Identification of a Matrix Framework to Study the Life Cycle of Water in Indian Domestic Sector

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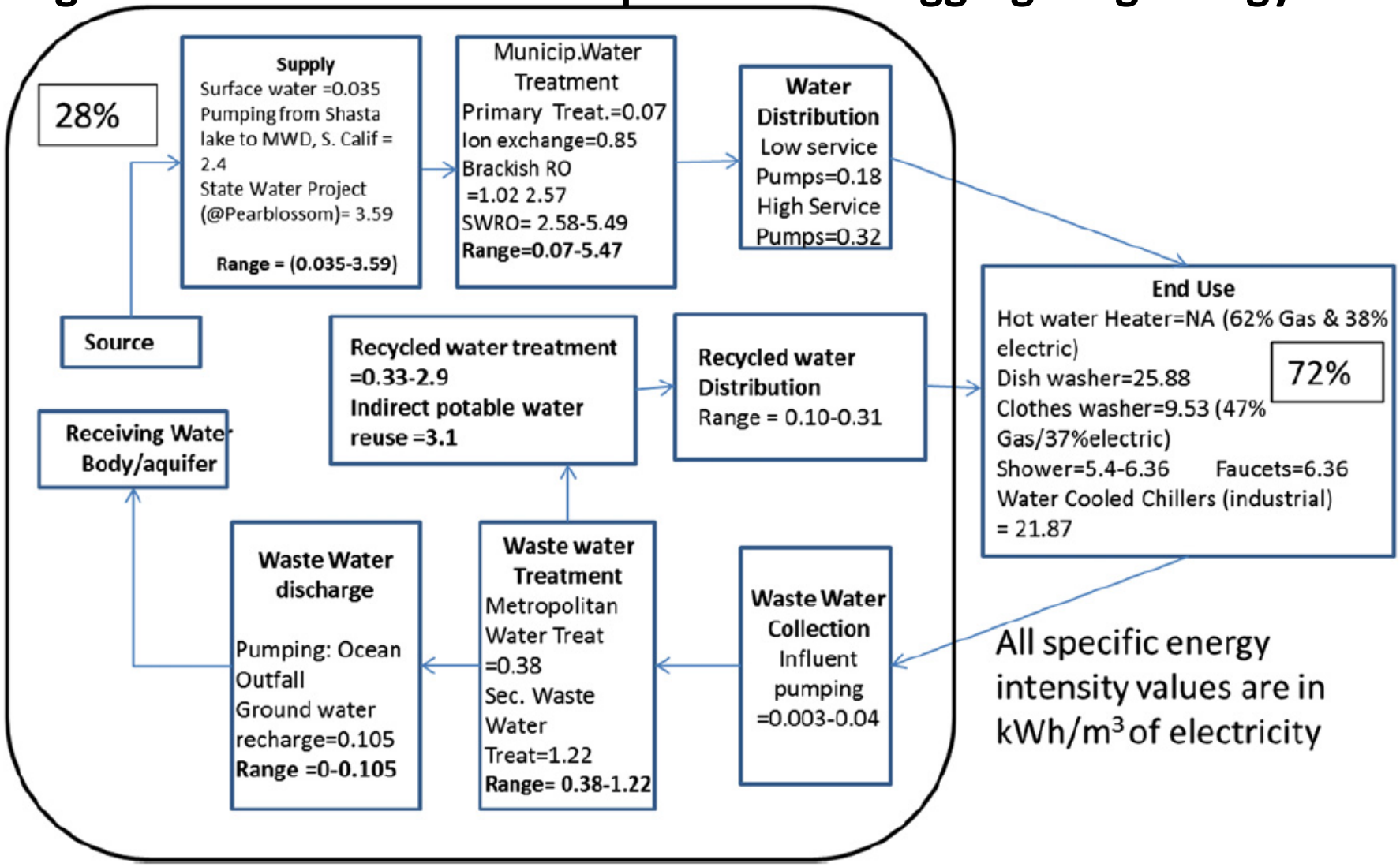
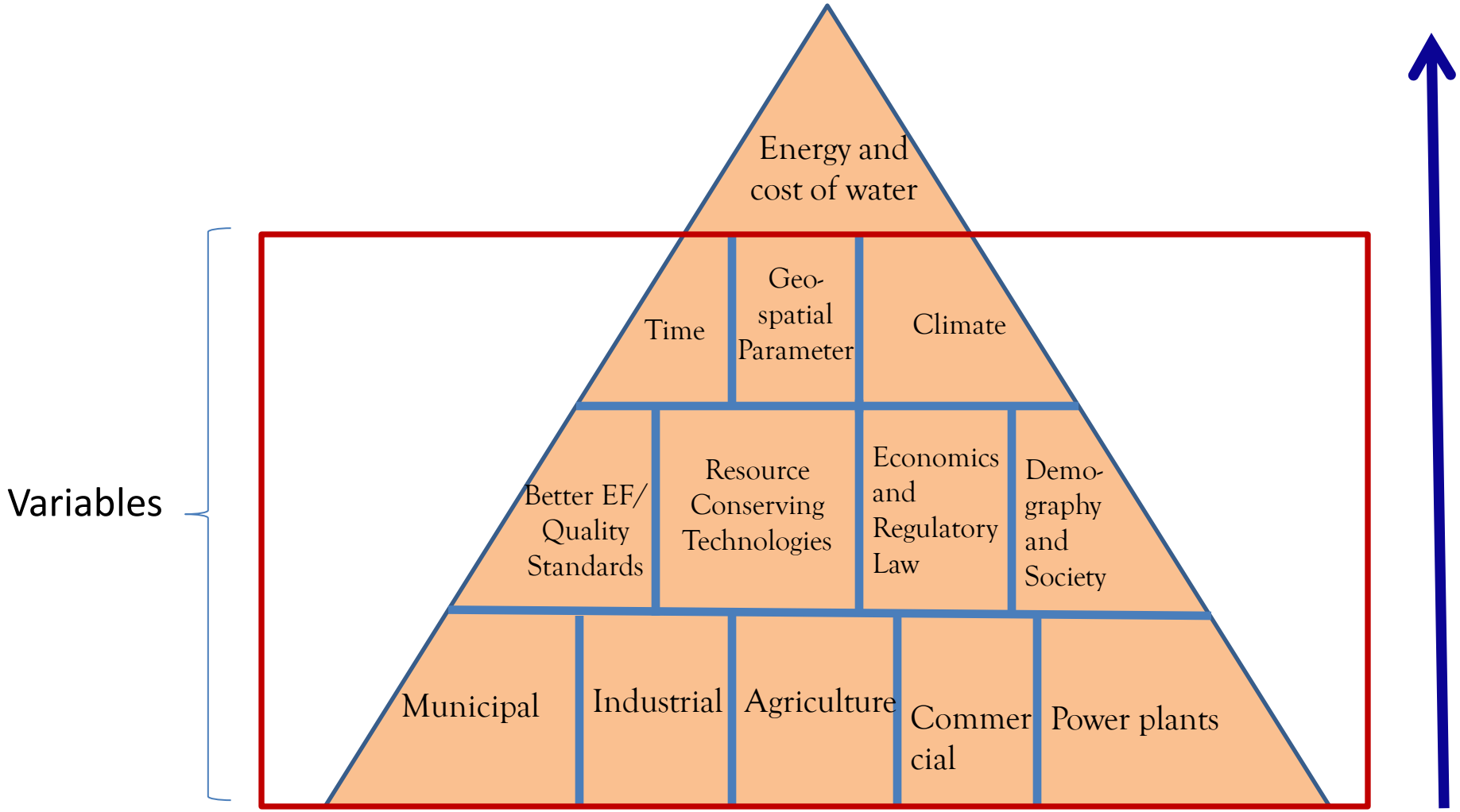
Stages in the water life municipal sector disaggregating energy use



Reference: Plappally and Lienhard, 2012



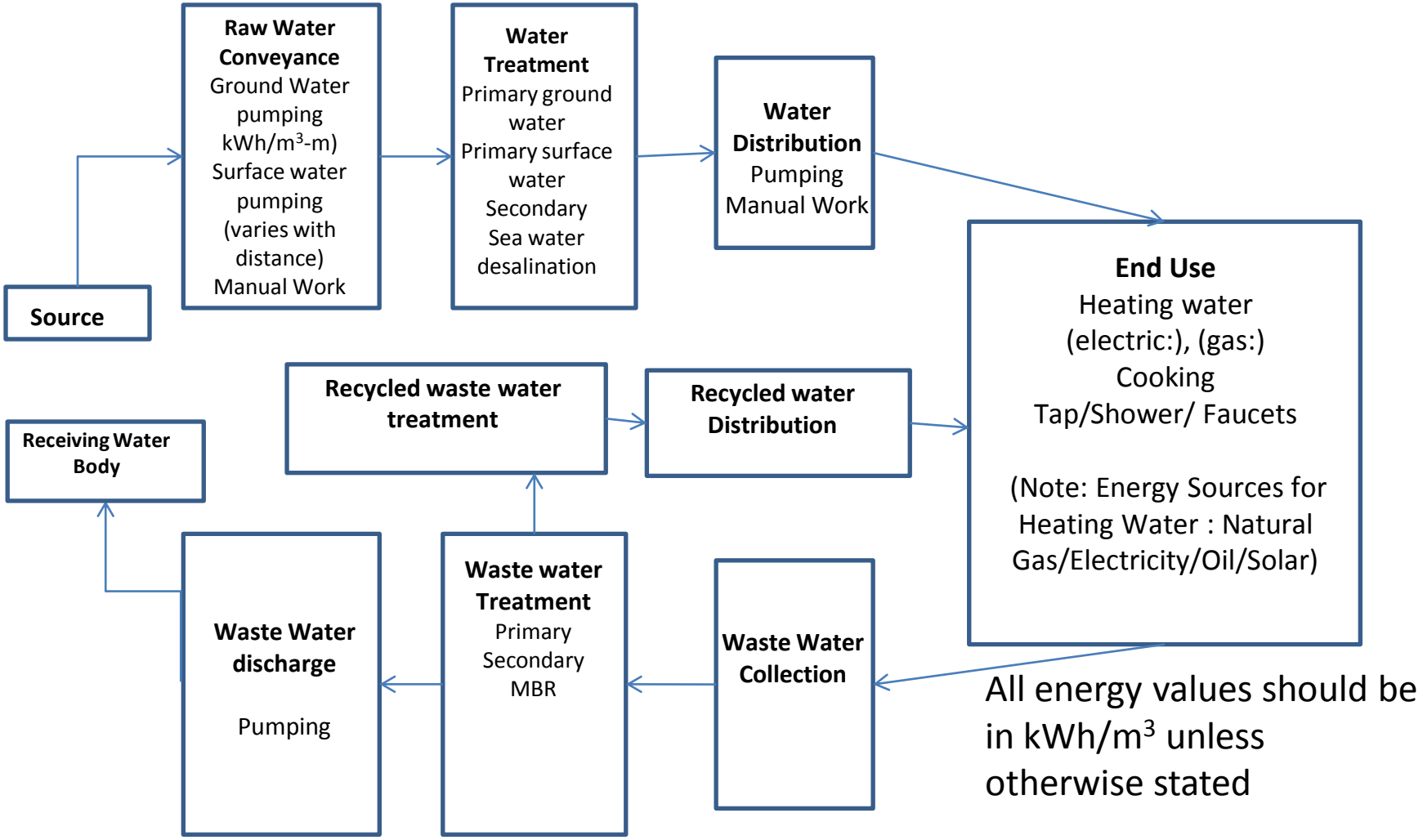
Source is confidential: Plappally, A. K., 2011, MITEI Interim Report to British Petroleum BPESC

Contents

1. The topic and its background
2. The need of the hour
3. Draft and Transport of Water
4. Putting water management terms of energy consumed rather than availability.
5. Case Studies –Micro-scale water stress results can be inferred from Macro-scopic analysis
6. Why this framework?
7. The Denouement

THE NEED OF THE HOUR:

