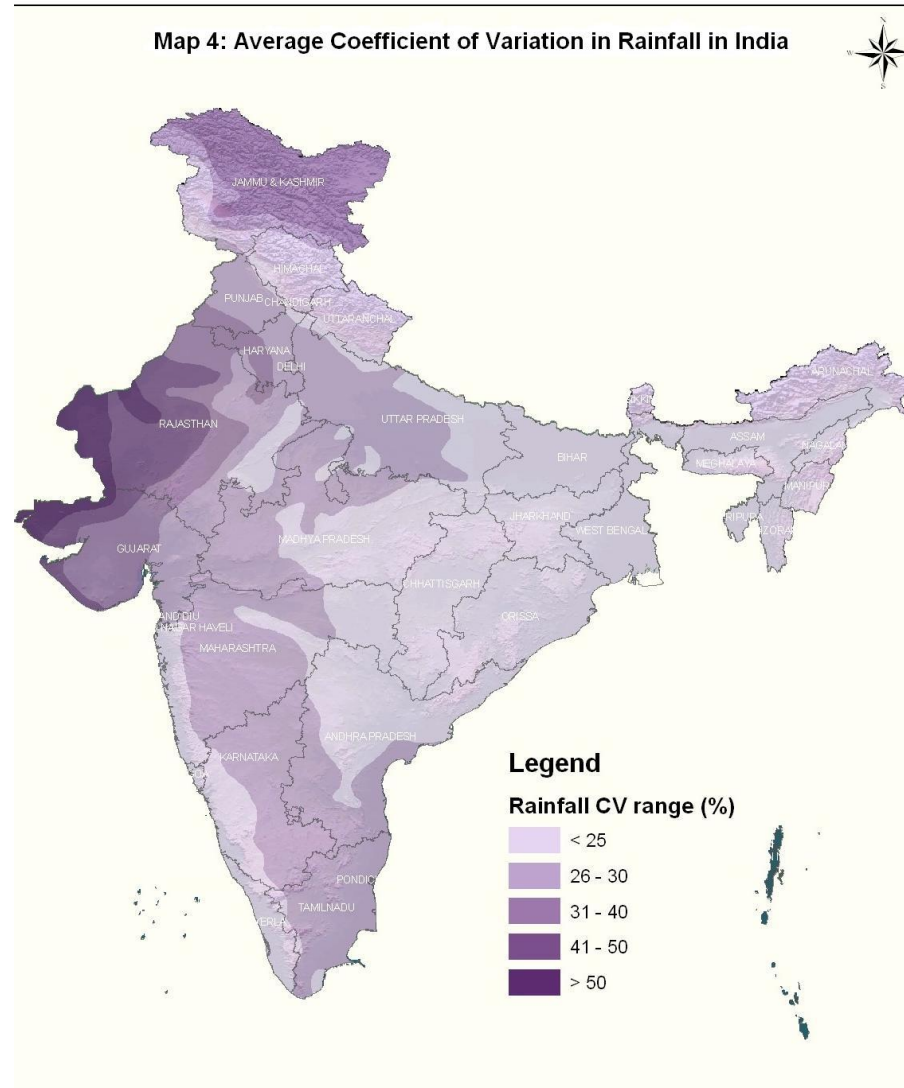
- Little consultation of the basin water users in planning and allocation decisions
- Groundwater rights are not defined; those who own land can access groundwater underlying it; no control over volumetric abstraction
- Electricity subsidy for groundwater pumping in most provinces: socio-political problem
- Surface water-groundwater interactions in the basin context are not fully understood or appreciated
- Groundwater does not form the part of any basin water allocation decisions by water dispute tribunals

