

Water Food Energy Nexus: Changing Scenarios in Recent Decades

Subimal Ghosh

Department of Civil Engineering
Indian Institute of Technology Bombay
Mumbai, India

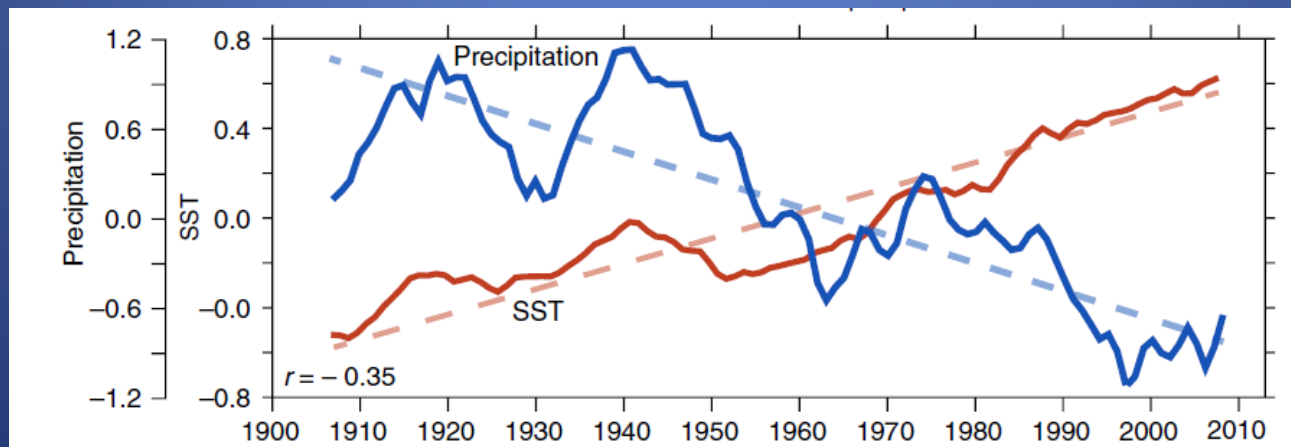
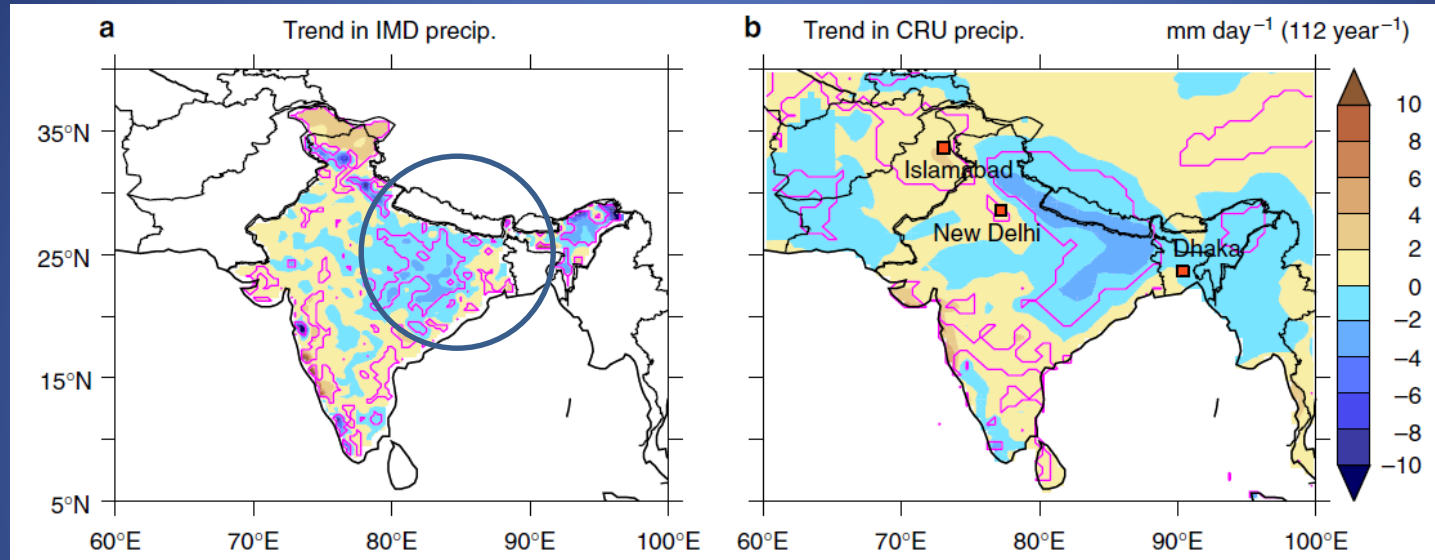
Introduction

- Total population of India is 1210.2 million.
- 68.84% and 31.16% is rural and urban population respectively out of the total Indian population (Census 2011).
- Agriculture largely dependent on Indian Summer Monsoon (ISM). [Rainfall during June to September]
- ISM highly unpredictable and variable, delayed onset and early withdrawal.
- Major source of irrigation : GROUNDWATER
- In the year 2011, 61% of the net irrigated area was irrigated using groundwater whereas only 24% was irrigated using canals.

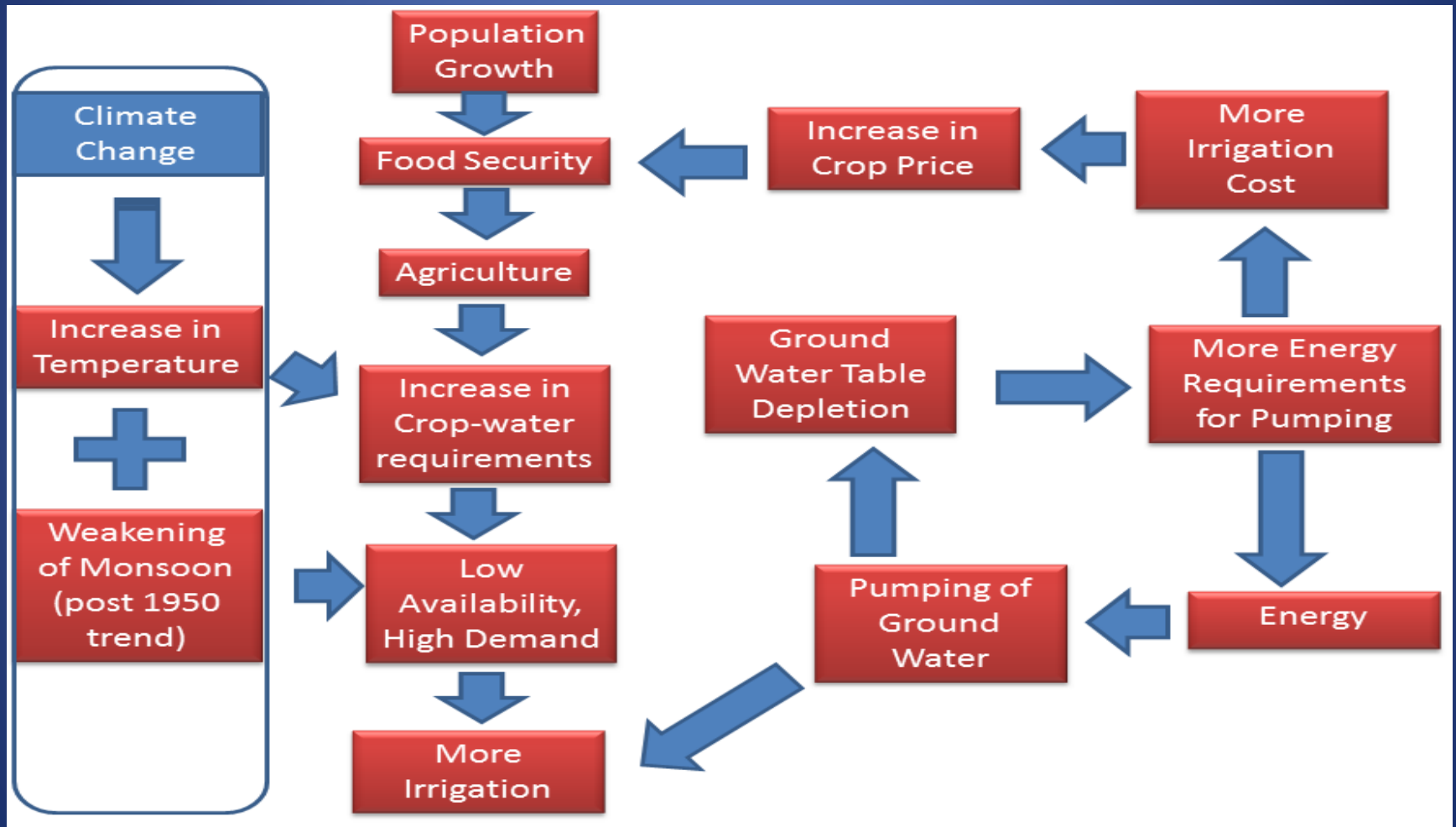
Water-Food-Energy Nexus

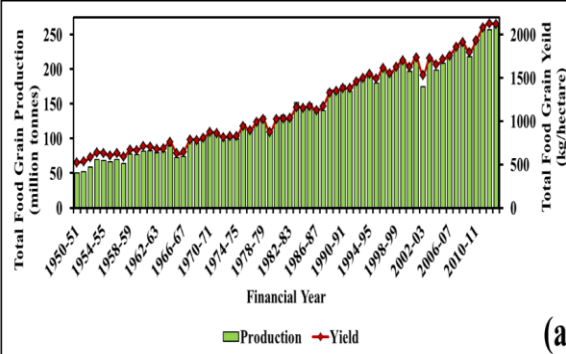
- Major source of water: Summer monsoon rainfall.
- Water requirement increases with increasing food demand due to high rise in population.
- Excess requirements: Ground Water Withdrawal.
- Highest energy demand (in agricultural sector): for ground water pumping.
- Needs an integrated assessment of water-food-energy nexus under climate change.