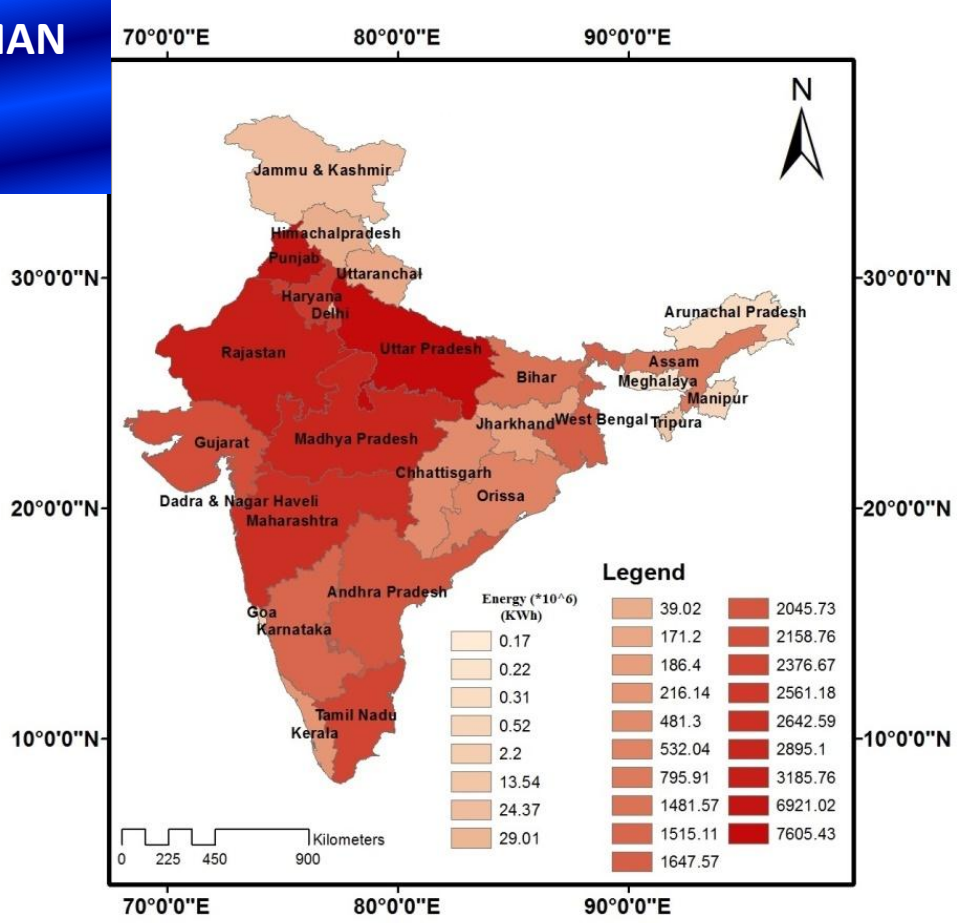
WATER LIFE CYCLE- FOR INDIA- DO WE HAVE DATA TO FILL THIS UP.

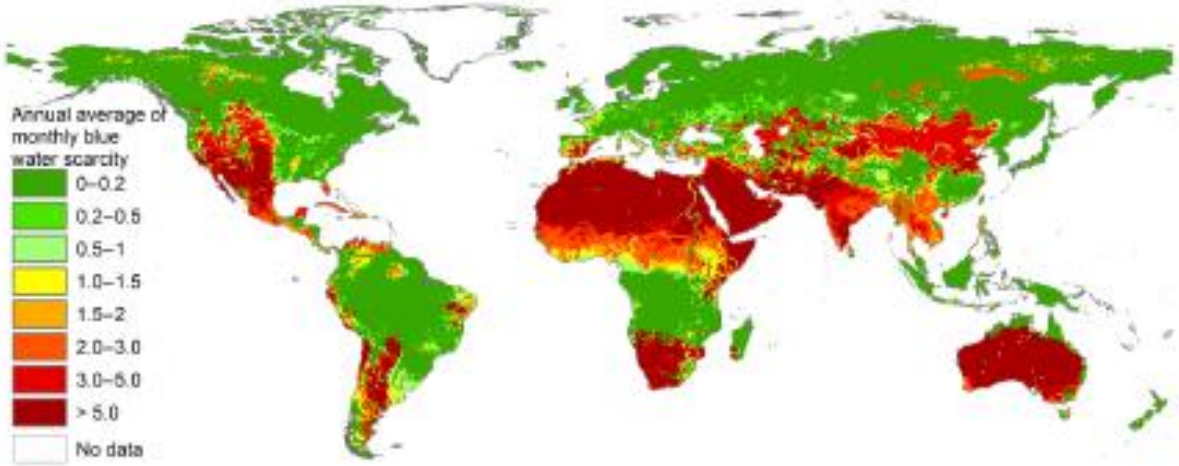


Reference: Plappally A K and Lienhard V, J H Energy Requirements for Water Production, Treatment, End Use, Reclamation, and Discharge,, MIT, Cambridge, Interim Report, British Petroleum Environmental Sustainability Challenge May 2011.

$10^0 00'00"$ – $25^0 00'00"$- N - moderate to severe water scarcity in India (Mekonnen and Hoekstra 2016),

$15^0 05'00"$-$30^0 79'\ 00"$N- and $73^0 83'90"$-$80^0 91'\ 00"$E- Maximum amount of electricity expended to draw ground water

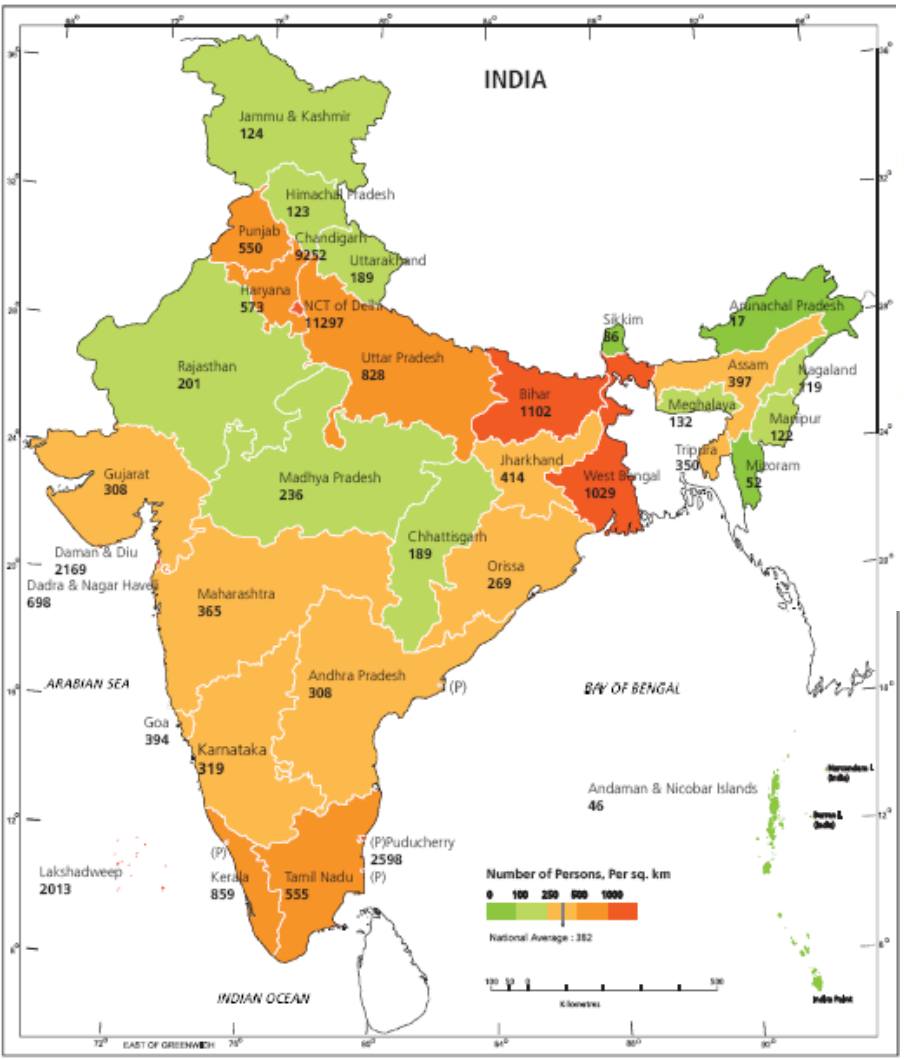


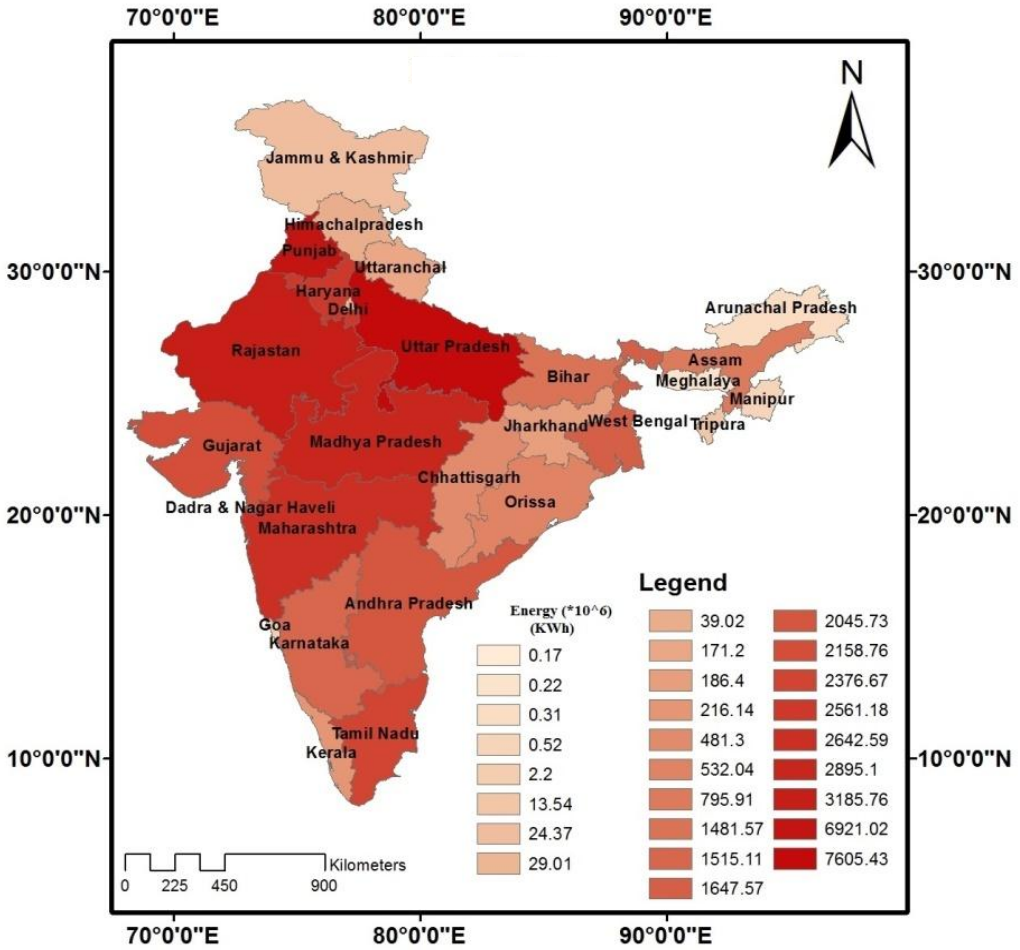


Ganges Basin in Uttar Pradesh extensively mines water but does not cater to severe water scarcity due to countercyclical blue water consumption and availability[1]

Figure on blue water scarcity is Sourced-
1. Mekonnen and Hoekstra Sci. Adv. 2016; 2 : e1500323

Average energy required for ground water drafting for each state during 2011 in India.