# Rainfall and climate varies drastically within the Indus

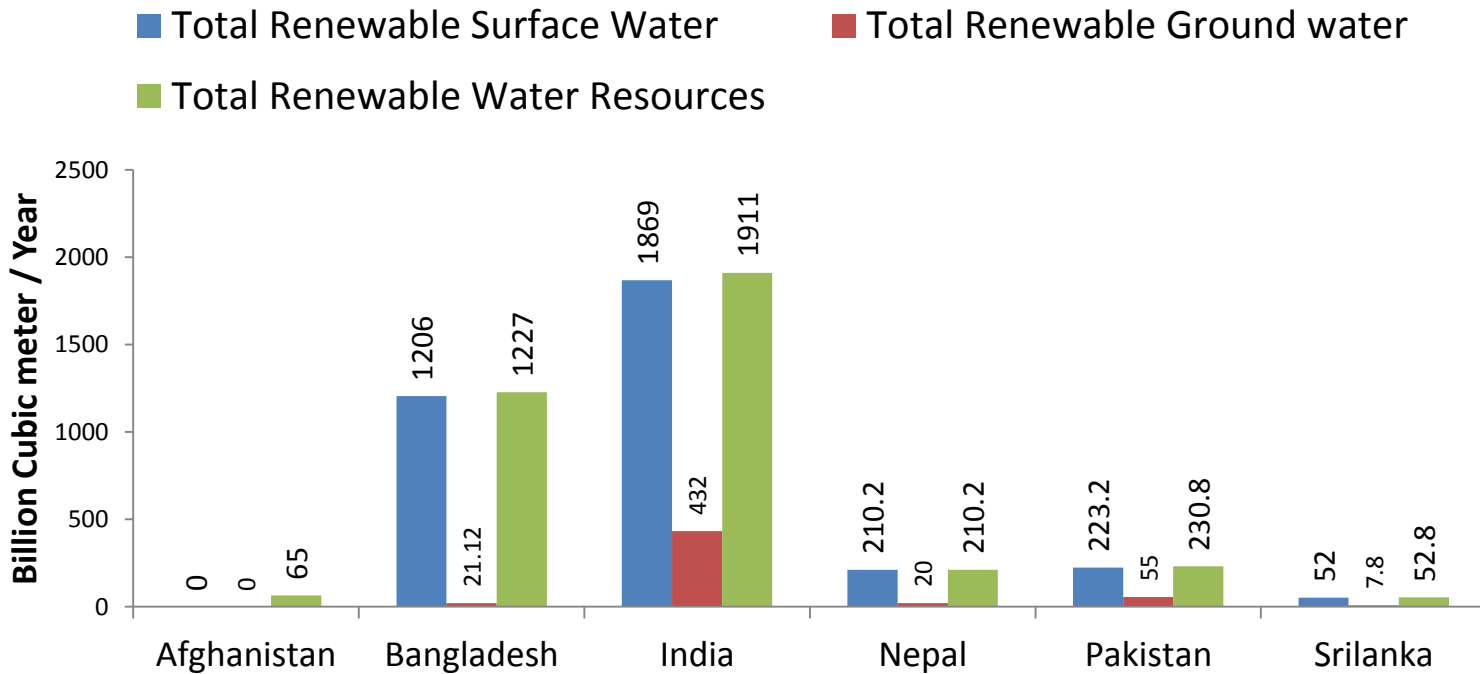


# Low rainfall areas have high variability and vice versa

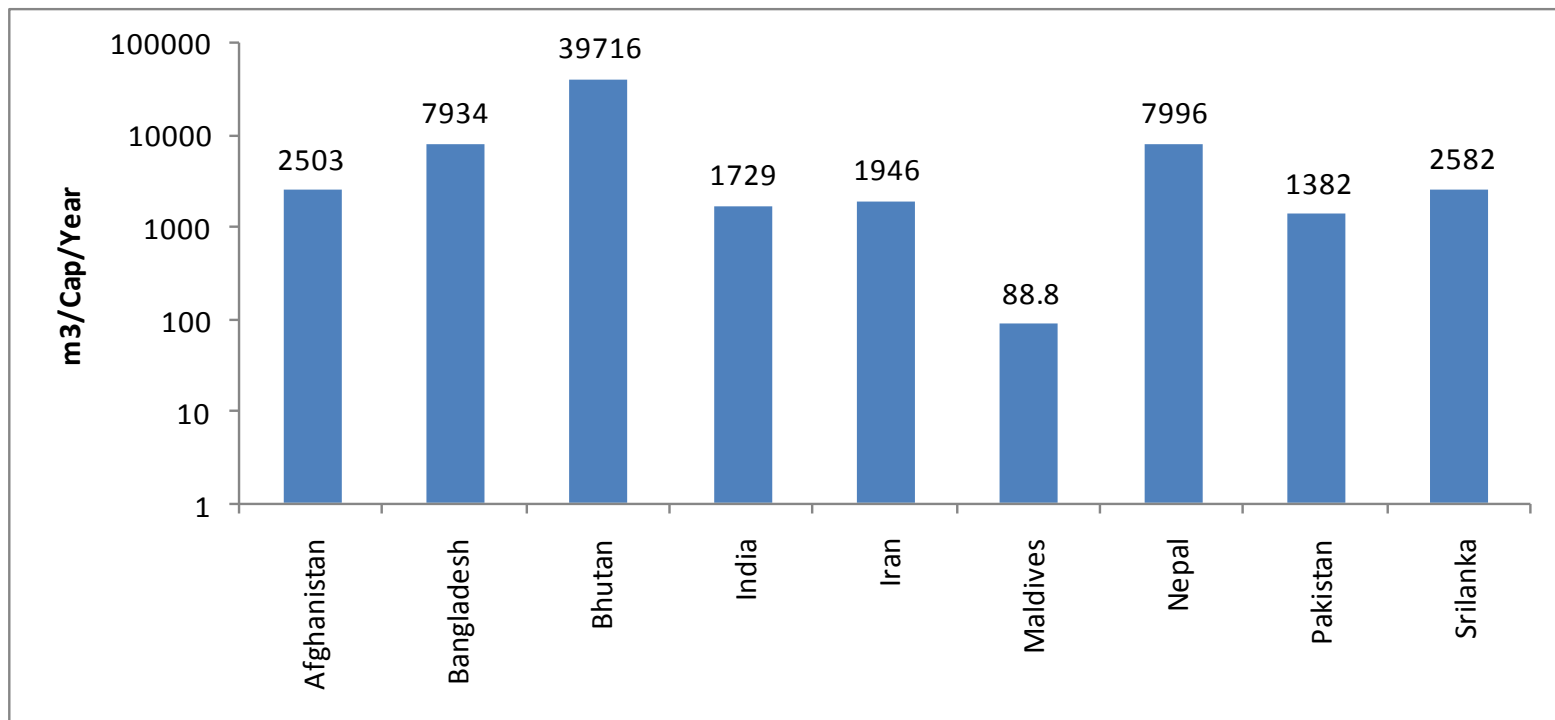