Changes in major source of water: Indian Summer Monsoon Rainfall

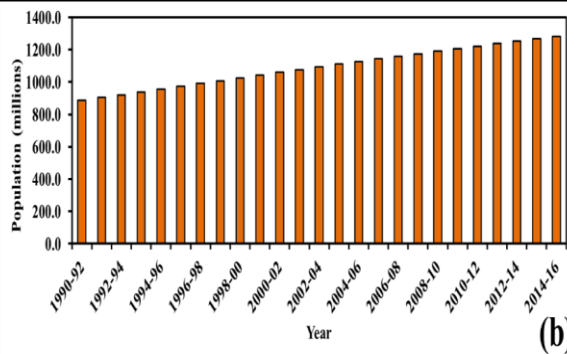


Water-Food-Energy Nexus in Changing Climate



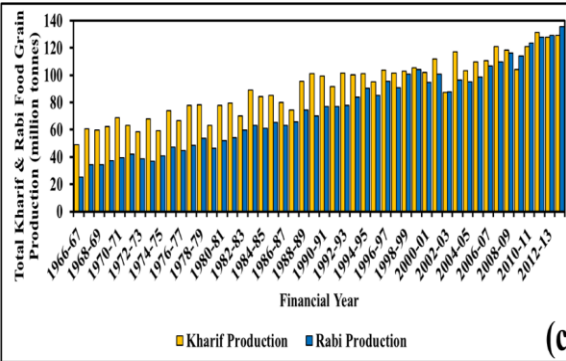


(a)

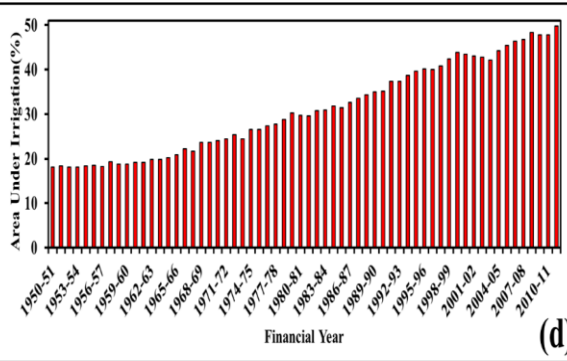


(b)

Increase in food production is necessary to maintain food security of the ever increasing population.



(c)

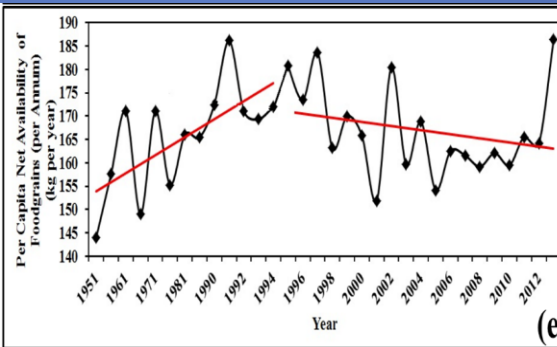


(d)

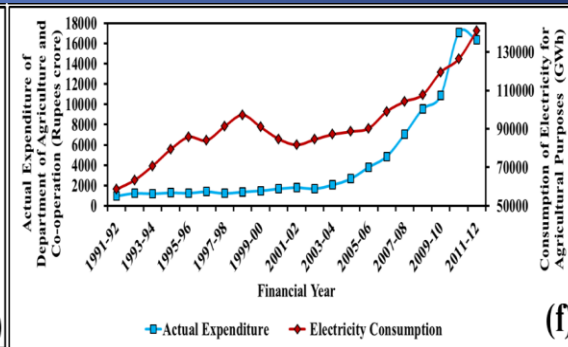
Larger areas under irrigation is a major contributor to the increased food production.

However, per capita availability of food production had declined post 1997.

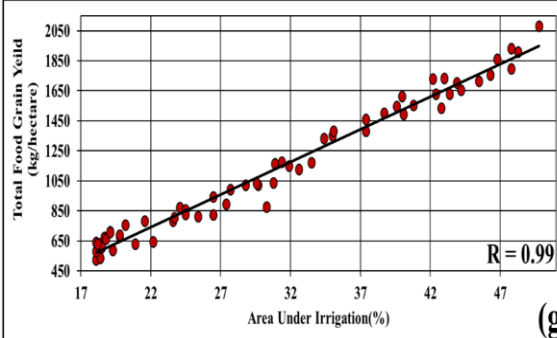
But, along with increased food production electricity consumption for agricultural purposes has increased



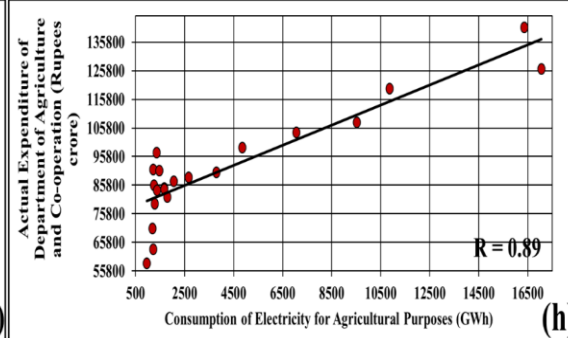
(e)



(f)

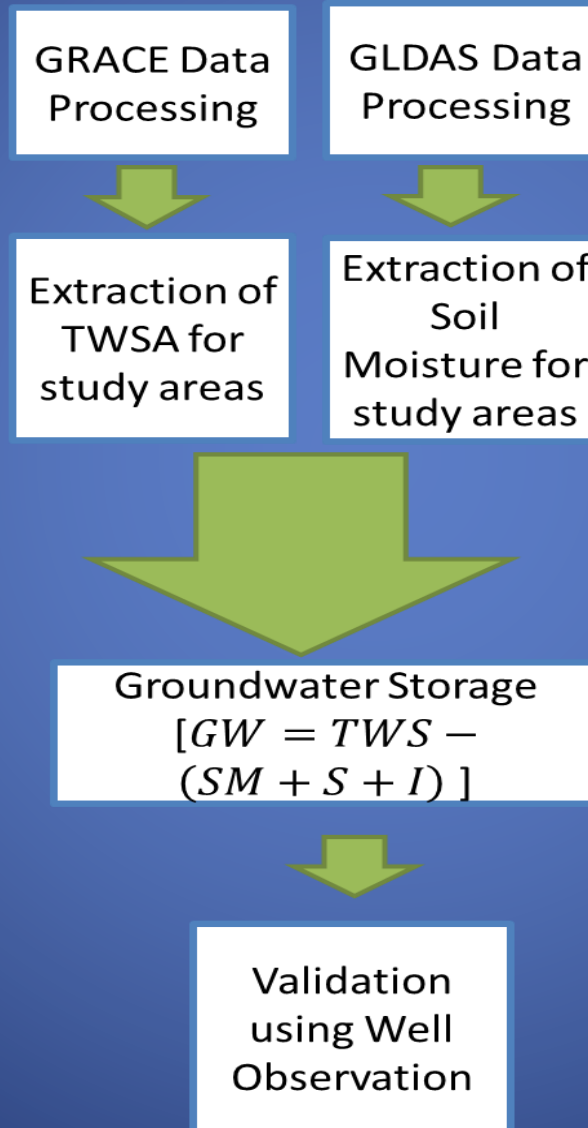


(g)

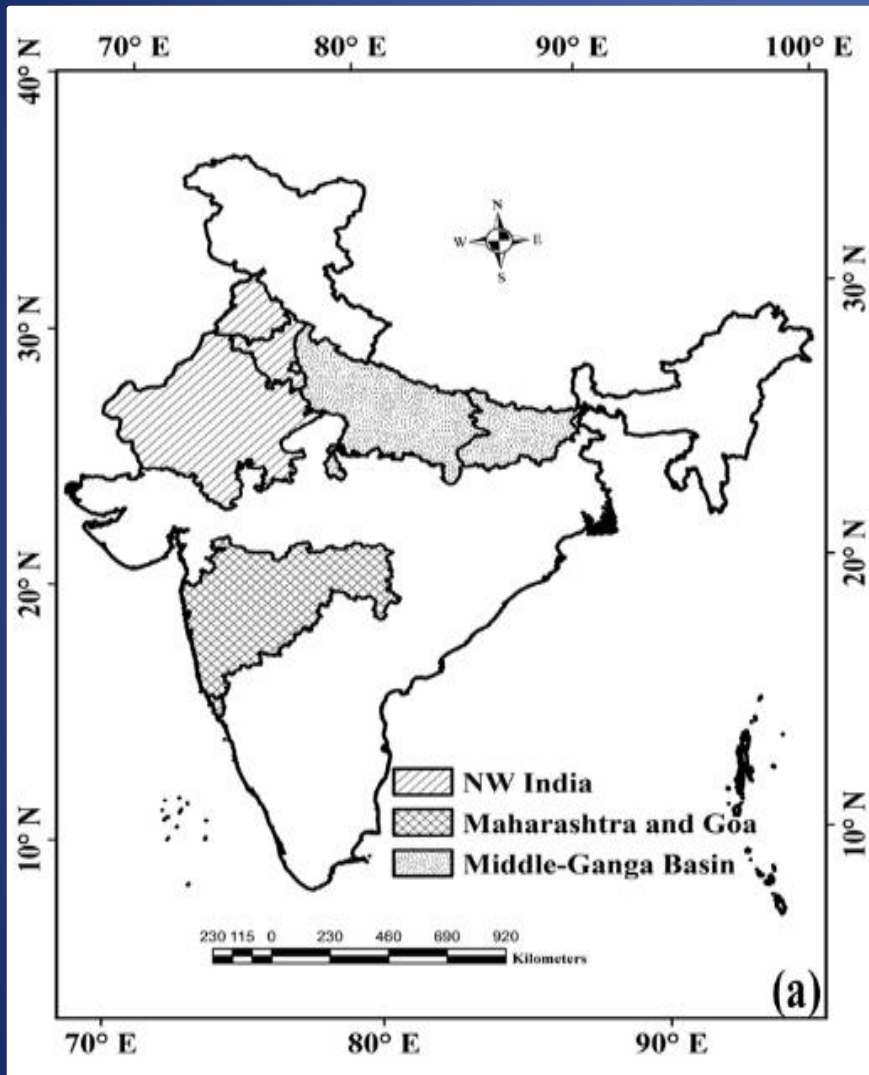


(h)