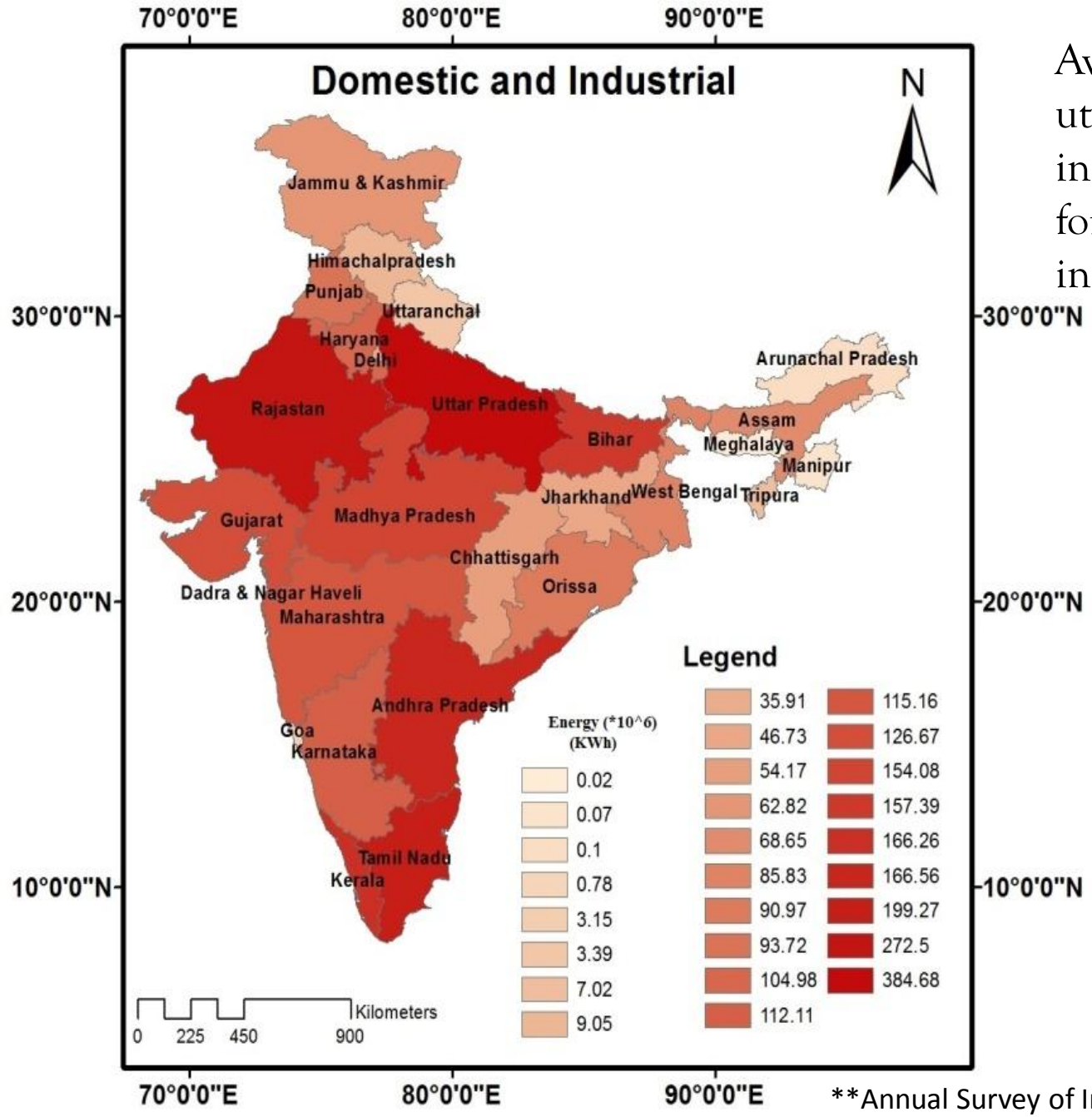




Energy expenses are correlated to water scarcity levels in regions (Mekonnen and Hoekestra 2016)

1. With high population Density
2. Less dense populations but with low natural availability (arid regions of Rajasthan

Population Density in 2011 Map Source: http://censusindia.gov.in/2011-prov-results/data_files/india/Final_PPT_2011chapter7.pdf



Average electrical energy utilization for domestic and industrial ground water use for each state during 2011 in India.

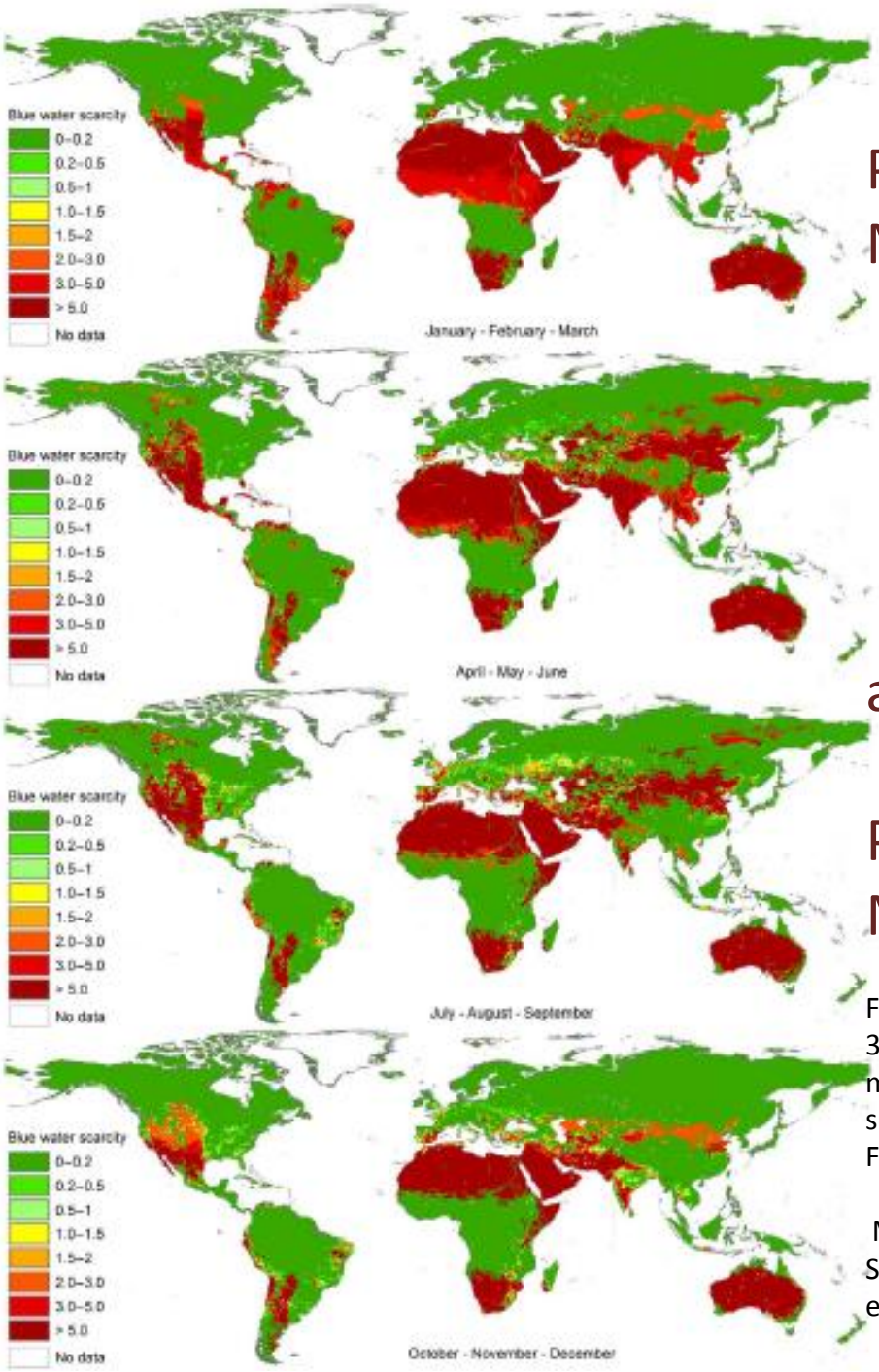
49% of India lives in Uttar Pradesh, Maharashtra, Bihar, West Bengal and Andhra Pradesh*.

Top 5 states with highest sharing of urban population : Goa, Mizoram, Tamil Nadu, Kerala and Maharashtra*.

Maharashtra, Gujarat, Tamil Nadu , Karnataka and Uttar pradesh – 5 most industrialized states**

**Annual Survey of Industries (ASI) 2012-13

*http://mospi.nic.in/Mospi_New/upload/SYB2015/ch2.html



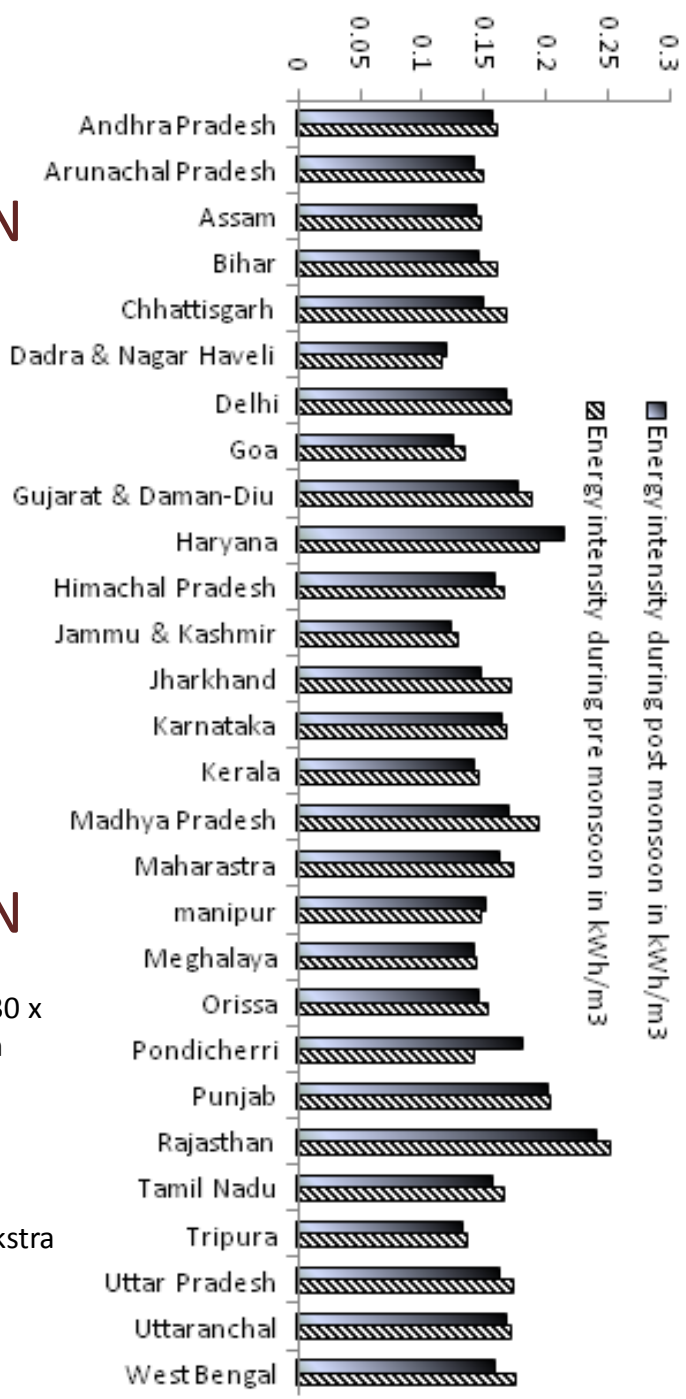
PRE-MONSOON

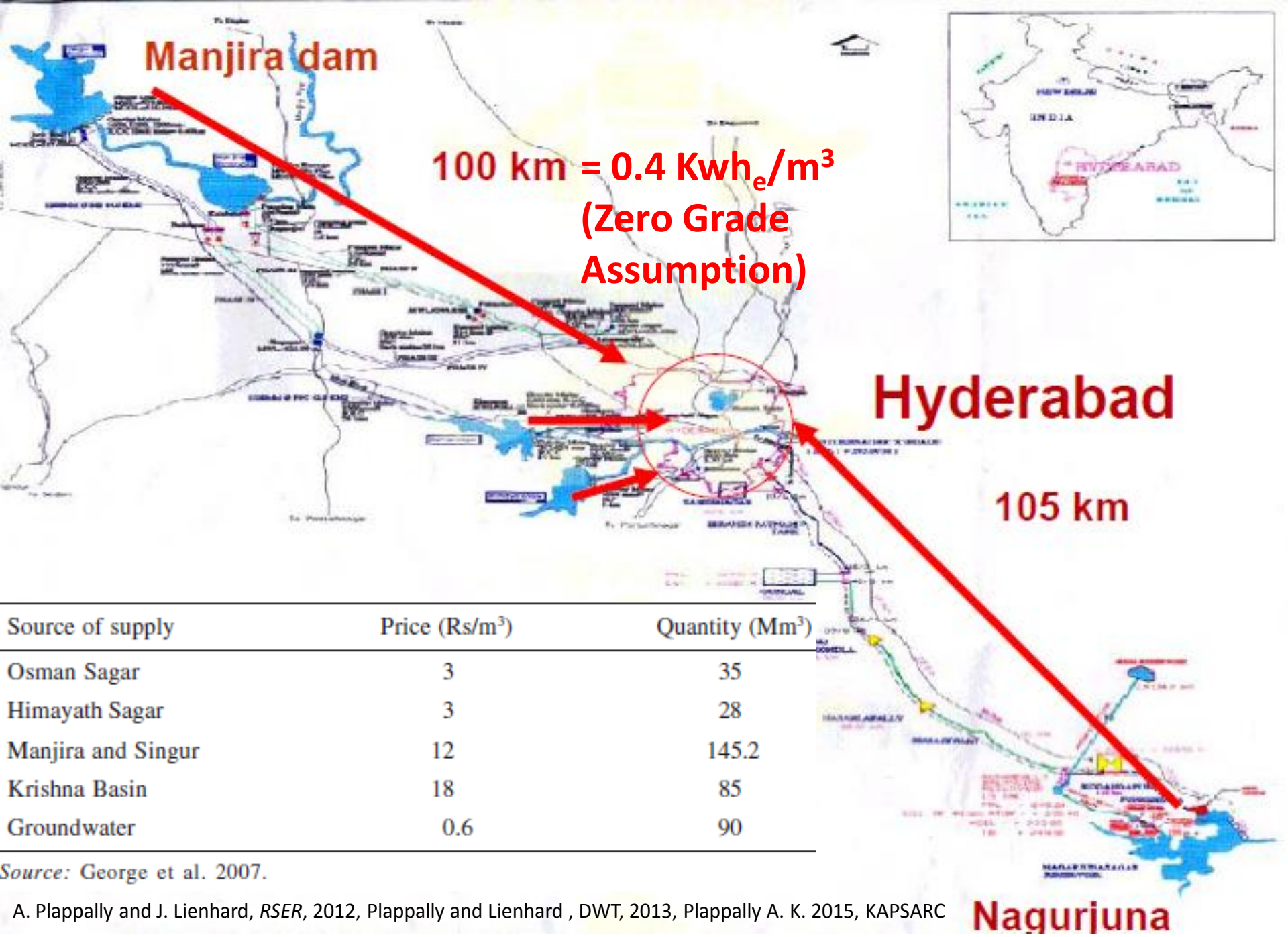
and

POST MONSOON

Figure on the Left: 30 x 30 arc min resolution monthly blue water scarcity is Sourced-From