## versa



# Total renewable water resources in South Asian countries

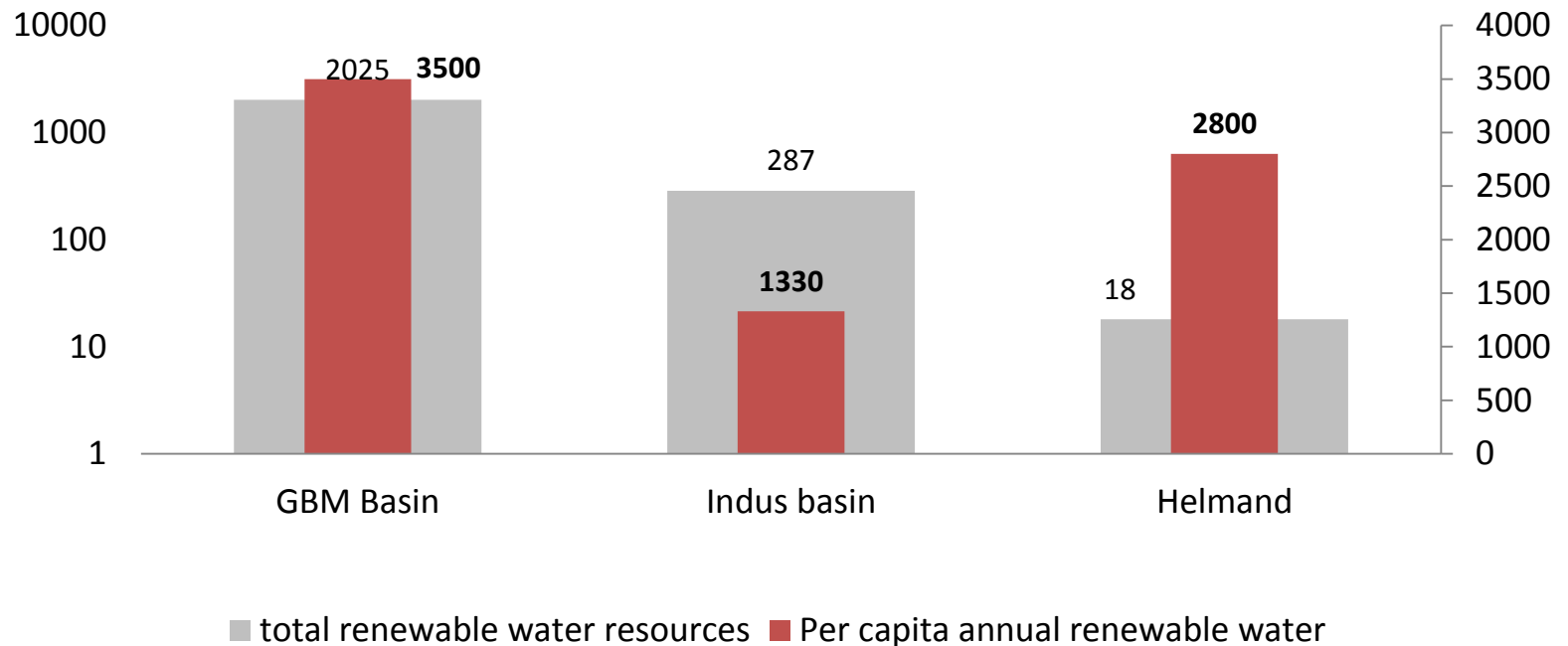


# Per Capita Renewable Water Resources in South Asian Countries



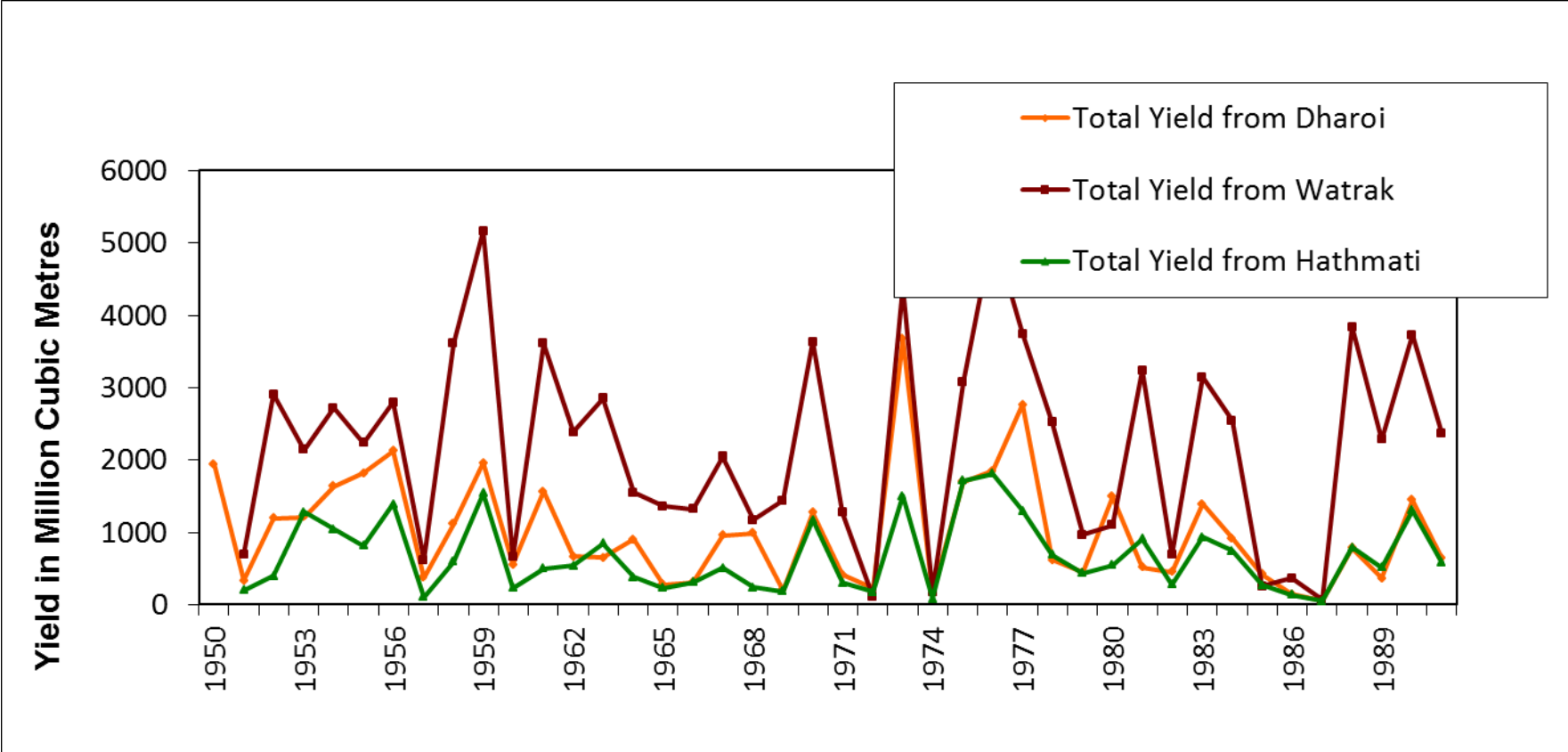