Total Water Storage from Satellite Data

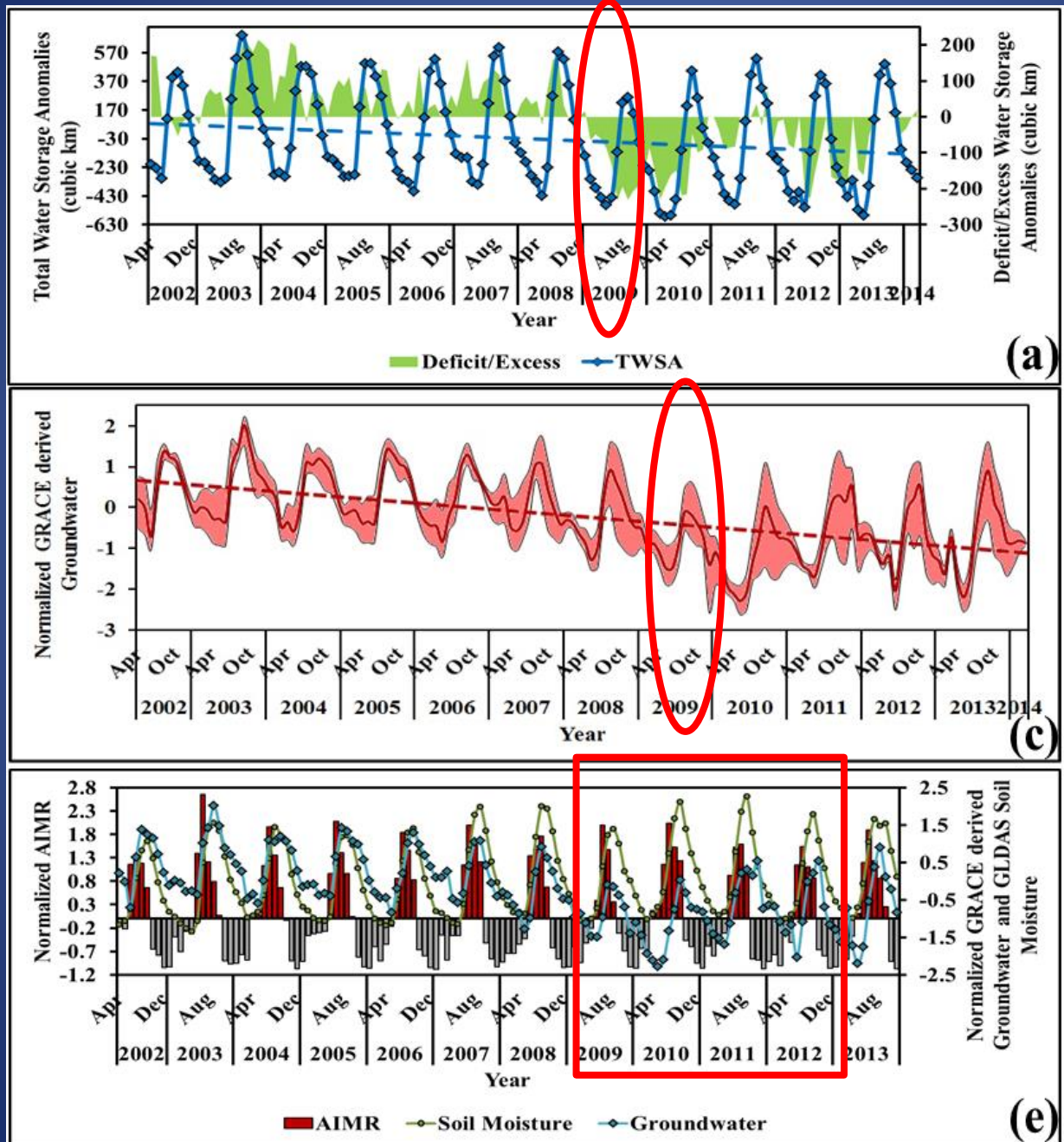


Study Area



- India has an area of 3,311,173.21 sq. kms.
- Middle-Ganga Basin has an area of 339,488.09 sq. kms.
- Peninsular India has an area of 311,249.34 sq. kms.
- North-West Indian has an area of 437,739.14 sq. kms.

India's Groundwater Status



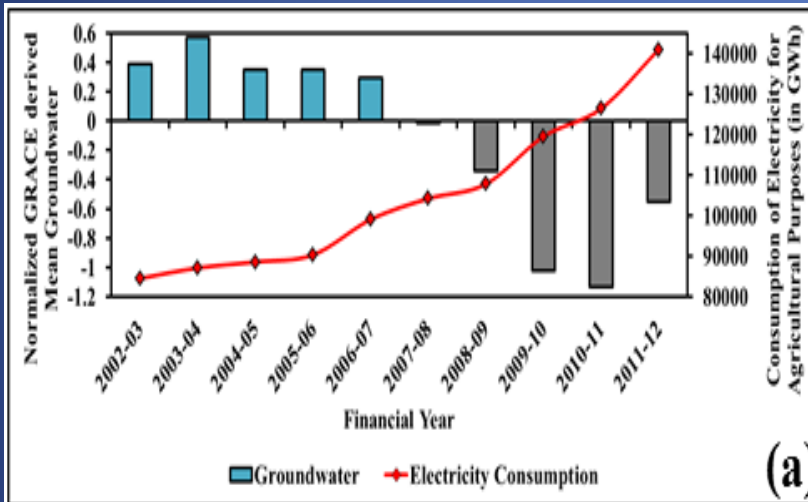
TWSA shows a declining trend.

Groundwater also has a declining trend, and complete recovery has not been achieved after 2009 which was a major drought year.

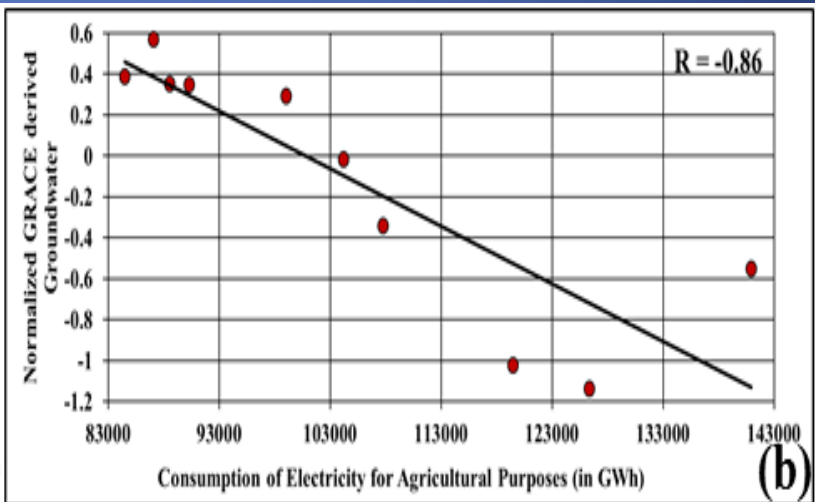
Soil moisture improves with normal monsoon years but groundwater still shows a declining trend.

Energy Consumption, Groundwater & AIMR

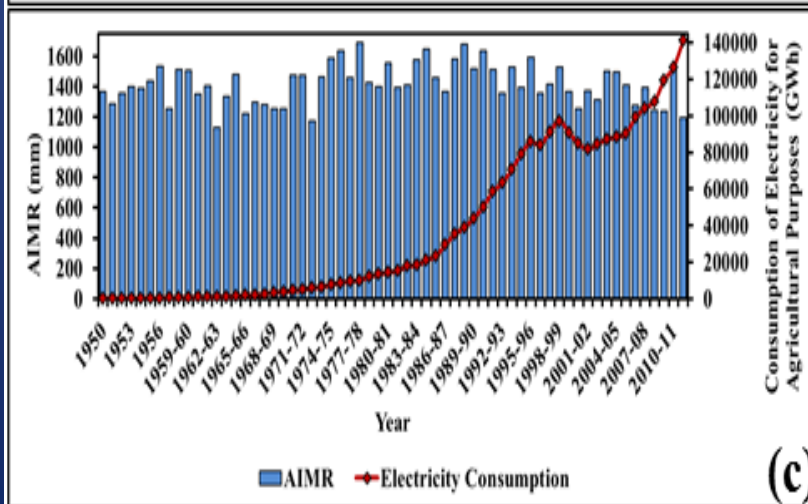
Electricity made available at subsidized rates to farmers to maintain food productivity. Hence, with increasing consumption of electricity the groundwater depletes further.