Mekonnen and Hoekstra Sci. Adv. 2016; 2 : e1500323

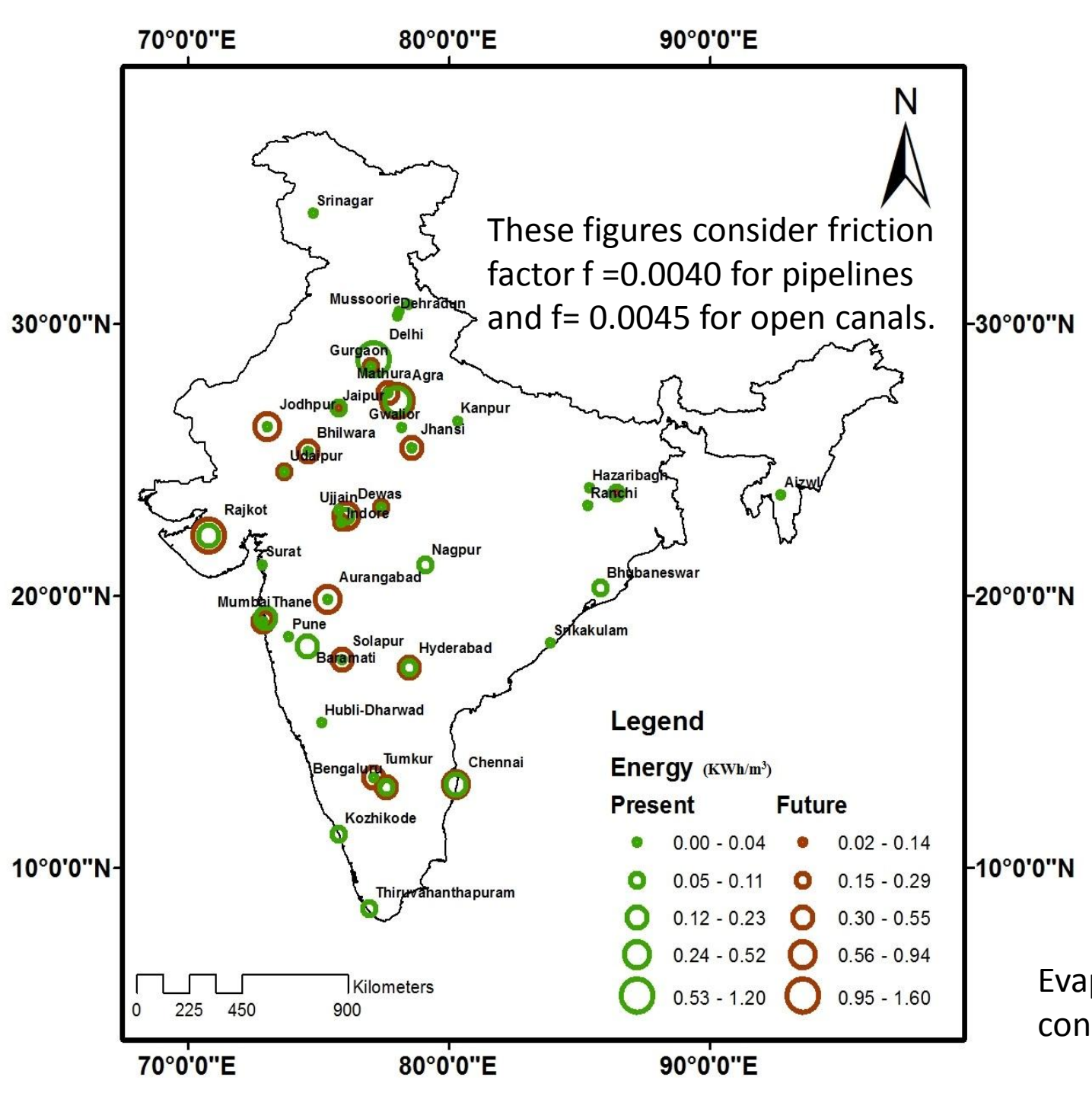




Source of supply	Price (Rs/m^3)	Quantity (Mm^3)
Osman Sagar	3	35
Himayath Sagar	3	28
Manjira and Singur	12	145.2
Krishna Basin	18	85
Groundwater	0.6	90

Source: George et al. 2007.

A. Plappally and J. Lienhard, *RSER*, 2012, Plappally and Lienhard , DWT, 2013, Plappally A. K. 2015, KAPSARC



average total energy utilized "presently" for transporting surface water to cities (**Green symbols**)

energy required to source water in the "future" from additional planned sources. (**Orange symbols**)

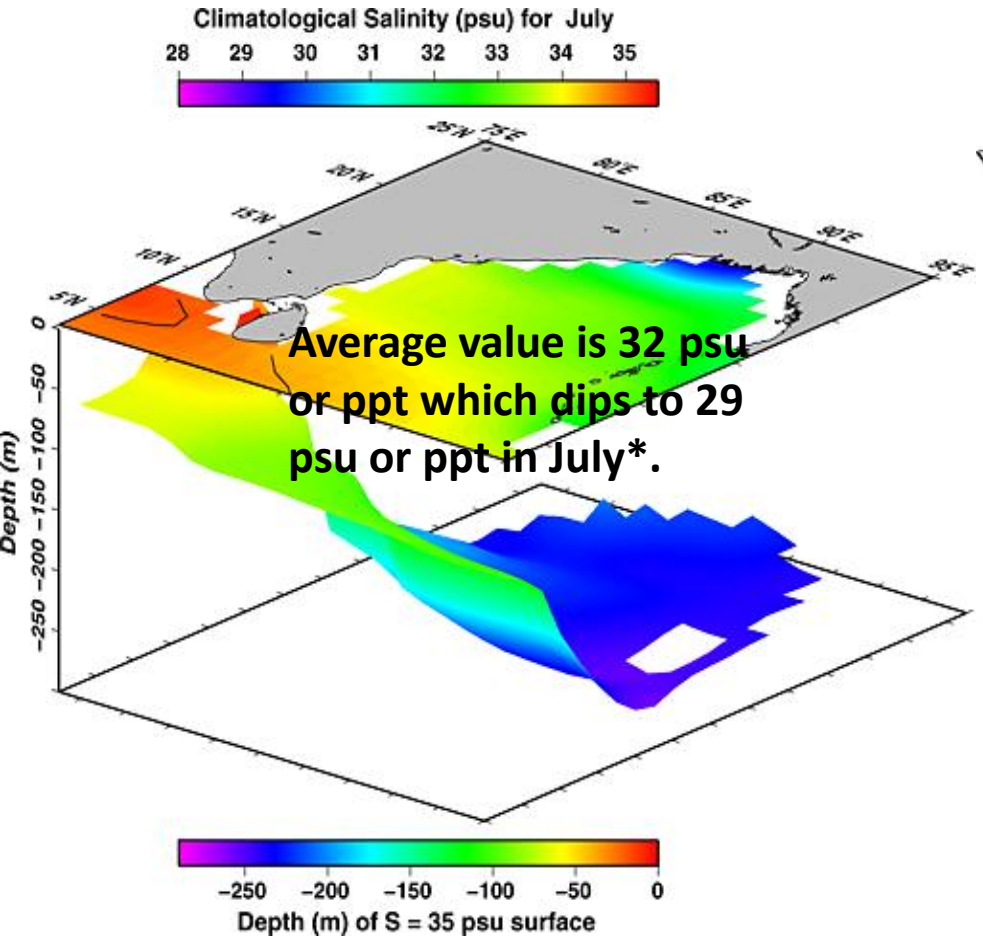
Evapo-transpiration is not considered

Policy Take on Water Transport

1. Long distance transport of water is said unviable due to
   a. high energy cost requirements to push water across terrains (Plappally and Lienhard 2013)
   b. evapo-transpiration losses (2151-2527mm/year- largest in India- Indira Gandhi Canal Project) and percolation losses.
   c. Water logging and salinization (Example- Indira Gandhi Canal Project – 5-6Mha (Bhakar R. 2007, Master Thesis, ITC and IIRS)
2. Obsolete wetlands or water bodies or infrastructure at point of use (Making water everybodies business, CSE 2009)
3. Conversion of clayley wetland soils or predominant agricultural land for building construction.
4. No institutionalization of education on water at household level (Baker and Ngai 2015)

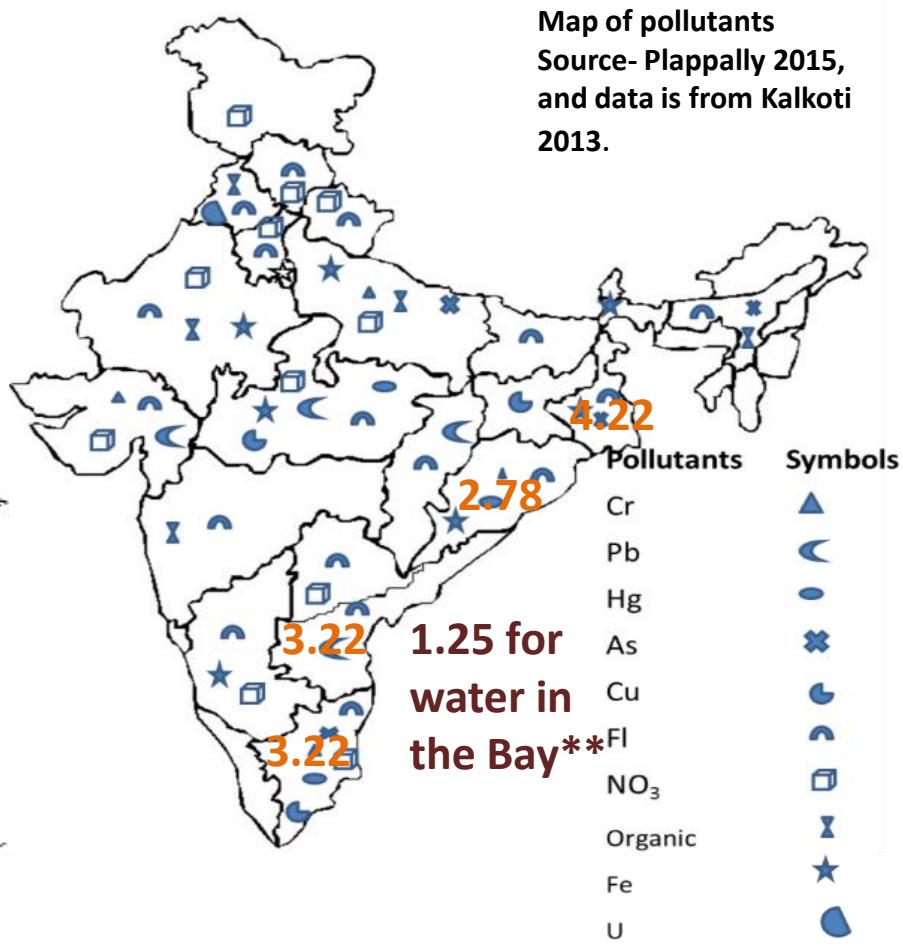
Treatment

"A summer monsoon pump to keep the Bay of Bengal salty"*



Average value is 32 psu or ppt which dips to 29 psu or ppt in July*.