# Annual water resources in three river basins

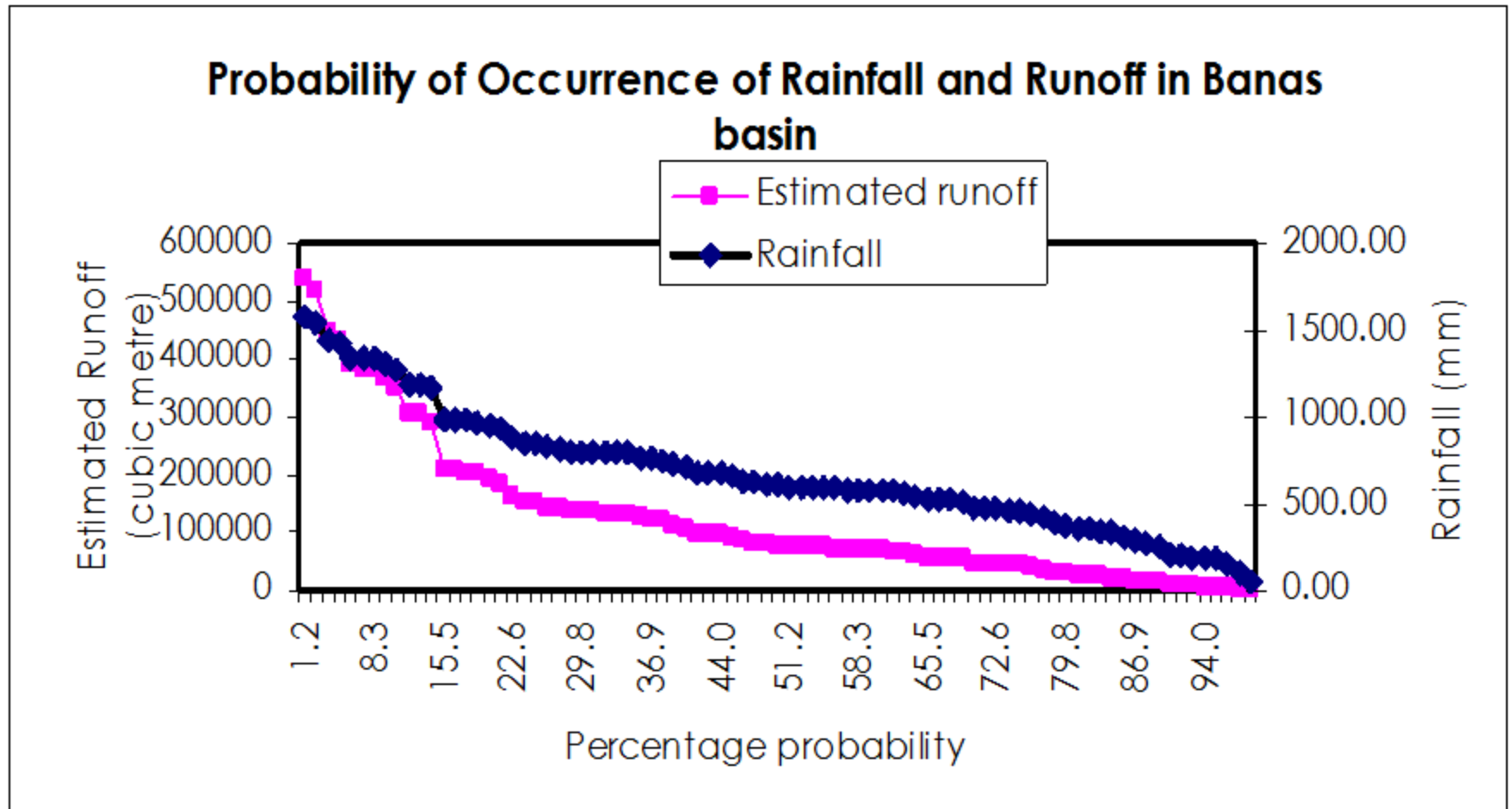


In 30 per cent of GBM area, which houses 40% of the basin population, per capita renewable water is less than 1300 m<sup>3</sup> per annum