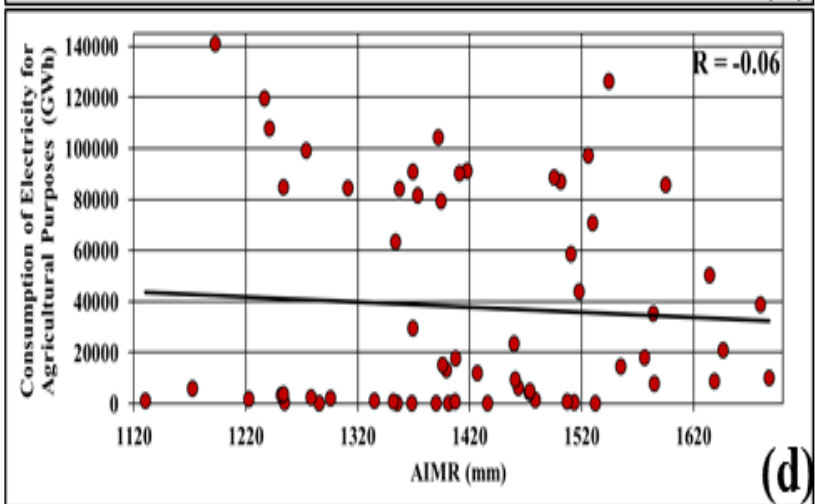
(a)



(b)

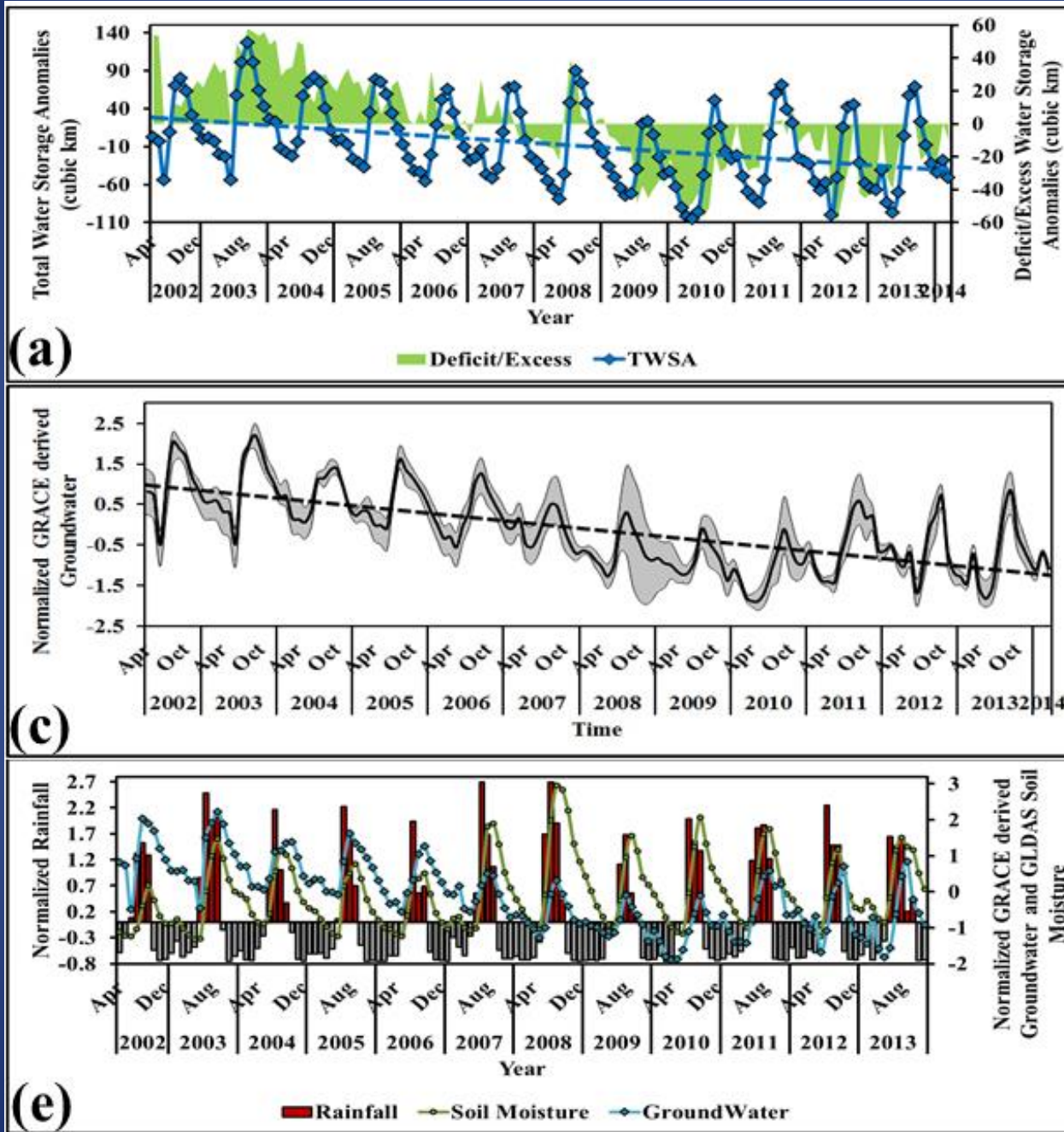


(c)

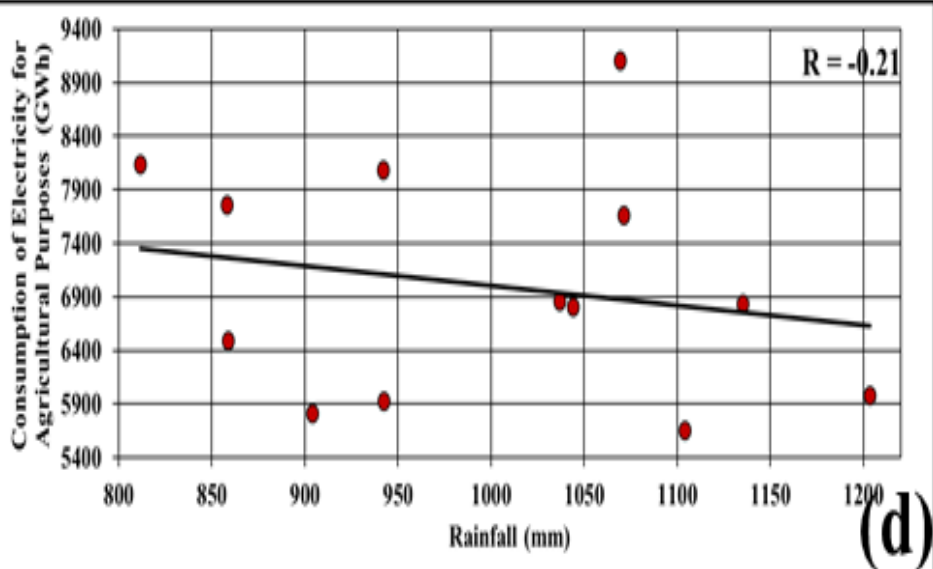
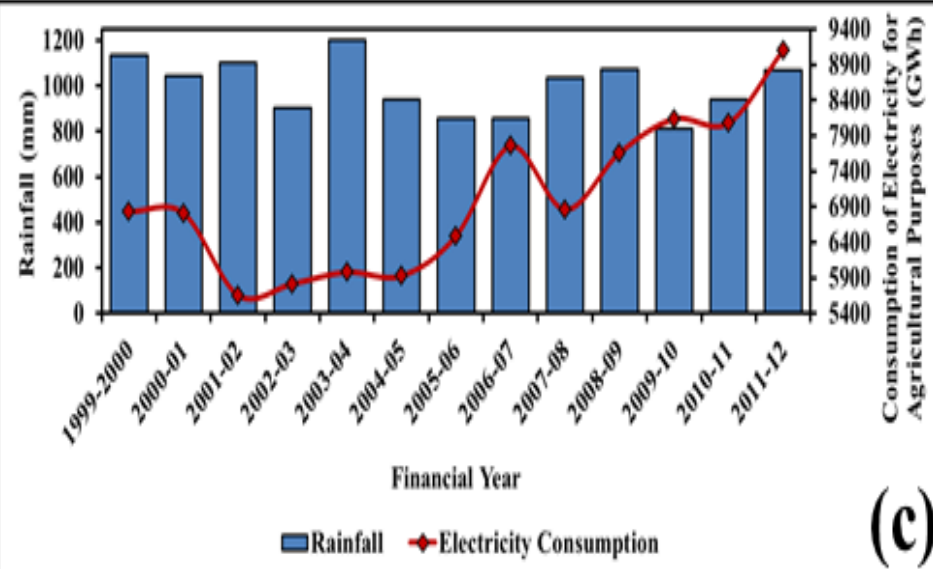
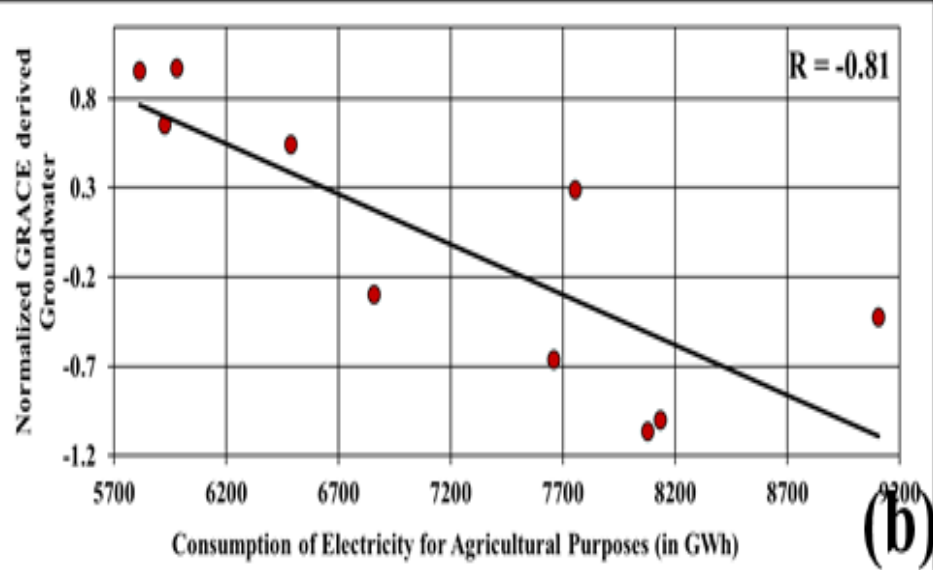
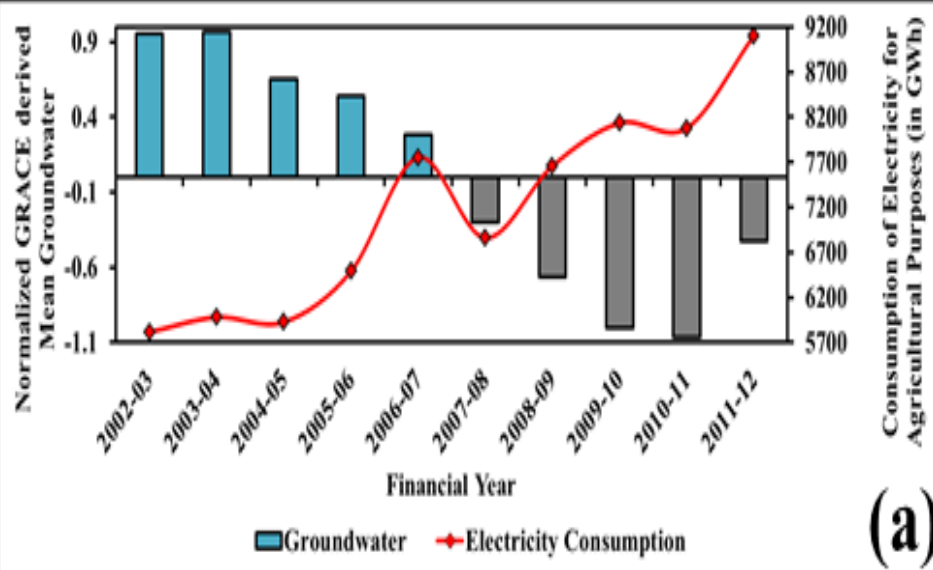