Map of pollutants Source- Plappally 2015, and data is from Kalkoti 2013.



Energies for Extracting and Treating Ground Water in kWh_e/m^3

****The Calculation of Theoretical energy for treating 1.805 moles of salt, assuming R=0.082 l-bar/deg mol, at T= 31^{0}C**

*P. N. Vinayachandran, Geophysical Research Letters
Volume 40, Issue 9, pages 1777-1782, 14 MAY 2013 DOI: 10.1002/grl.50274
http://onlinelibrary.wiley.com/doi/10.1002/grl.50274/full#grl50274-fig-0001

Polluted rivers in India with water quality close to Bathing requirement of BOD 3mg/L *

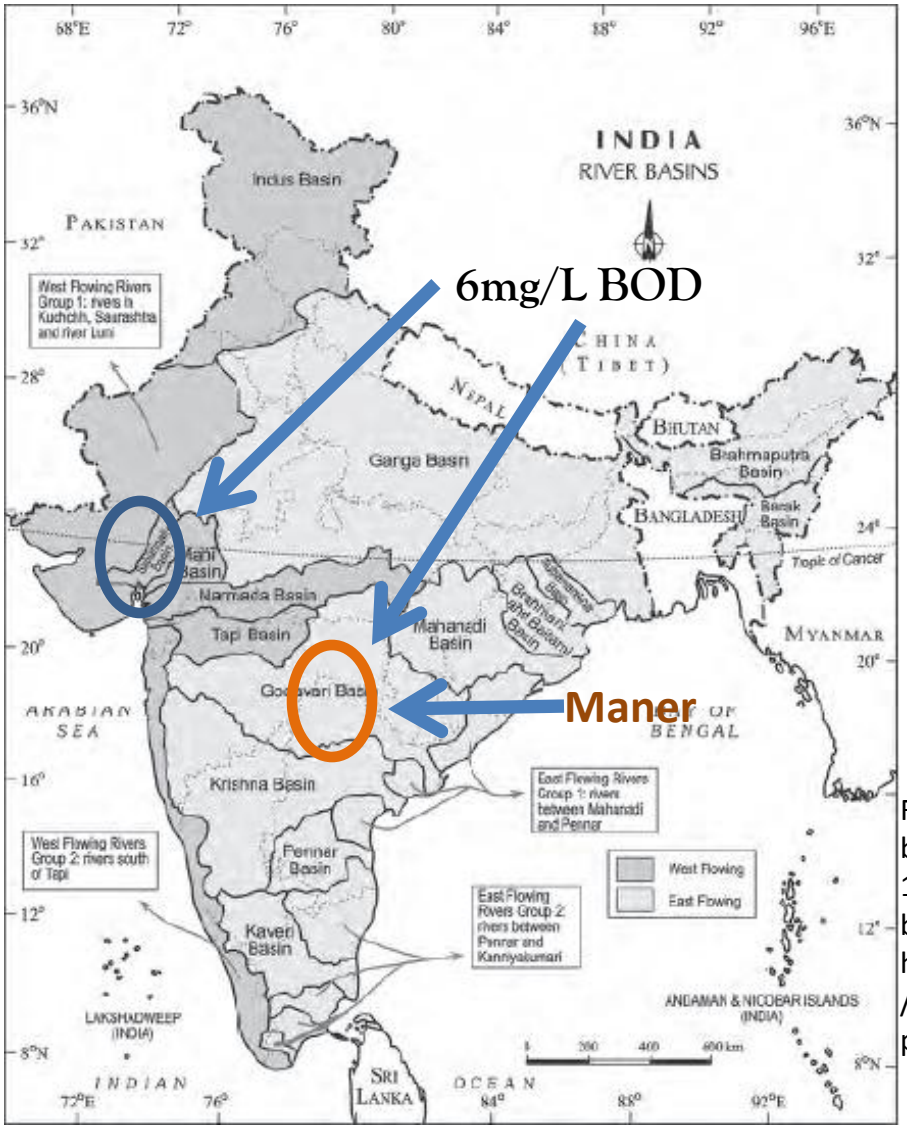
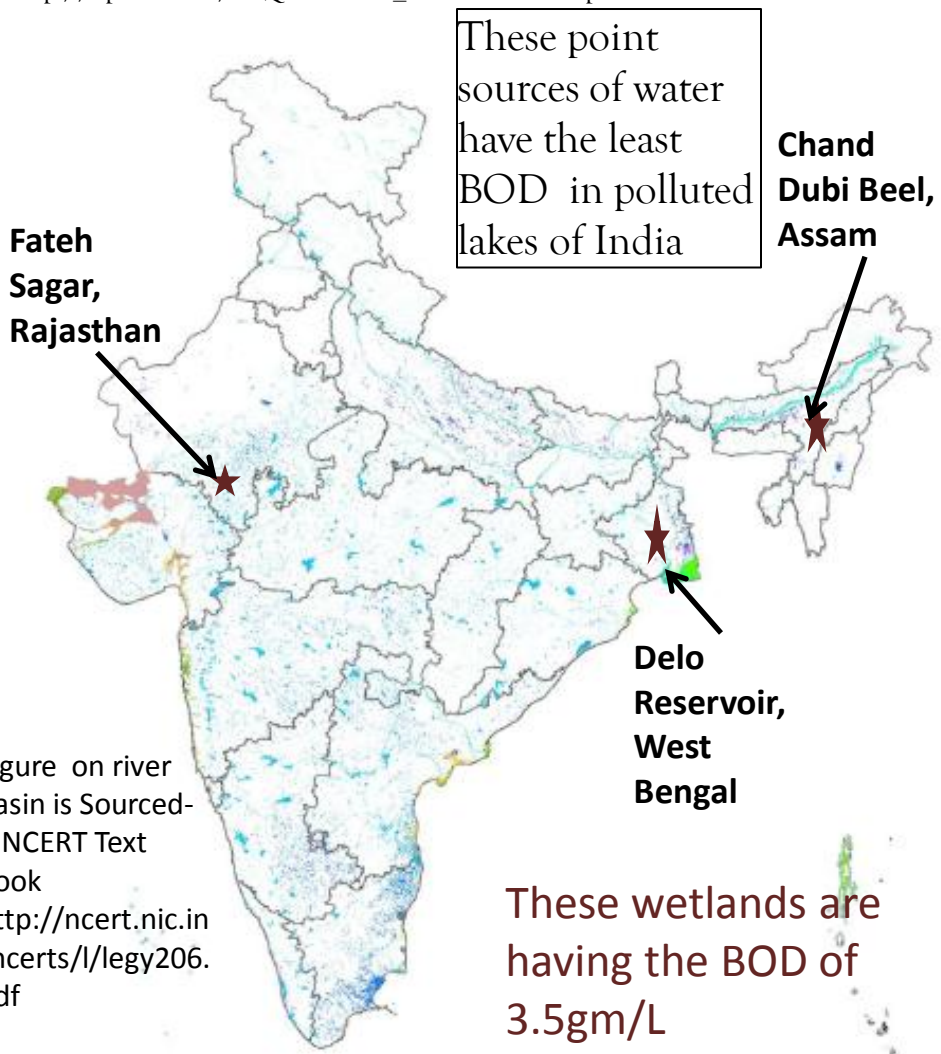
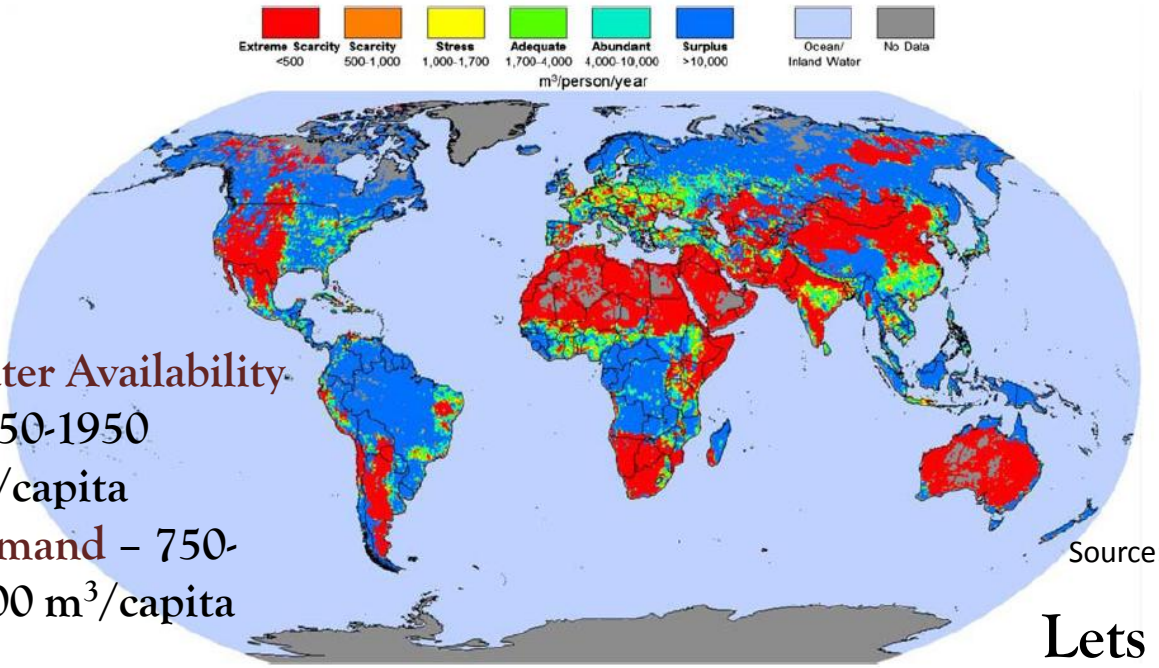


Figure on river basin is Sourced-
1.NCERT Text book http://ncert.nic.in/ncerts/l/legy206.pdf

Polluted lakes or ponds or wetlands in India with water quality close to Bathing requirement of BOD 3mg/L

Figure on wetlands below is Sourced-
1. Status of Water quality in India 2010-Monitoring of Indian National Aquatic Resources Series: MINARS/ /2010-11, CPCN, MEF, New Delhi. Retrieved from http://cpcb.nic.in/WQSTATUS_REPORT2010.pdf