# Stream flows in Sabarmati river basin

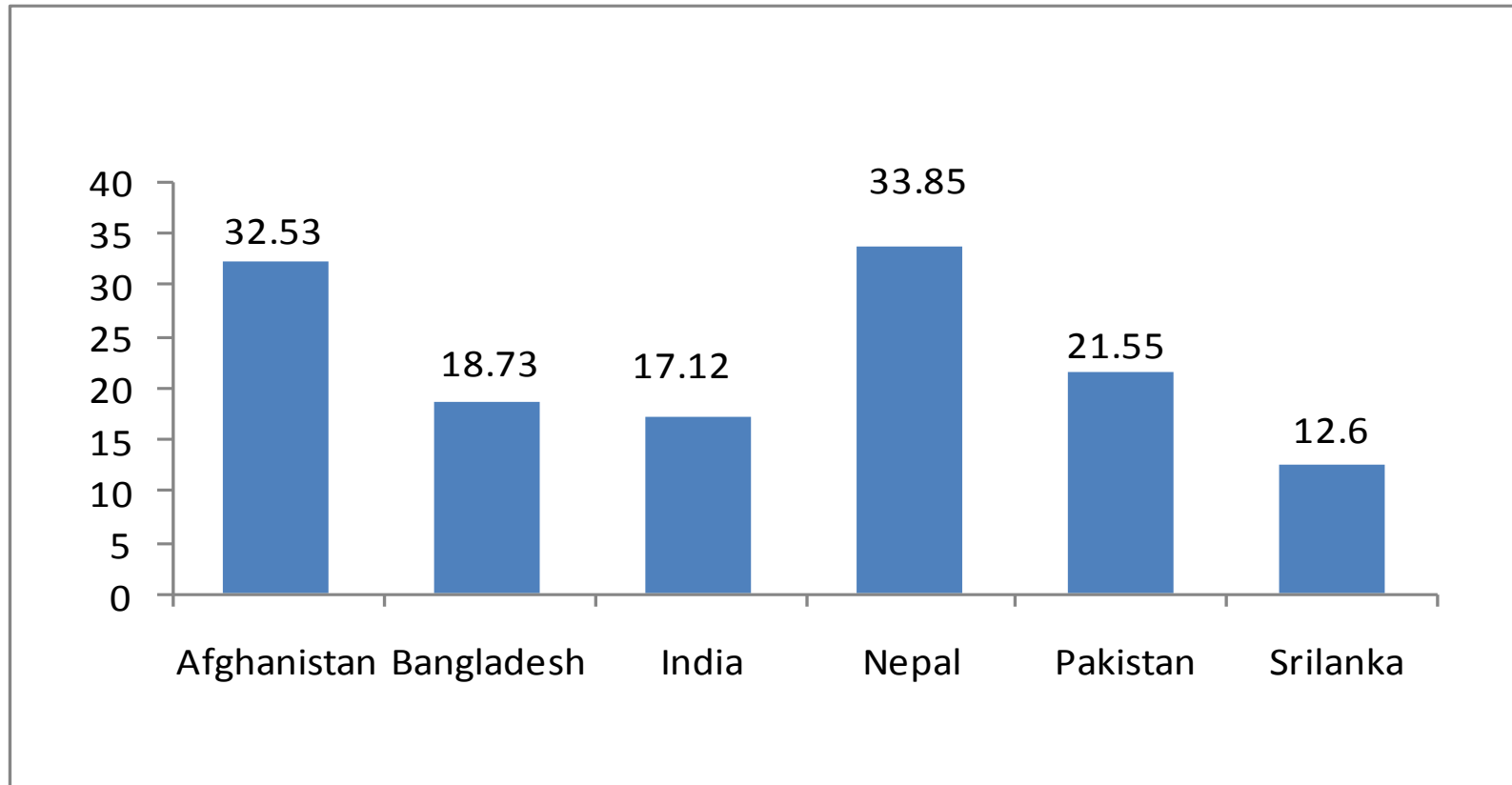


# Runoff probability in Banas basin

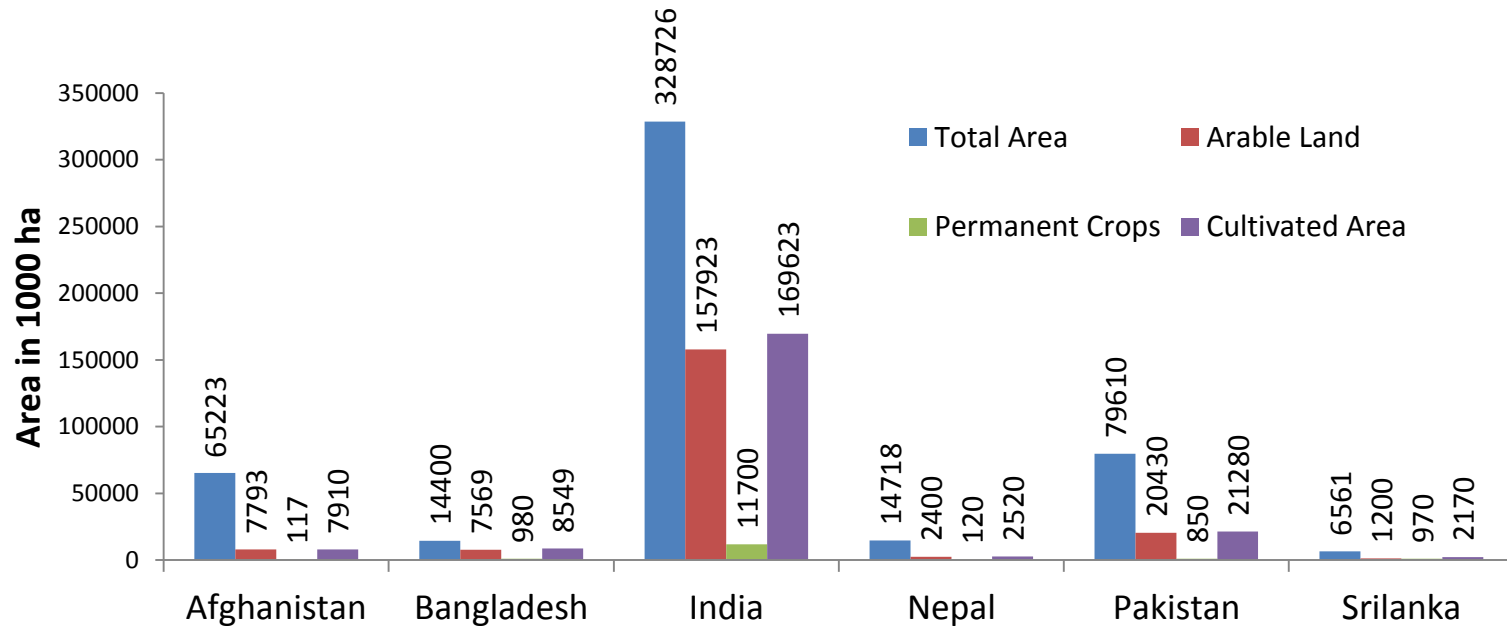




# Agricultural component of GDP (%) in South Asian