(d)

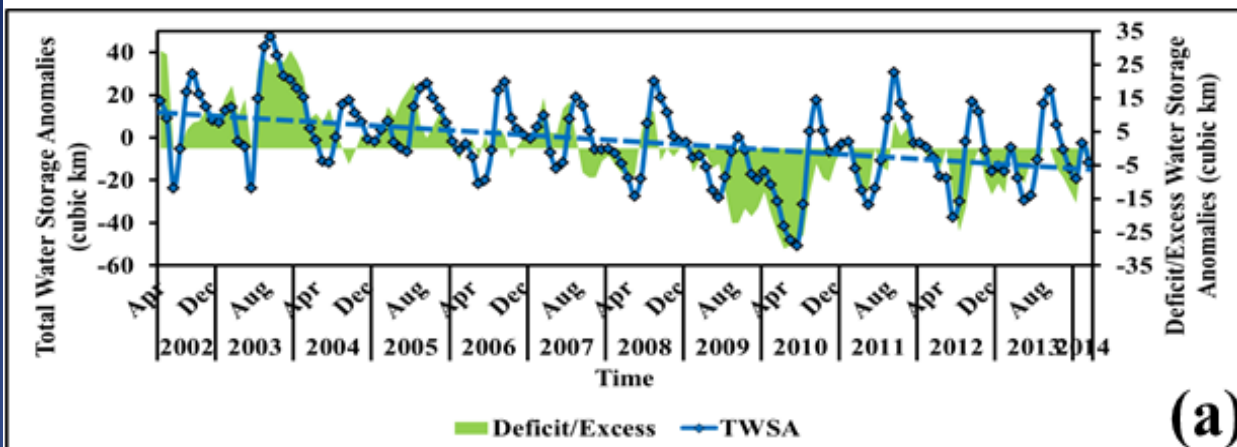
Groundwater Status of Middle Ganga Basin



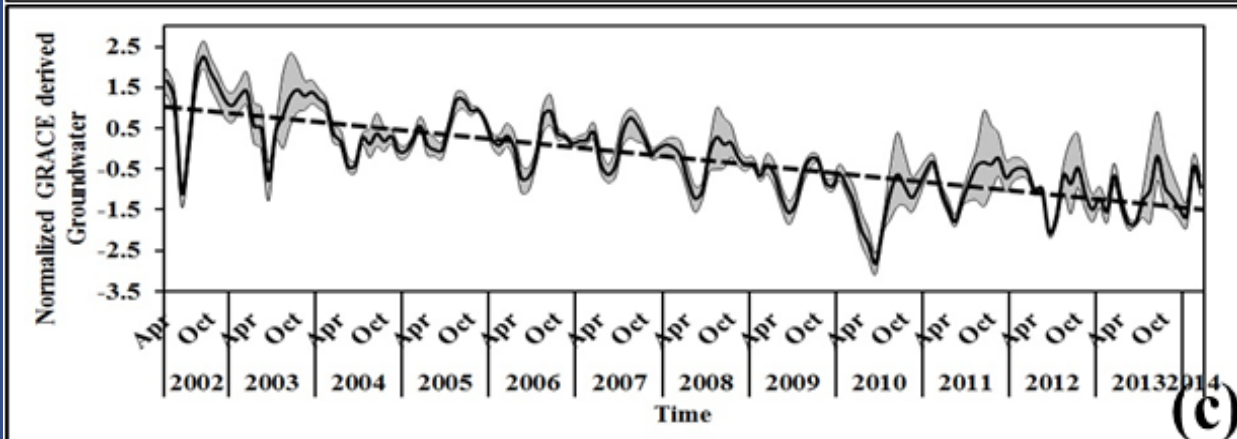
Energy Consumption, Groundwater & Rainfall of Middle Ganga Basin



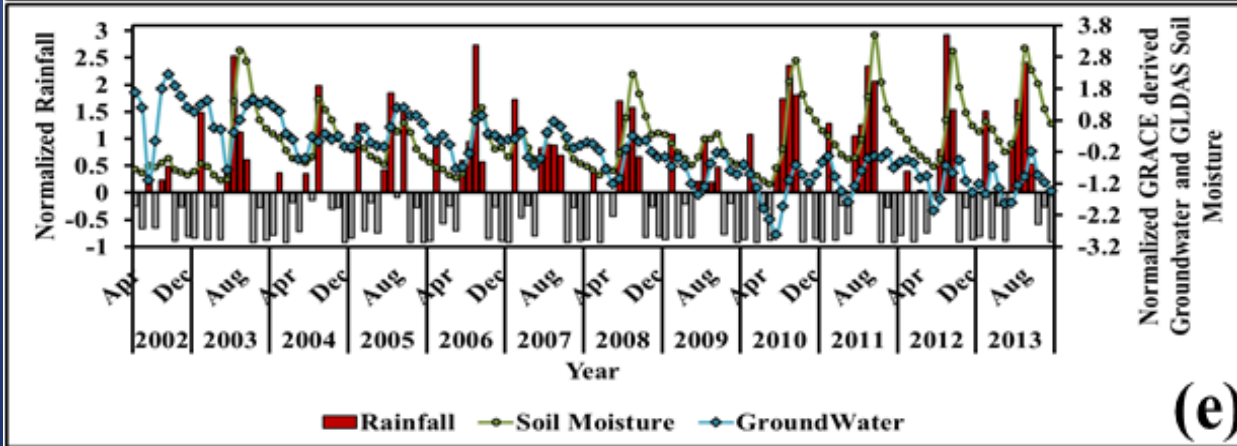
Groundwater Status of North-Western India