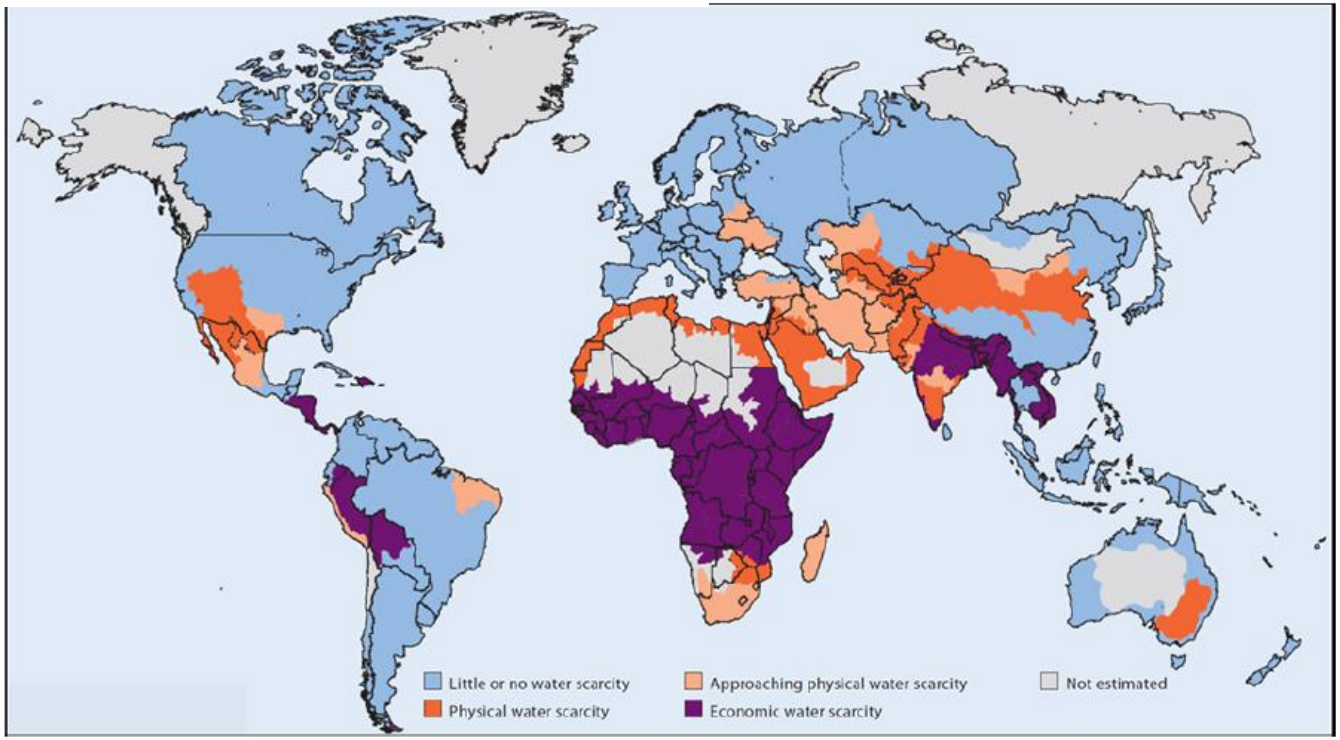


Water Availability – 850-1950 m^3/capita

Demand – 750-5400 m^3/capita

Source: International Network Archive , Princeton University

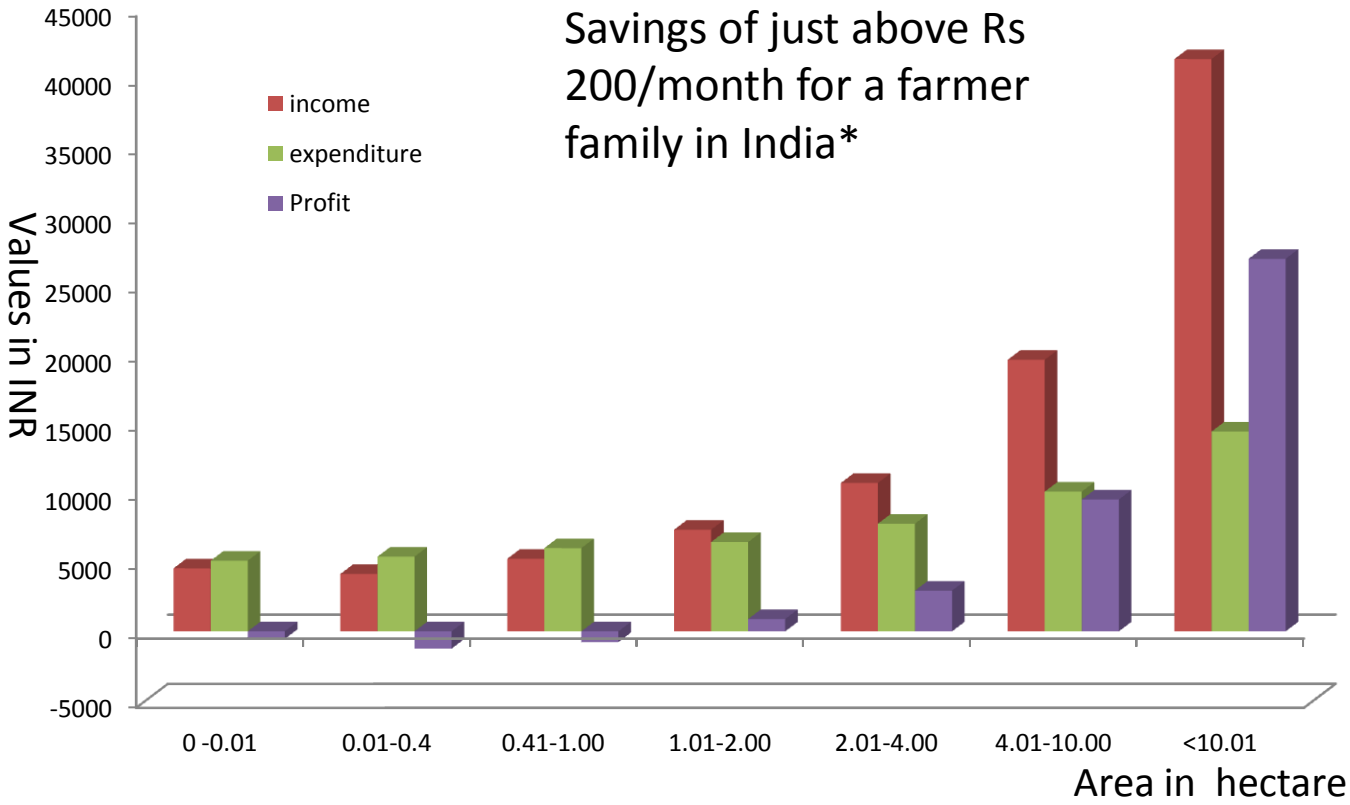
Lets Try to Marry the plots



22% of India's population (17.6% of world's population) earn less than $1.25/day/person (MDG 2014)

Map Source: Plappally and Lienhard,2013, DWT; UNEP/ARENDAL 2008

Saving of a farmer in India , (Area Vs Income)



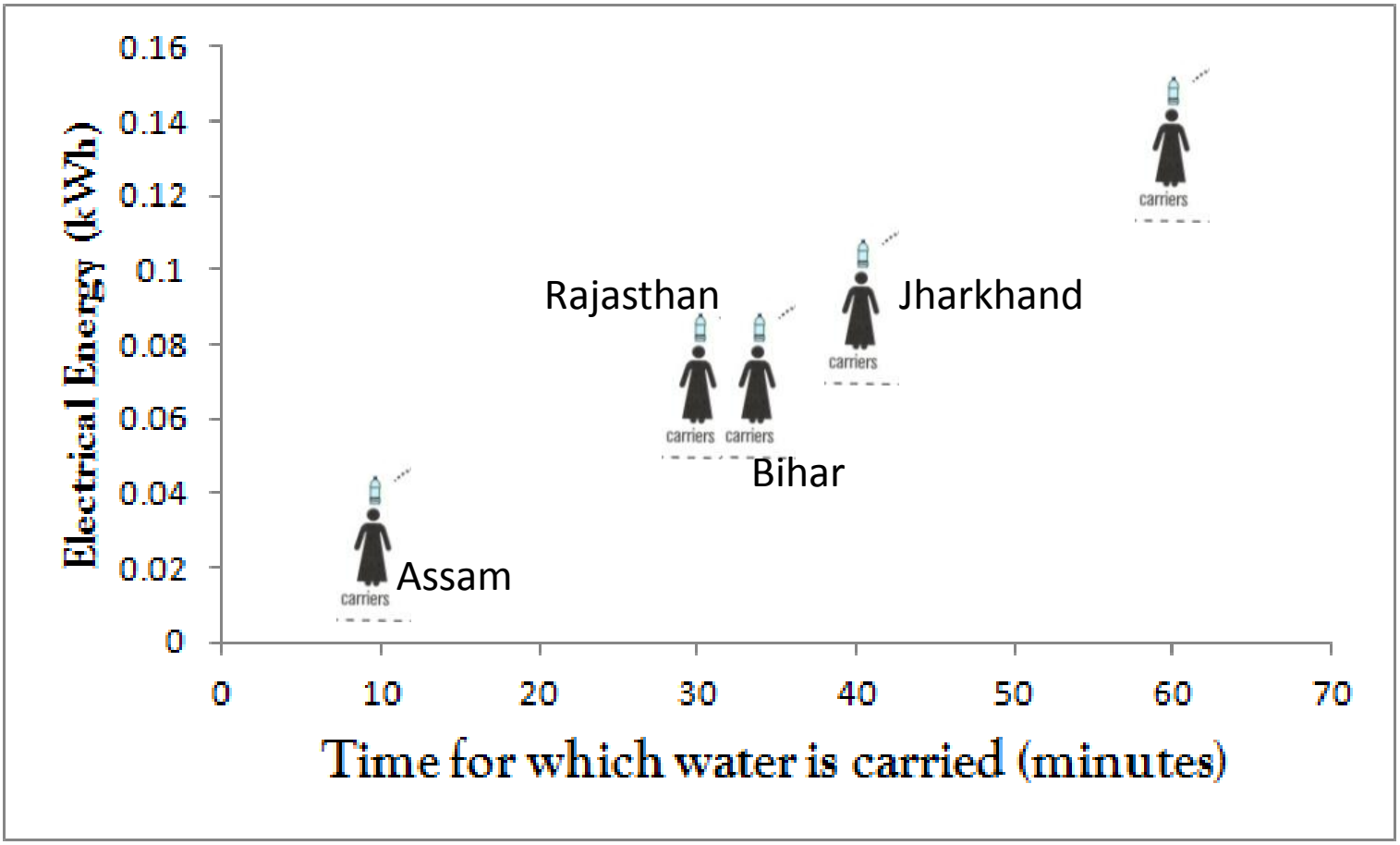
Approximately 1 hectare land can provide you with Rs. 6000-7000 monthly income and expense of the same range (NSSO, Feb 2016)*.

*Souce : MT, 2016, Visual edit, It doesn't pay to be a farmer in India, Mail Today, Thursday, March 3, 2016, page 24.

Society Specific Aspects

1. Cultural obligations of water use and designated community specific locations of water draft in rural India (CSE 2009- Water Everybodies business.)
2. Cultural demarcations for a set of task related to sanitation and water (Mehta 2013)
3. Stubborn mind of the farmer to adapt resource conserving technologies and cropping pattern that can defy climate abnormalities.
4. With advent to new technologies, traditional water structures were forgotten and dumped with waste or flattened for construction.
5. Departure of farmer to other trades for better financial aspects and self sustenance.
6. Value of water is under-estimated; need to remove subsidies

Water distribution for End Use by Women

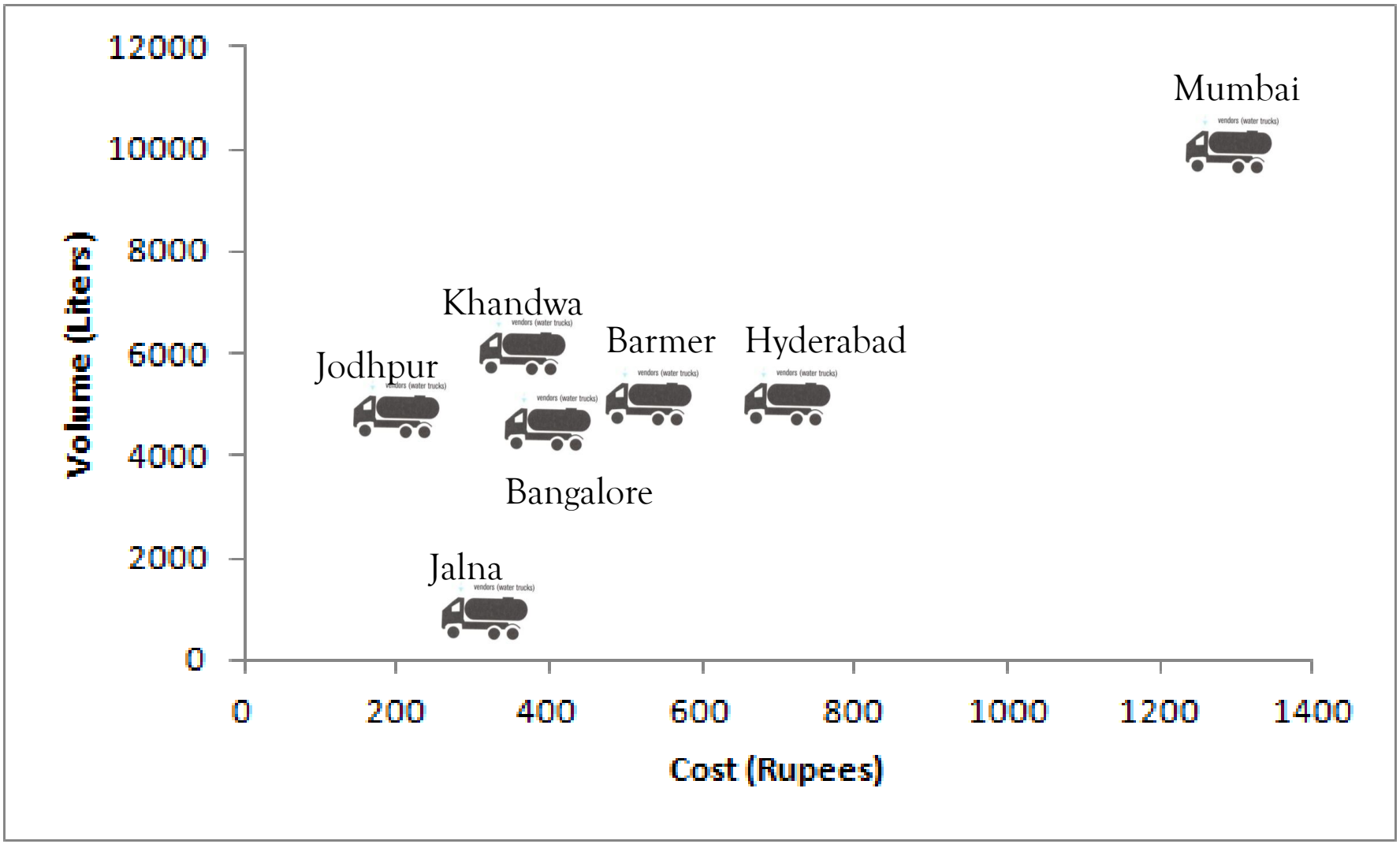


Every second woman in rural India may consume an average of 360 kWh_e for every cubic meter of water transported per year.