countries



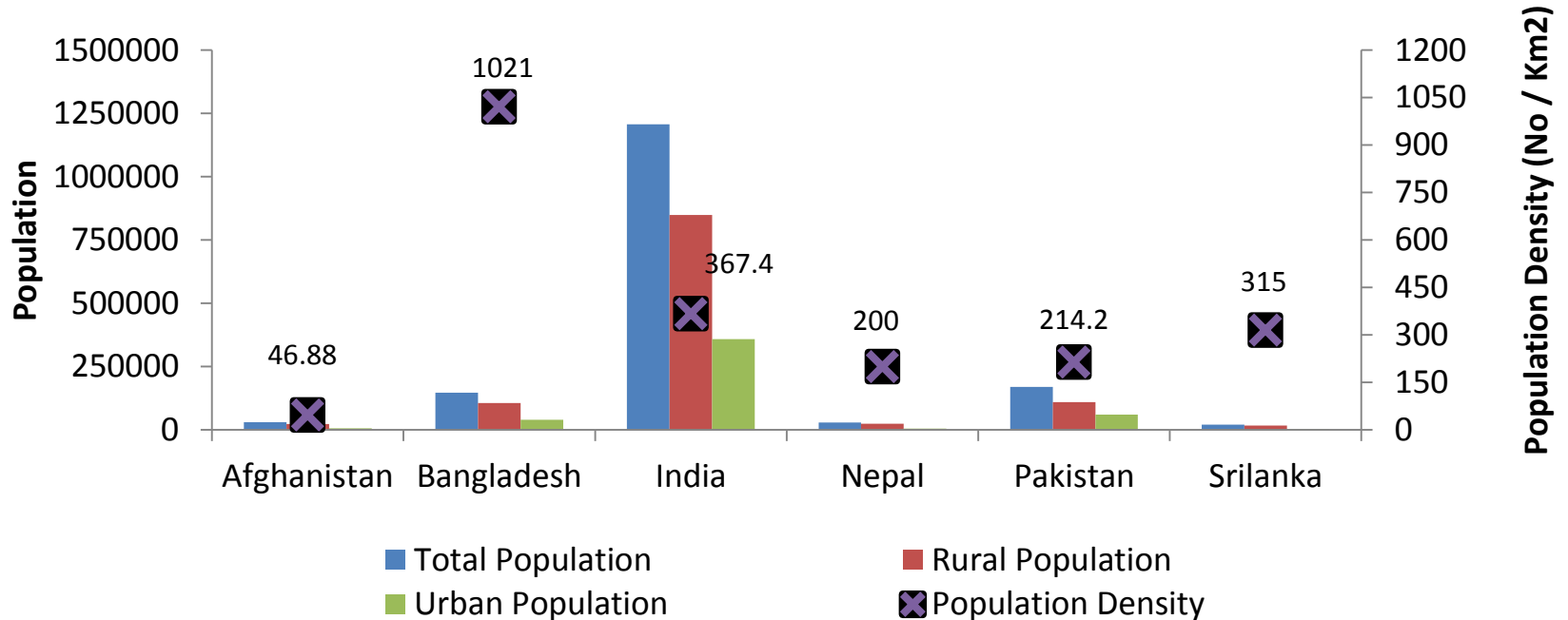
# Land use in different south Asian countries



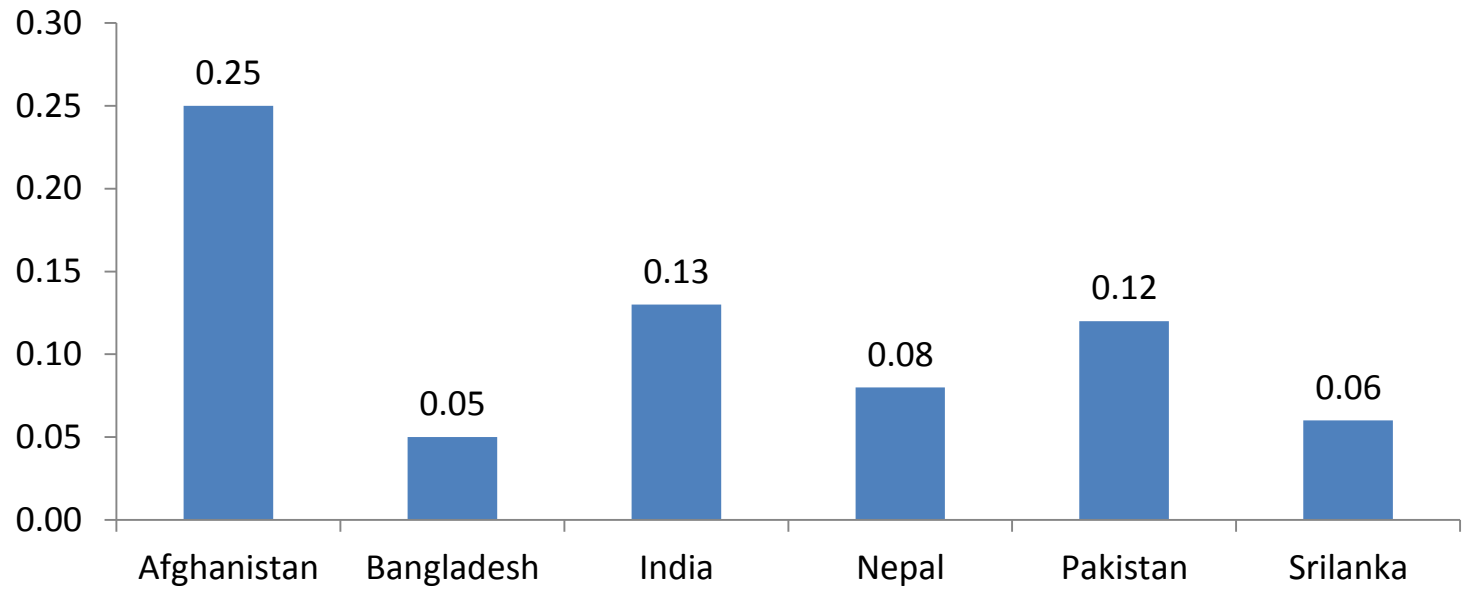
The percentage arable land is .. In India, ...in Pakistan and ... in Afghanistan