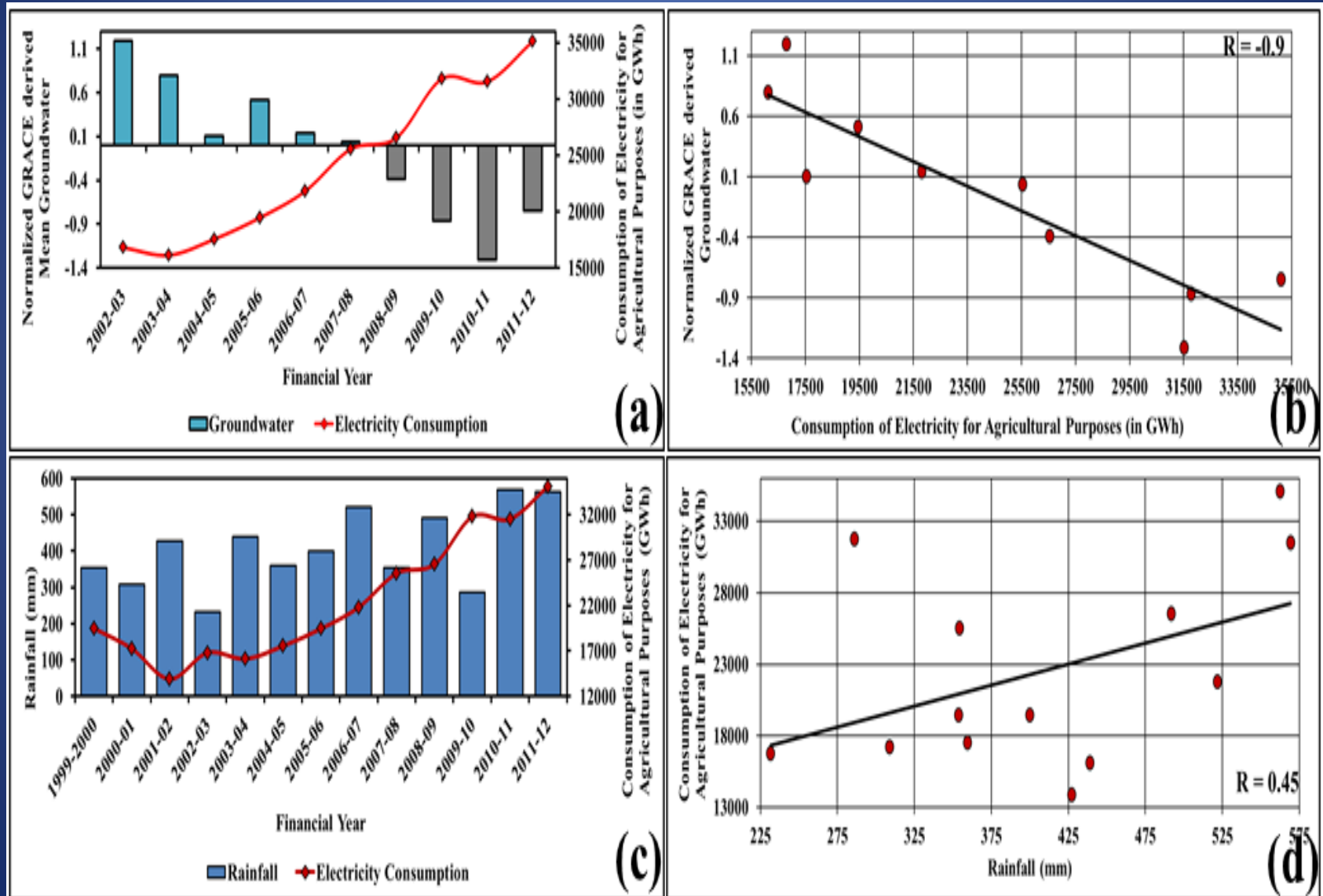
2009 already being a drought year the TWSA falls further in the consecutive year.



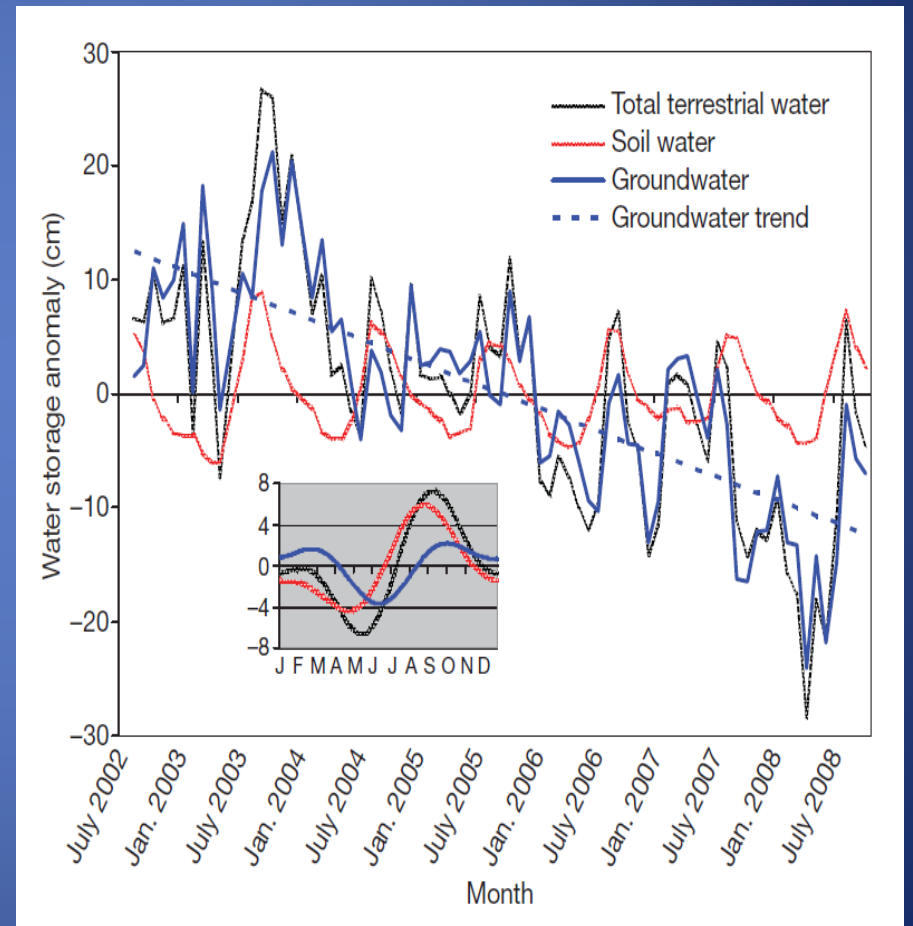
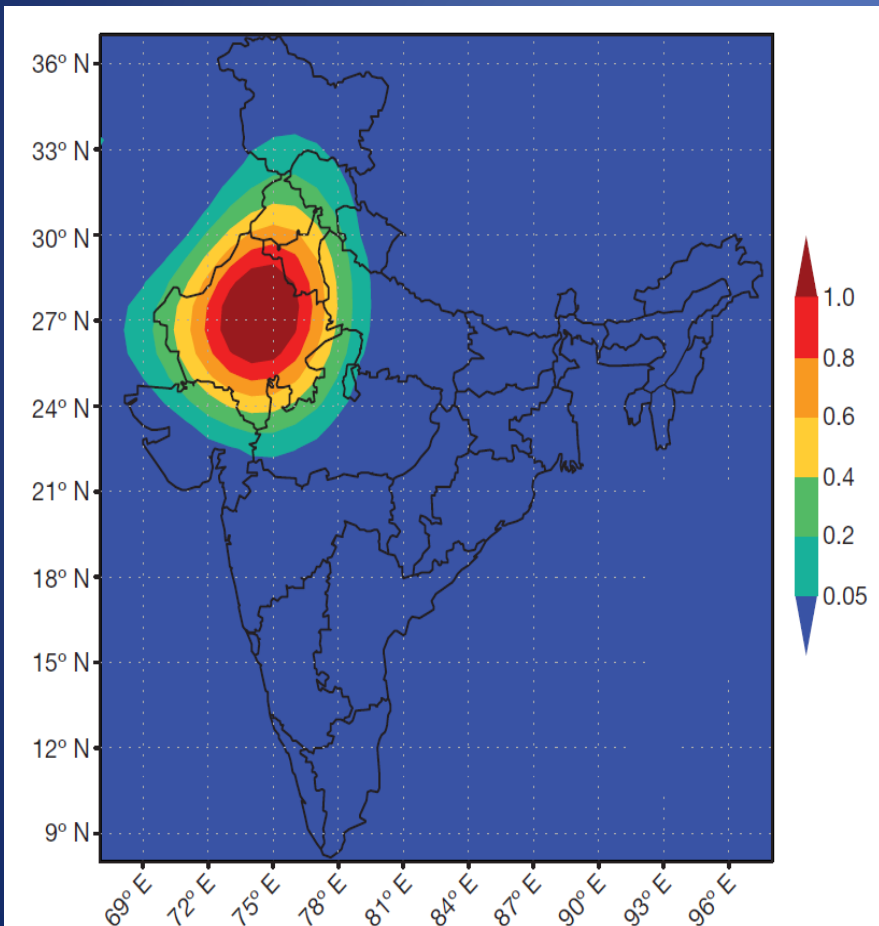
A good monsoon year results in greater amount of groundwater withdrawal, hence not allowing it to be recharged.



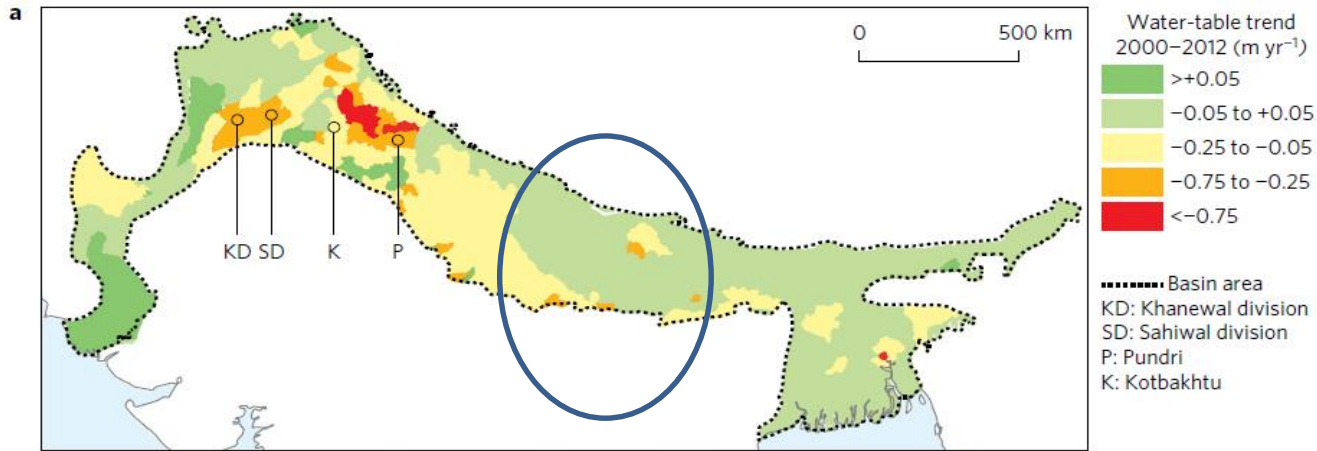
Energy Consumption, Groundwater & Rainfall of North-Western India