"54% of rural women had to travel between 200 metres and five kilometres daily to get drinking water. They walked 20 minutes a day, on an average, and spent another 15 minutes at the source"*.

*National Sample Survey Office (NSSO), Aug 24. 2015

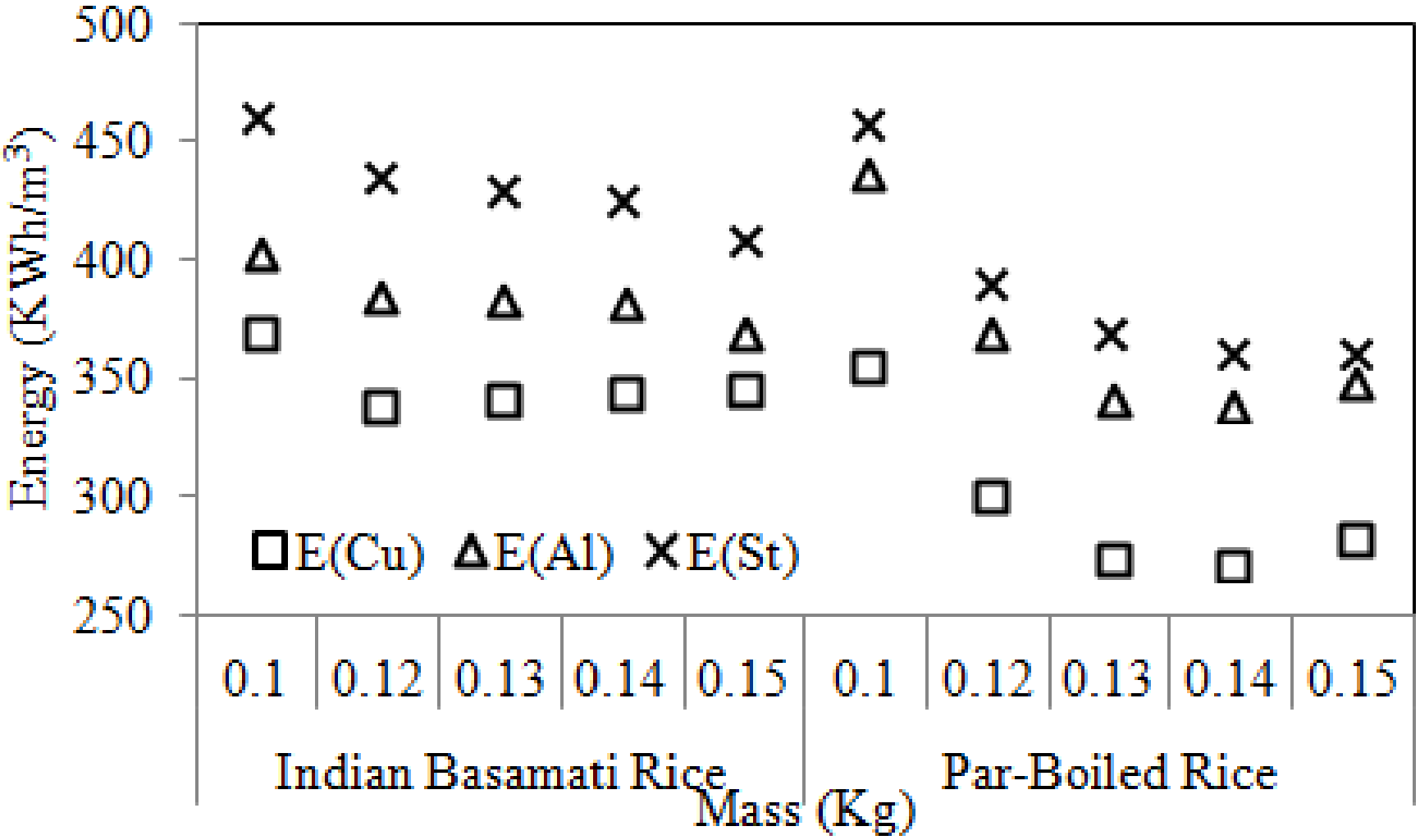
Water distribution for End Use using Tanker



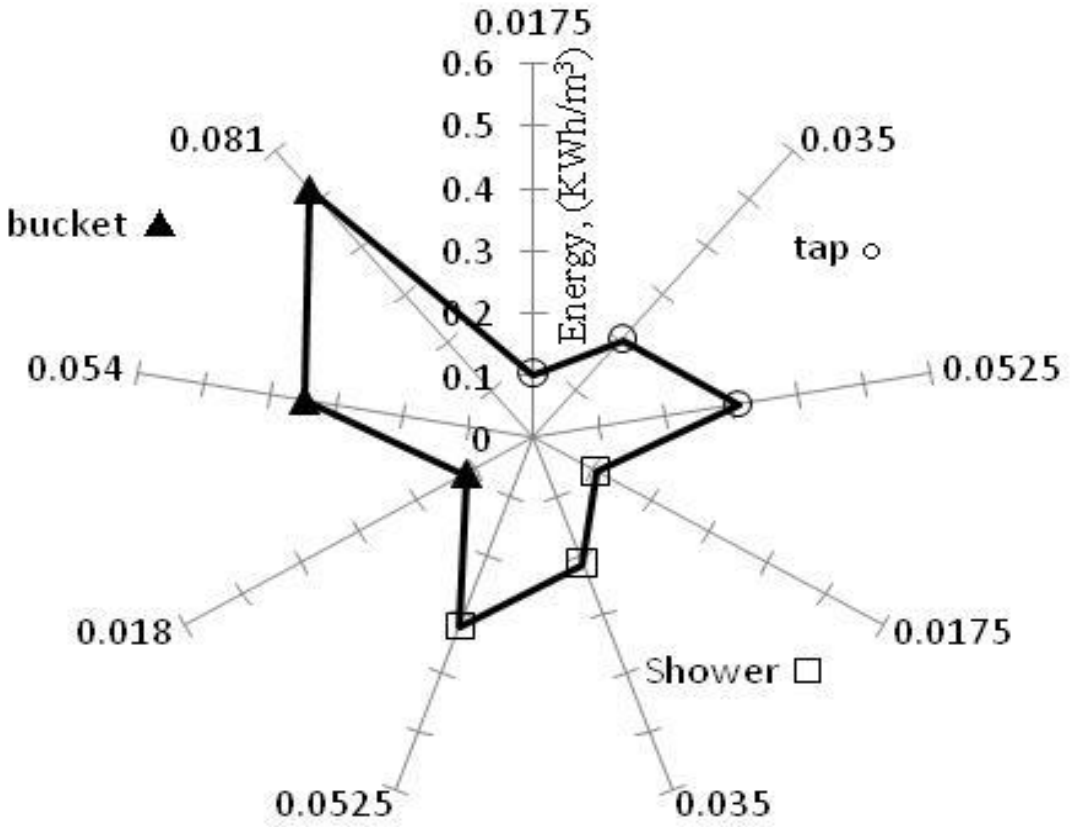
Policy Take on Water Organizations

1. Lowest paid sanitation and water jobs
2. Public sanitation on political agenda first time in history in 2015
3. Contractual jobs
4. Technical experts 'Manage' rather than implement policy
5. Lack of subject specialists on water jobs. Less research on management of waste and water.
6. Academia and Research not a part of policy formulation
7. Less data interaction between electrical department and water departments.

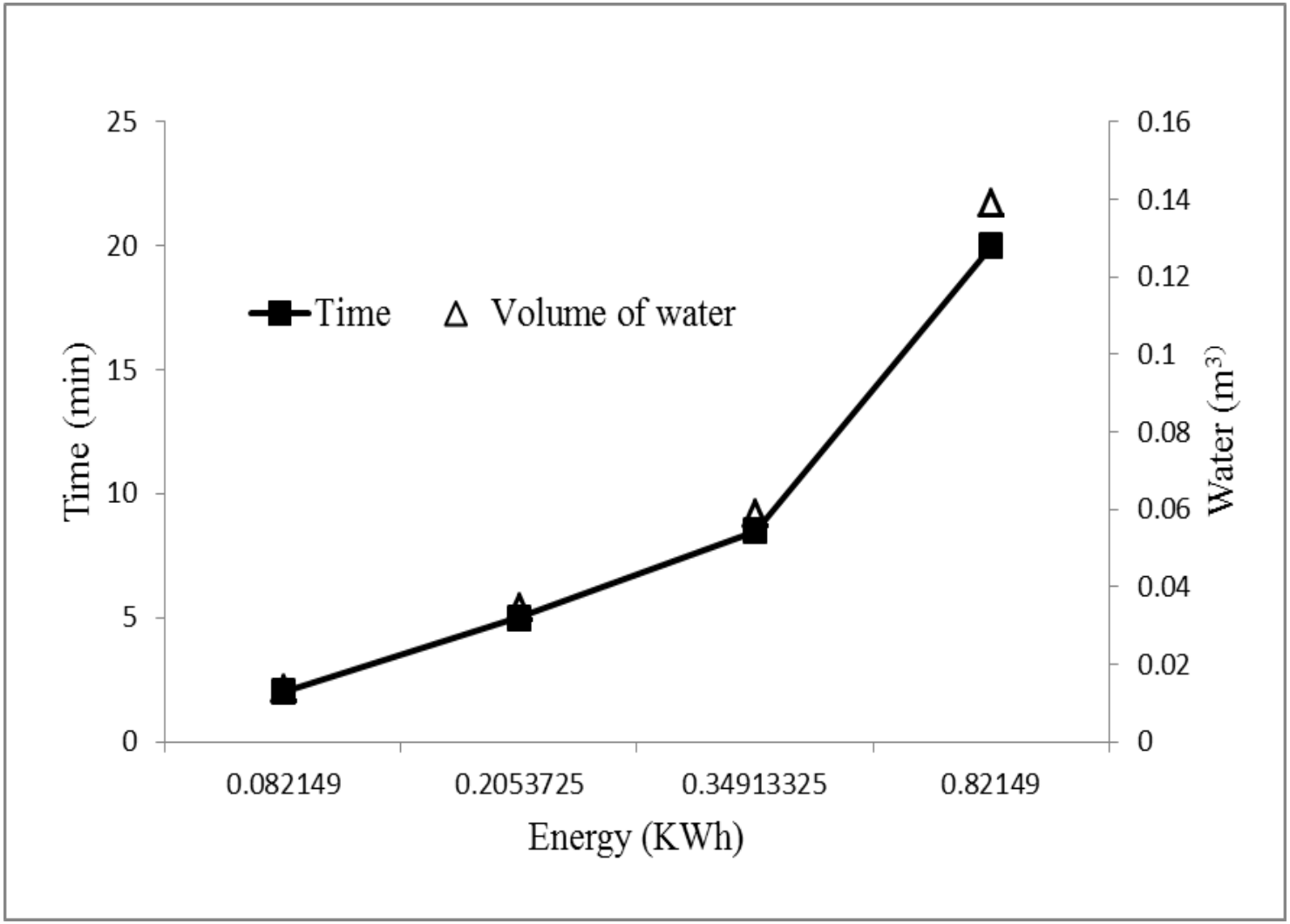
End Use –Case on Cooking, Bathing and Manual Washing Utensils



Equivalent electrical energy Intensity for cooking rice in India



A radar graph showing variation of energy versus quantitative variation in water (m^3) with the shower, tap and bucket mode of bathing