# Population and urbanization

## Rural & Urban Population and Population Density in South Asia

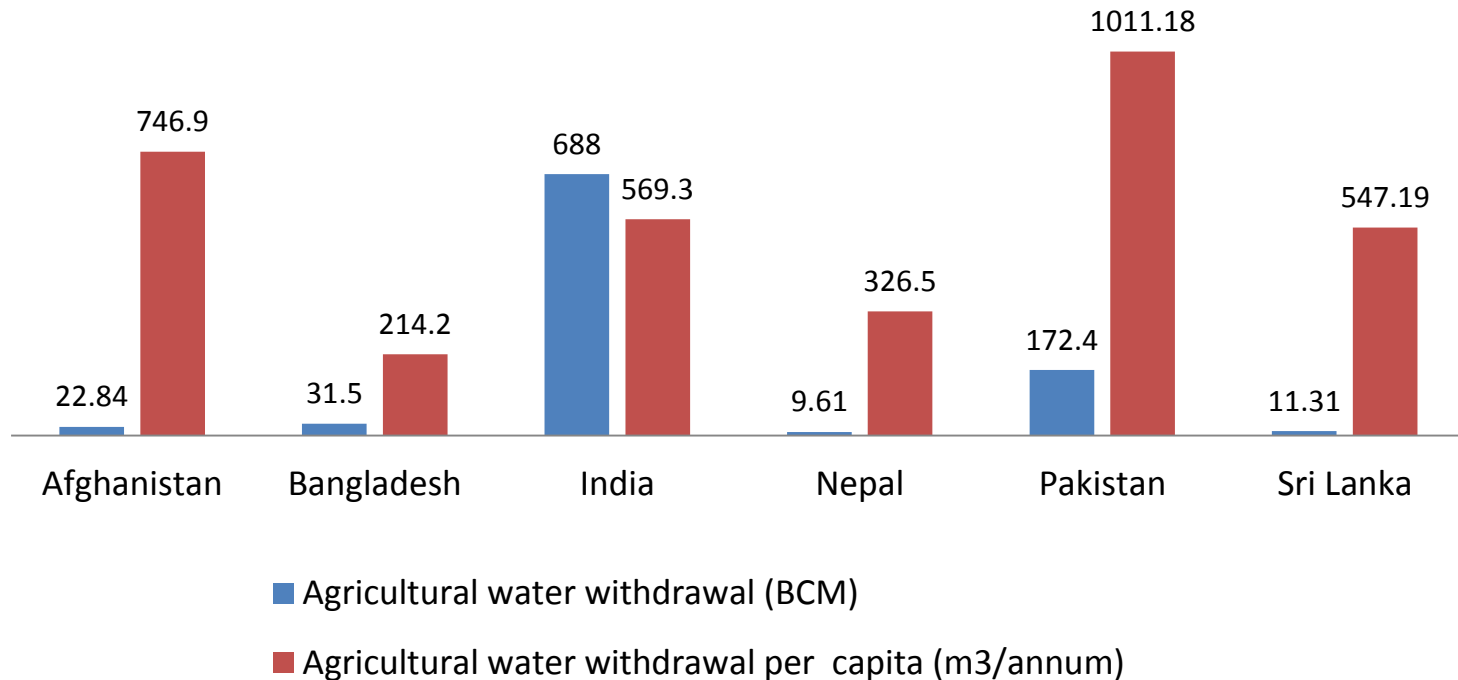


## Per capita arable Land (ha)

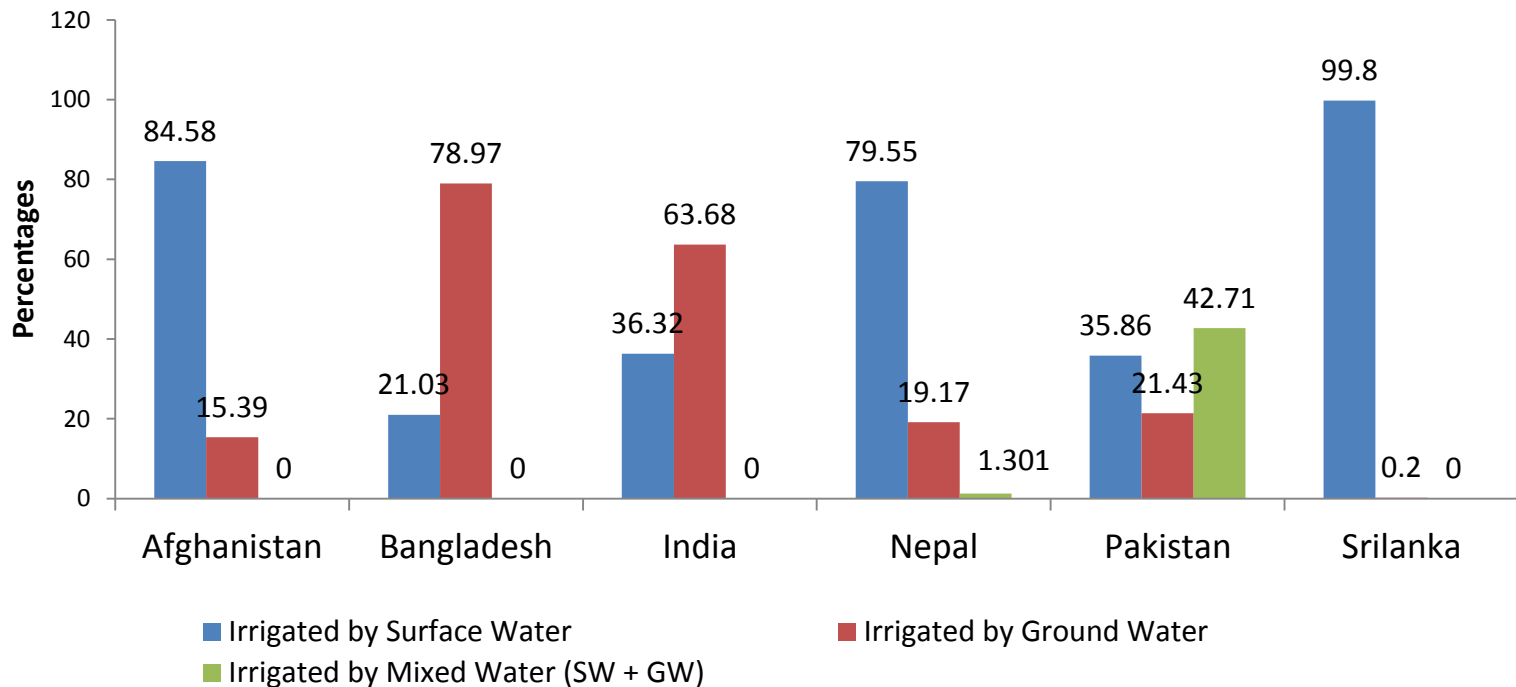




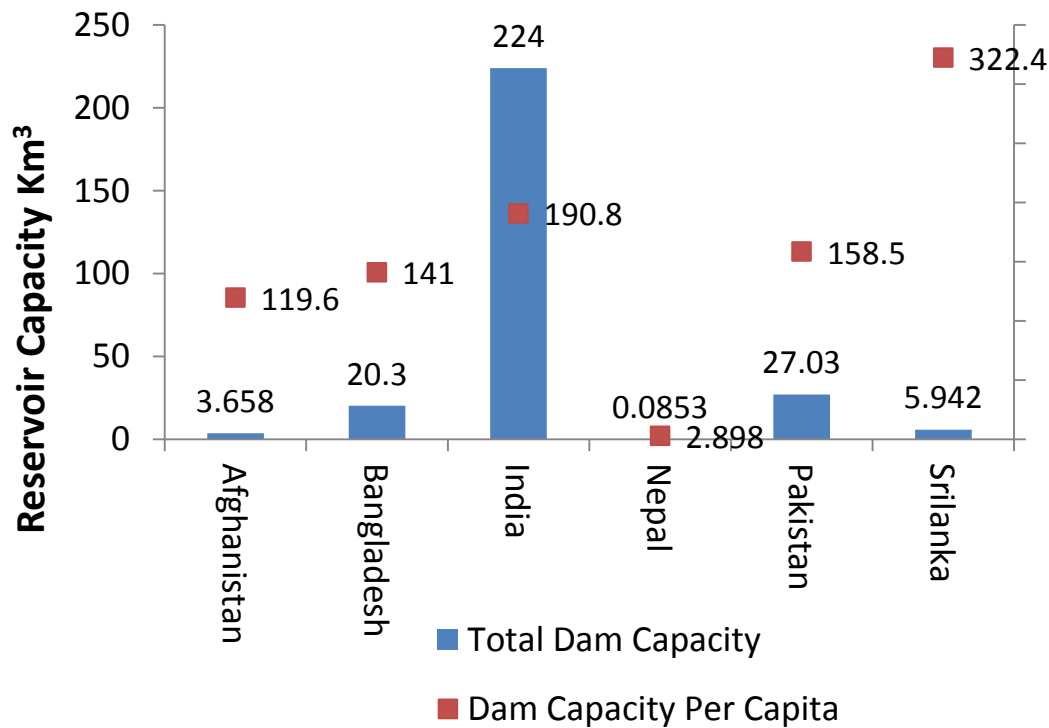
# Water withdrawals for agriculture in South Asian countries



# Percentage of Area under Different Sources of Irrigation



# Reservoir Storage and Per Capita Storage Capacity



# Water resource stresses of selected river basins in South Asia

Basin	Indicators		Parameters	
	Available water resources $\text{m}^3.\text{capita}^{-1}$	Coefficient of variation in precipitation	$RS_s$	$RS_v$
<b>GBM</b>	3,473	0.11	0.00	0.37
<b>Indus</b>	1,329	0.23	0.22	0.76
<b>Helmand</b>	2,589	0.37	0.00	1.00

$RS_s$  = Water scarcity parameter;  $RS_v$  = Water variation parameter

# Water development pressures of selected river basins in South Asia

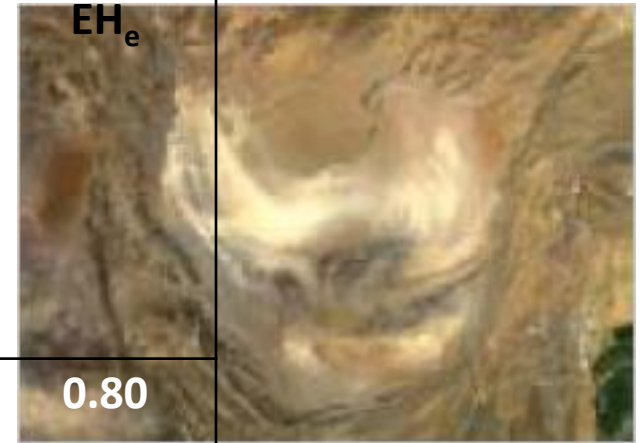
Basin	Indicators			Parameters	
	Total water use billion m <sup>3</sup> year <sup>-1</sup>	Water resources billion m <sup>3</sup> year <sup>-1</sup>	AISDW per cent of population	DP <sub>e</sub>	DP <sub>d</sub>
<b>GBM</b>	304	2,025	83	0.15	0.17
<b>Indus</b>	257	287	87	<b>0.89</b>	0.13
<b>Helmand</b>	9	18	43	<b>0.49</b>	<b>0.57</b>