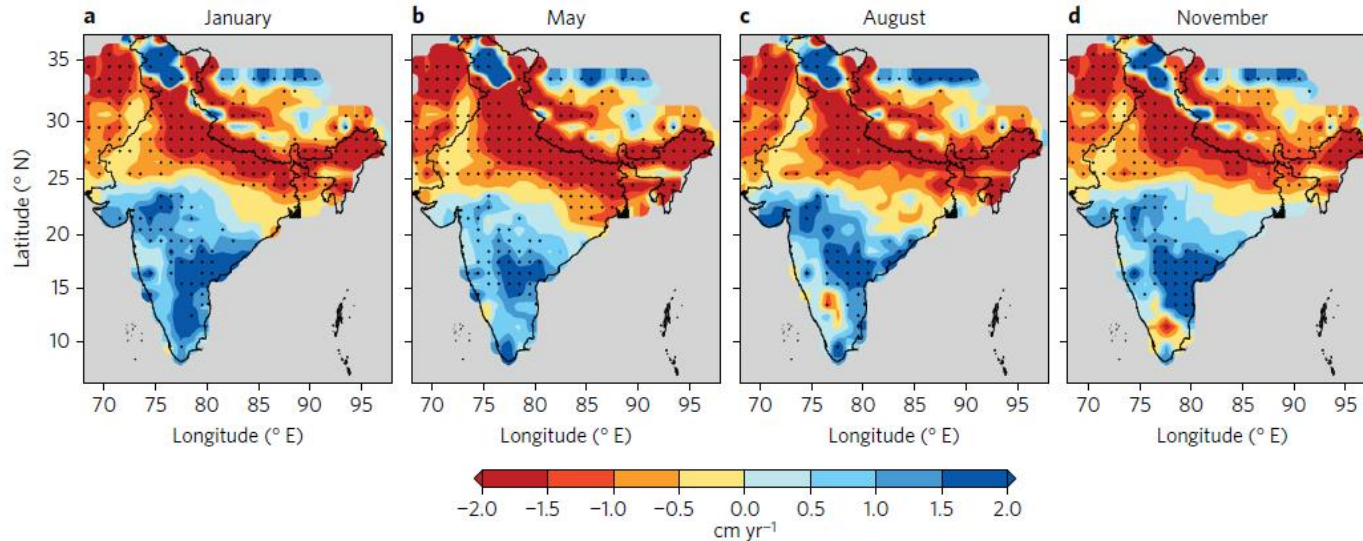
North-Western India: Hotspot for Ground Water Depletion



Debate Exists for Ganga Basin



MacDonald et
al. (2016),
Nature
Geoscience



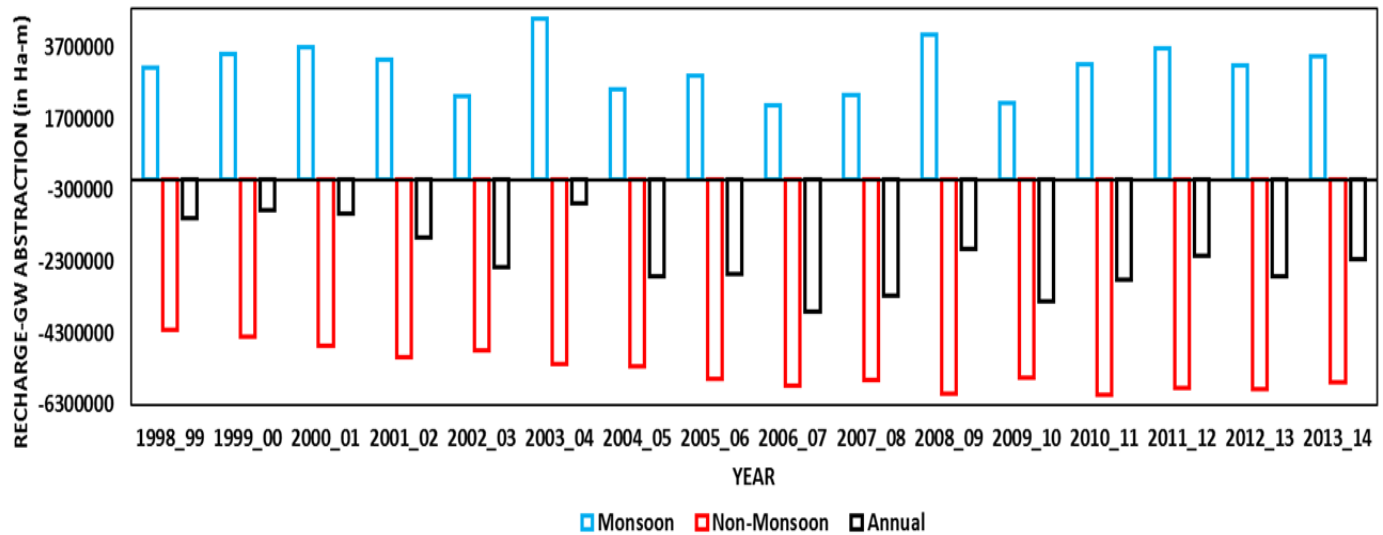
Ashoka et al.
(2016), Nature
Geoscience

Let us Estimate Abstraction and Recharge

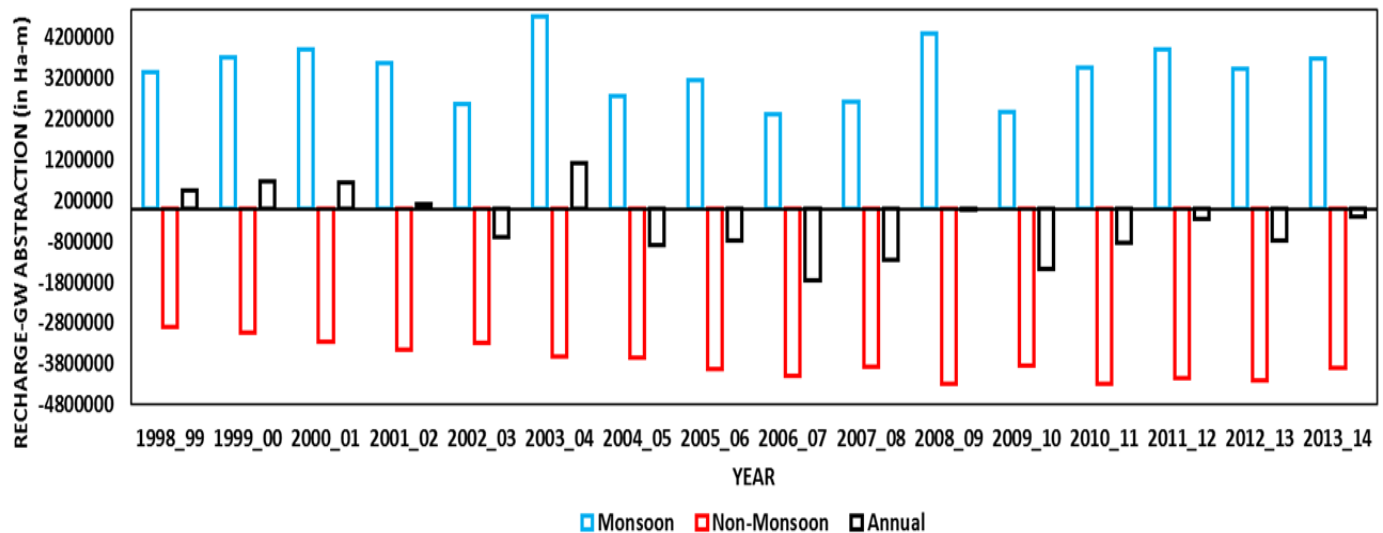
- Abstraction is computed based on flood and drip irrigation usage (as per literature and available data).
- Recharge is estimated based on the empirical formulae given by Central Water Commission, Ministry of Water Resources.
- The irrigation data and ground water component is obtained from Govt. of India.

UTTAR PRADESH

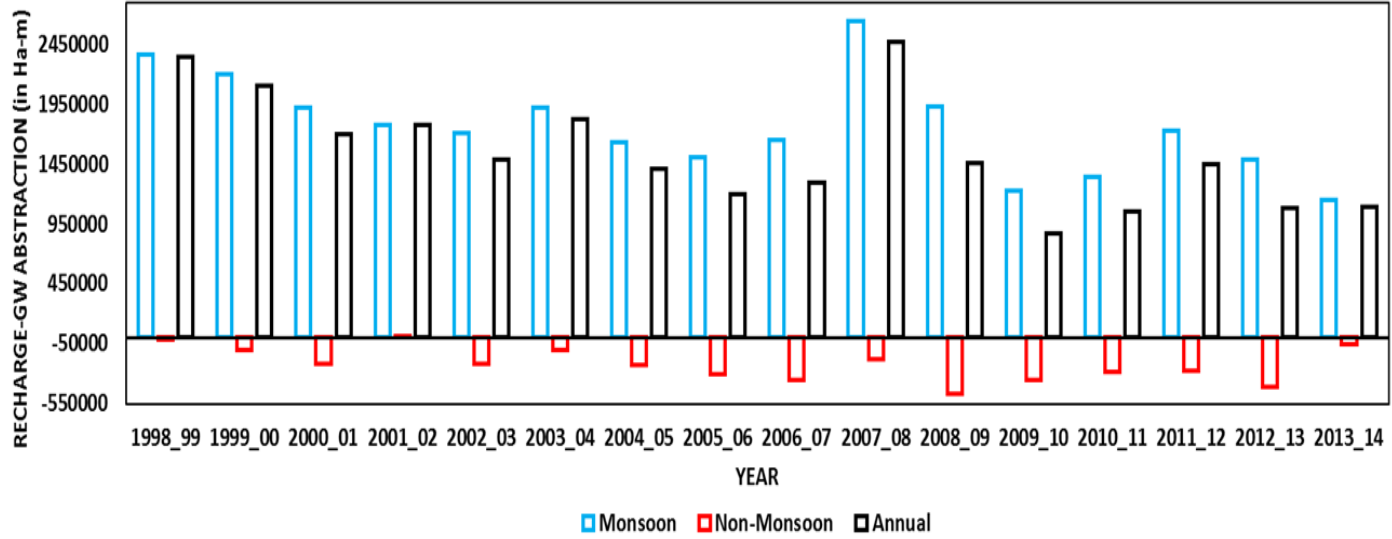
RECHARGE-ABSTRACTION (flood irrigation scenario)