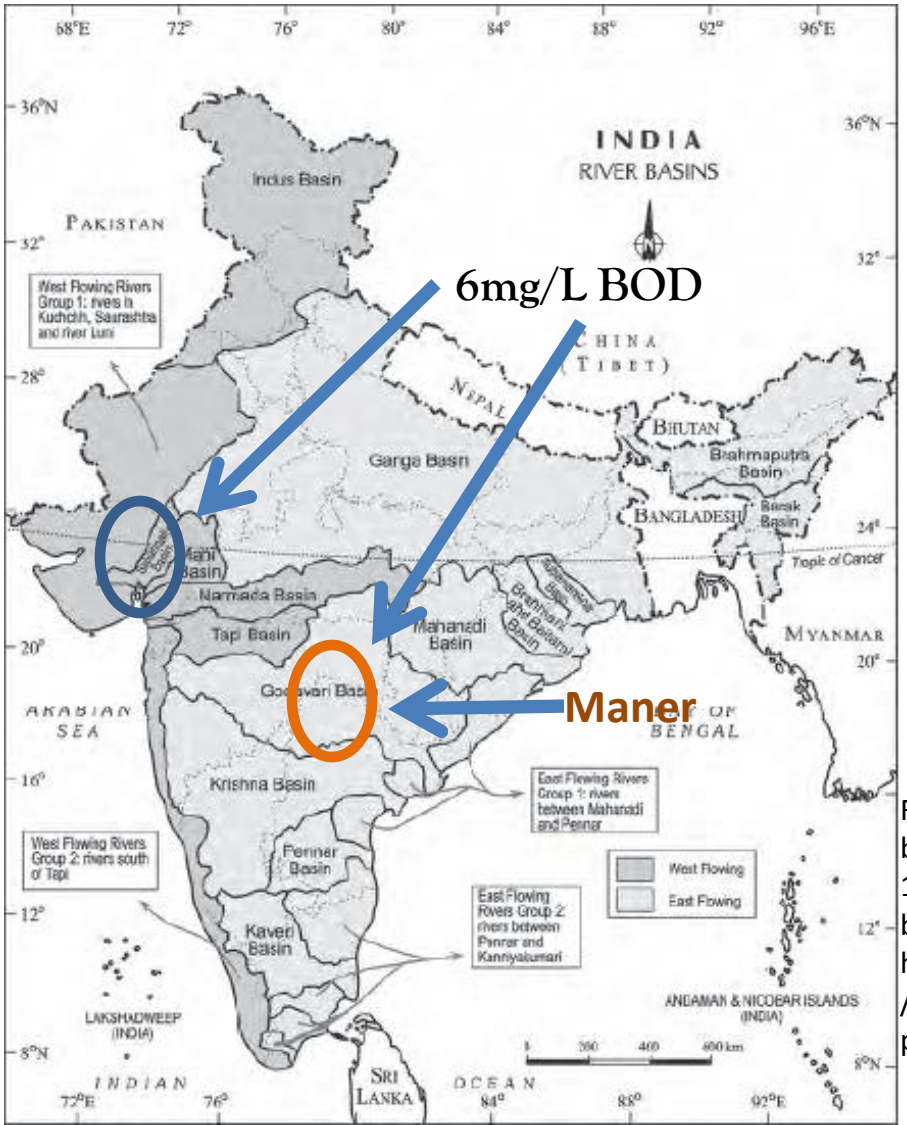


Energy consumption in washing utensils for different lengths of time in Jodhpur Rajasthan, India

Policy Take on End Use

1. Energy is applied on water
2. Human Behavior appends to theoretical analysis of the process or devices
3. Randomness
4. In case of cooking, water intensive foods consume corresponding energies and these are region specific.
5. Material plays an important role in optimizing water and energy use.
6. Expert in cooking saves the most
7. Water use corresponds to energy expended

Polluted rivers in India with water quality close to Bathing requirement of BOD 3mg/L *



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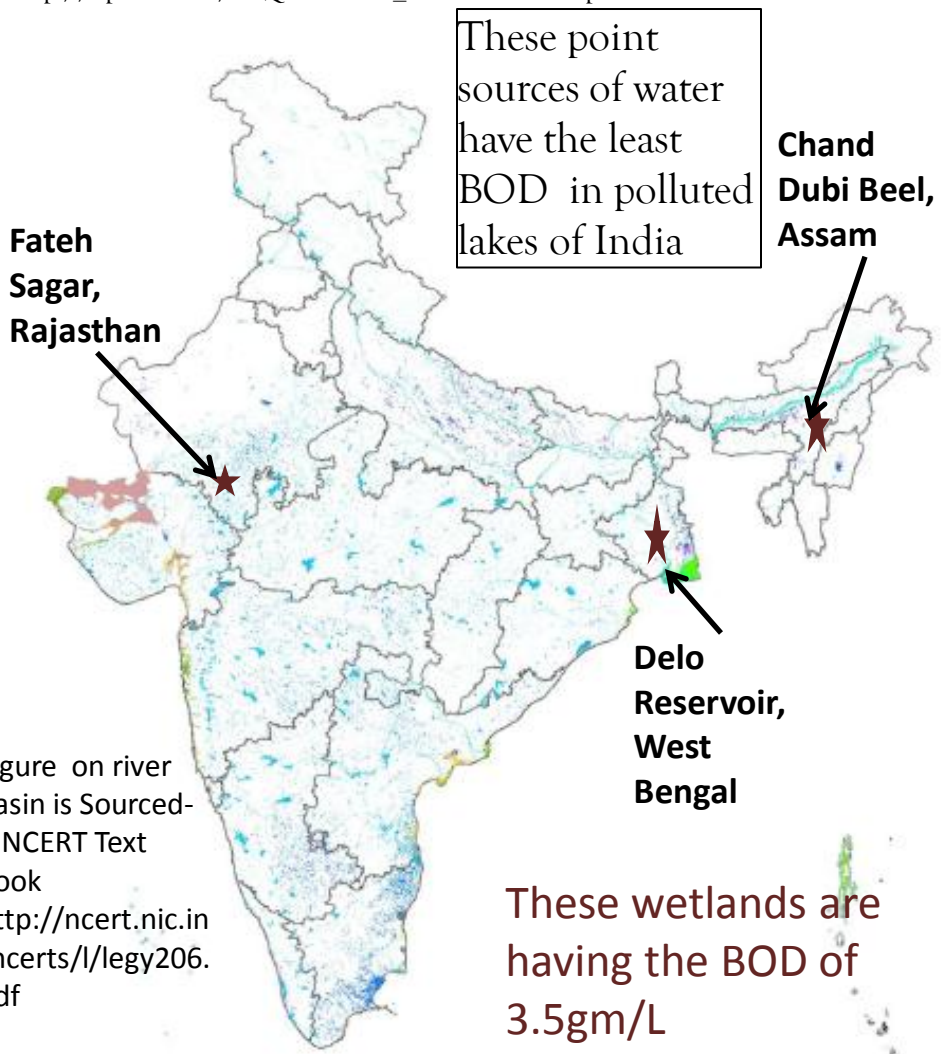
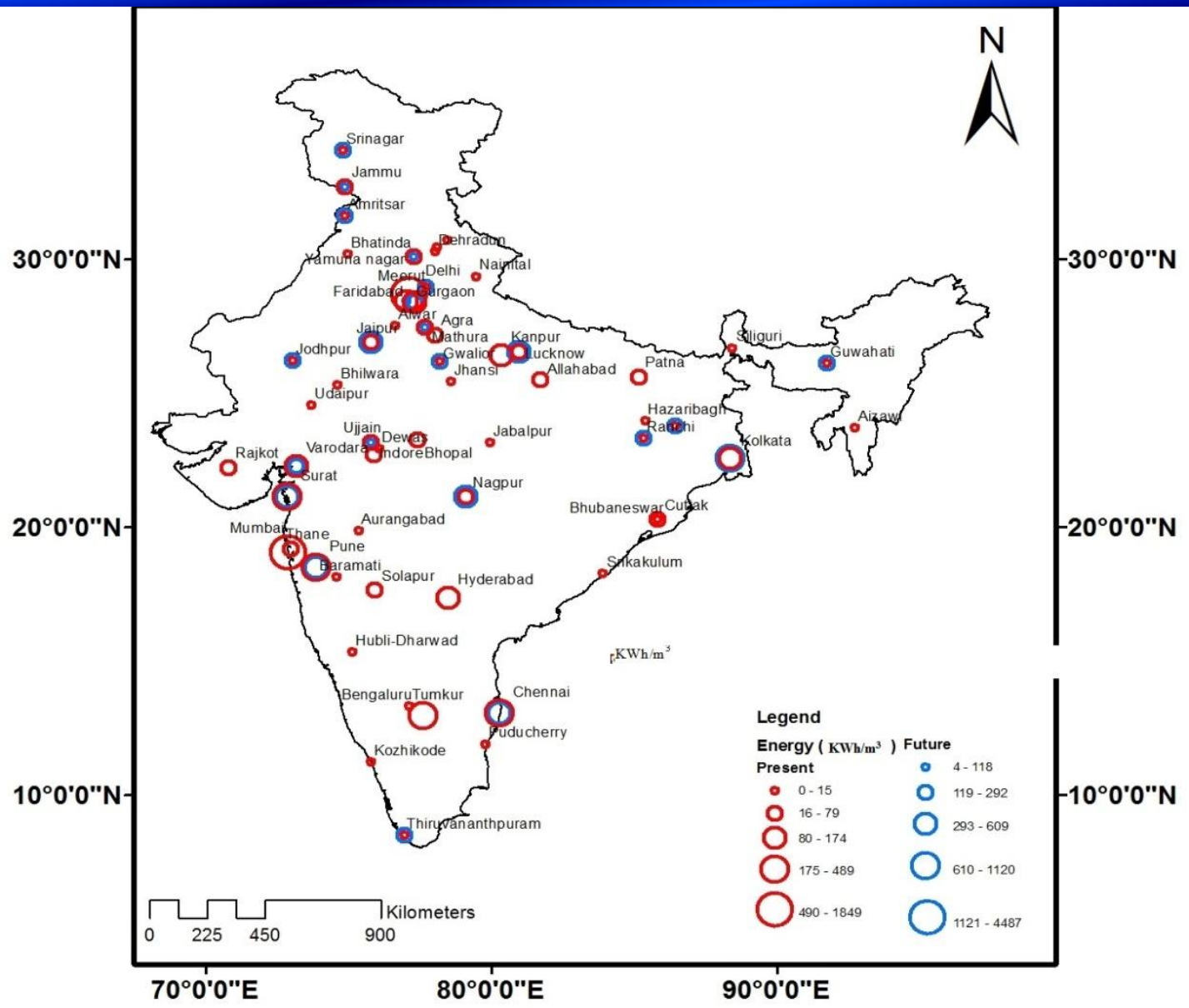


Ganga	States	Energy x 10^6 (in kWh) At present capacity	Energy x 10^6 (in kWh) For total treatment
Basin	Bihar	470.32	1071.9
	Uttar Pradesh	1260.65	2375.25
	Uttrakhand	51.24	329.39
	Best Bengal	1560.72	3733.27
Tributaries	Bihar	5.69	1273.46
	Haryana	888.26	712.60
	Jharkhand	0	370.96
	Madhya Pradesh	357.69	2612.97
	IG canal, Rajasthan	0	998.72
	Uttar Pradesh	2326.28	5843.75
	Uttarakhand	0	100.21
	West Bengal	263.34	1850.55
	Delhi	6633.51	8392.95
	Bihar	5.69	1273.46
Total		**13817.74 GWh (in a year)**	**29666.02 GWh (in a year)**

Energy consumption in treatment of produced water before draining it to Ganges.

- Produced water or Sewage



energy utilized presently for treating waste water

actual demanded treatment energy (which is represented as future energy in this plot)

Policy Take on Waste and Waste Water Management

1. Treatment Capacity is far below requirements
2. Non abiding industry and municipality. Missing stringency to make institutions to follow regulations.
3. Ill manned plants and missing element of ownership (Chait 2014)
4. Subject knowledge is important for personnel and untrained personnel. Work ethics is absent (Pathak 2014).
5. Less information availability. First report tabled by government in 2011 (Plappally and Lienhard 2013).
6. Cleanliness and sanitation jobs considered by less educated class and responsibility of a third person or considered a job of lower status.

Conclusions

1. Use of energy as a parameter to evaluate technology efficiency, treatment and transport aspects, because energy of processes and technologies do not change but costs will.
2. Remove subsidization; incorporate cost for quantitative and qualitative usage rather than flat tariff.
3. Understand the 3 x 3 linkages between water, energy and agriculture production or manufacturing sectors
4. Policy and its Stringent regulatory framework for society to be aware and abiding to it
5. Data on water and its interaction with energy, subjects, economics, type of technology, type of material, and skill set required to be provided utmost importance.
6. Take up sanitation jobs irrespective of cultural backgrounds.
7. Long Term planning i.e more than 50 year plans to be worked .
8. Research and Academia in this area needs to be strengthened and made part of government policy making procedures.

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लोकाः समस्ताः सुखिनो भवन्तु

lokāḥ samastāḥ sukhino bhavantu

(low-kaah'-ha suh-muh-staah'-ha soo-khee-no' bhuh'-vun-too)

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