**AISDW** = Access to Improved Source of Drinking Water, **DP<sub>e</sub>** = water exploitation parameter  
**DP<sub>d</sub>** = Safe drinking water inaccessibility parameter

# Ecological health of selected river basins in South Asia

Basin	Indicators			Parameters	
	Wastewater volume billion m <sup>3</sup> year <sup>-1</sup>	Water resources billion m <sup>3</sup> year <sup>-1</sup>	Vegetation cover per cent of basin area	EH <sub>p</sub>	EH <sub>e</sub>
<b>GBM</b>	92.0	2,025	20.0	0.30	<b>0.80</b>
<b>Indus</b>	54.7	287.0	39.1	1.00	0.61
<b>Helmand</b>	2.8	18.3	40.0	1.00	<b>0.60</b>



EH<sub>p</sub> = water pollution parameter, EH<sub>e</sub> = ecosystem deterioration parameter

# Management capacity of selected river basins in South Asia

Basin	Indicators				Parameters		
	GDP(PPP) US\$ capita <sup>-1</sup>	Water use billion m <sup>3</sup>	Populati on million people	AISF percent of populati on	MC <sub>e</sub>	MC <sub>s</sub>	MC <sub>c</sub>
<b>GBM</b>	1,807	304	582.9	40.0	0.91	0.60	0.50
<b>Indus</b>	4,002	257	215.8	51.8	0.86	0.48	0.375
<b>Helmand</b>	1,272	9.04	7.1	39	0.96	0.61	0.675

**AISF** = Access to Improved Sanitation Facility; **MC<sub>e</sub>** = Water use inefficiency parameter; **MC<sub>s</sub>** = Improved sanitation inaccessibility; **MC<sub>c</sub>** = Conflict management capacity parameter