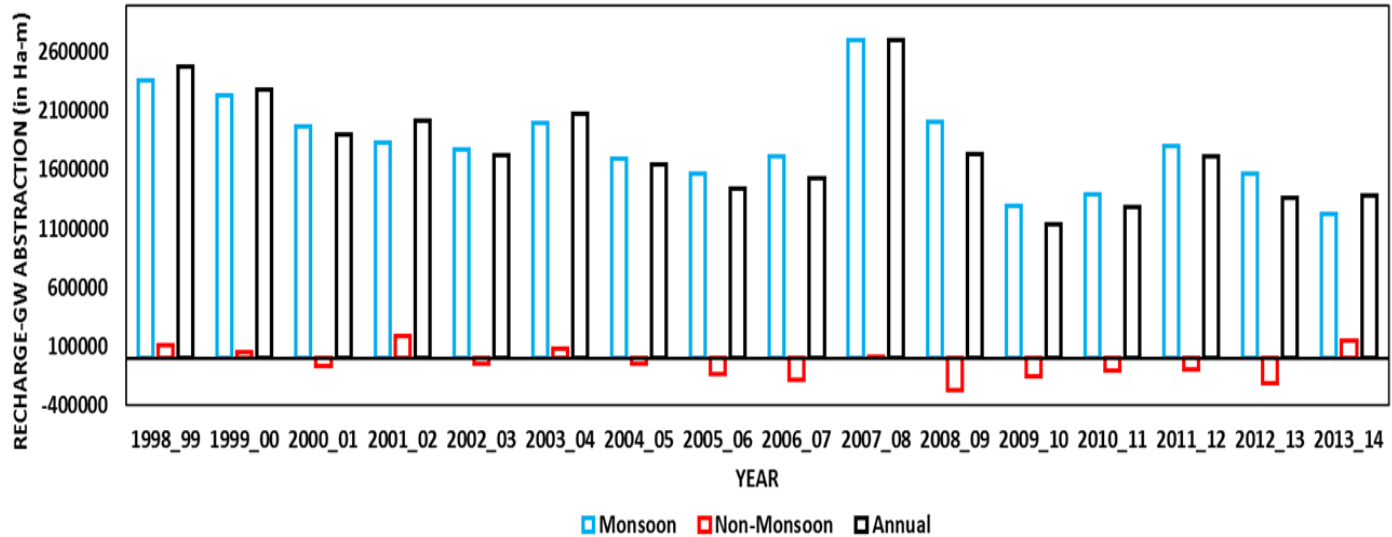
RECHARGE-ABSTRACTION (drip/sprinkler irrigation scenario)



RECHARGE-ABSTRACTION (flood irrigation scenario)



RECHARGE-ABSTRACTION (drip/sprinkler irrigation scenario)



Solution?

- Climate change simulations with GCMs → Regional Modeling → Hydrological Impacts Assessment → Adaptation Strategies?
- Real-time monitoring → Use of Weather Forecasts → improve irrigation efficiency → demand driven ground water pumping → improving scenario.

Are Climate Models “Good” for Monsoon

- Ashfaq et al. (2009):
 - Suppression
- Lee and wang (2014):
 - Increase
- Chaturvedi et al. (2012):
 - Increase
- Krishna Kumar et al. (2011):
 - Increase
- Salvi et al. (2013):
 - Non-uniform Changes with slight increase for few scenarios

GEOPHYSICAL RESEARCH LETTERS, VOL. 36, L01704, doi:10.1029/2008GL036500, 2009

Suppression of south Asian summer monsoon precipitation in the 21st century

Moetasim Ashfaq,¹ Ying Shi,² Wen-wen Tung,¹ Robert J. Trapp,¹ Xuejie Gao,² Jeremy S. Pal,³ and Noah S. Diffenbaugh¹

Clim Dyn (2014) 42:101–119
DOI 10.1007/s00382-012-1564-0

Future change of global monsoon in the CMIP5

RESEARCH ARTICLE

Multi-model climate change projections for India under representative concentration pathways

SPECIAL SECTION:

Simulated projections for summer monsoon climate over India by a high-resolution regional climate model (PRECIS)

K. Krishna Kumar^{1,*}, S. K. Patwardhan¹, A. Kulkarni¹, K. Kamala²,
K. Koteswara Rao¹ and P. Jones³

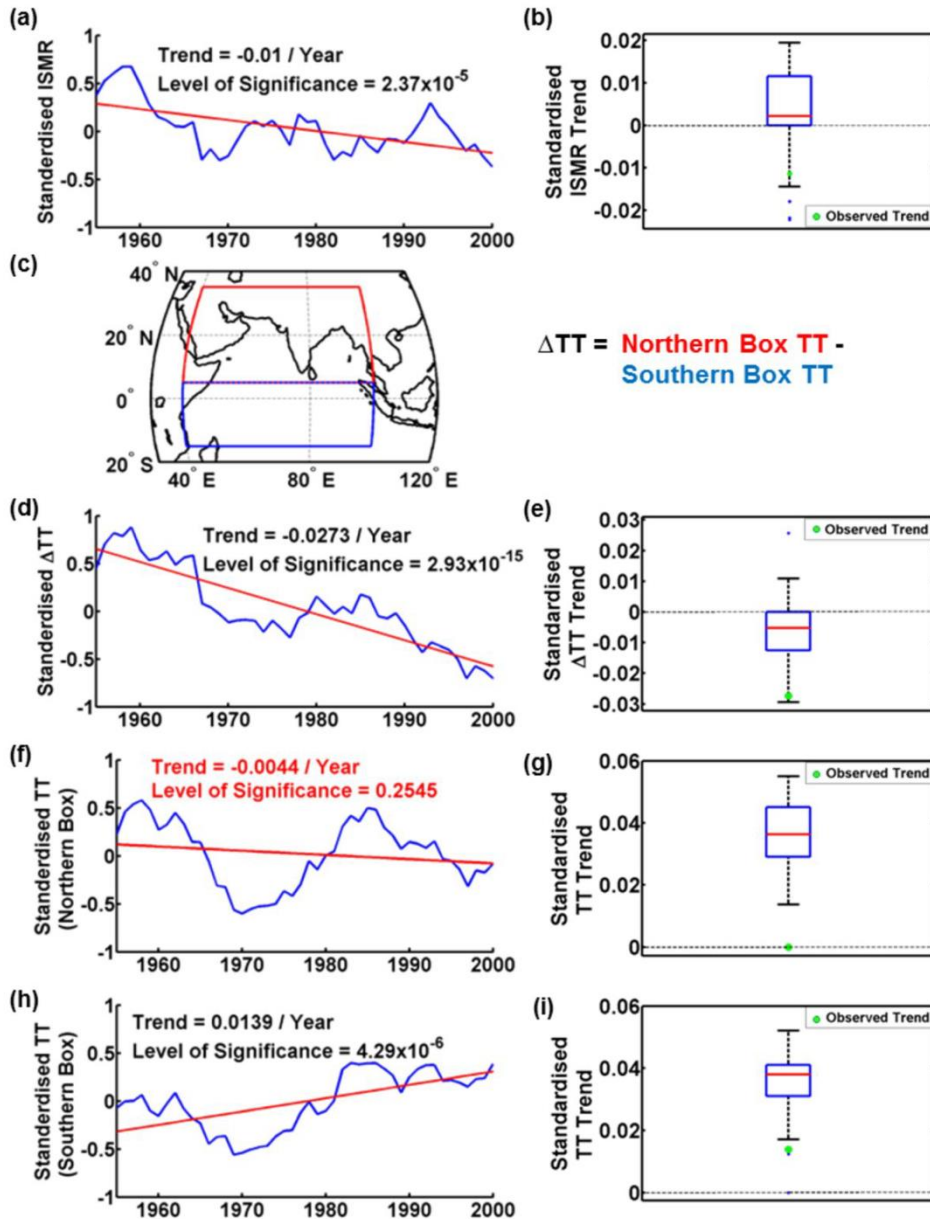
JOURNAL OF GEOPHYSICAL RESEARCH: ATMOSPHERES, VOL. 118, 3557–3578, doi:10.1002/jgrd.50280, 2013

High-resolution multisite daily rainfall projections in India with statistical downscaling for climate change impacts assessment

Kaustubh Salvi,¹ S. Kannan,¹ and Subimal Ghosh¹

Climate Change Projections of Indian Monsoon: More Confusion, Less Consensus

Evaluating New Generation Climate Models for Indian Monsoon



Even if you consider Multi-Model Average \rightarrow it will give opposite trend.

Next Step

- Monitoring of Soil Moisture.
- Ground Water Pumping → only if needed.
- Water availability and demand estimates for short term period → based on weather and extended range forecasts.
- We need to prove that weather forecast skills are good enough for sustainable water-food-energy nexus. (Ongoing work)

Thank you