Sustaining groundwater irrigation for food security in the Northwest Region of Bangladesh

Mohammed Mainuddin
Principal Research Scientist and Team Leader

Commonwealth Scientific and Industrial Research Organisation (CSIRO)

Global

Services

- Agriculture
- Energy
- Manufacturing
- Mineral resources
- Land and water
- Oceans and atmosphere
- Health and biosecurity
- Food and nutrition

Data and digital

- Astronomy and Space Science
- National Research Collections Australia
- National Computing Infrastructure
- Australian Animal Health Laboratory
- Marine National Facility

5,000+ talented staff

$1B+ per year budget

Top 1% global research agency

697 Patents

497 Active licenses

170+ Start-up companies

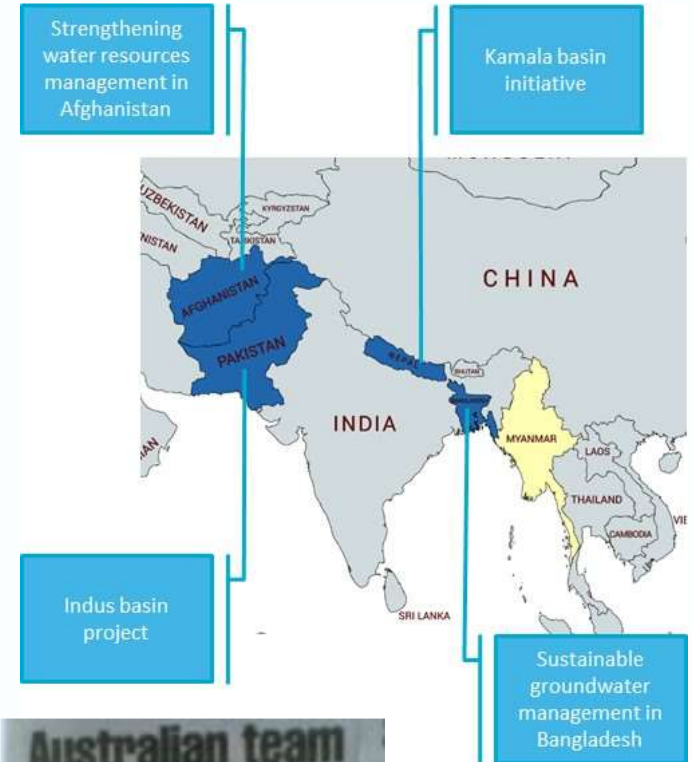
CSIRO – Global Connections

80+ countries

2400 Partners

CSIRO engagement in Bangladesh

- CSIRO has a long history of working in Bangladesh through ACIAR funded projects – mostly on agriculture
- First large-scale involvement on water sector started in 2010 with the Bangladesh Integrated Water Resources Assessment project (BIWRA) funded by the DFAT




Australian team arrives to study water resource

Bangladesh Integrated Water Resources Assessment (BIWRA)

Inaugurated 2011 with partners BWDB, WARPO, IWM, BIDS and CEGIS

As part of the project Australian High Commission organized high level seminar in June 2012 with Chief Guest Minister of Water Resources H.E. Ramesh Chandra Sen

Final delivery workshop was on 7 May 2014, where the Ministers and Senior Secretary were the main guests

The News Today
14th June 2012

Daily Ajkaler Khabor
8th May 2014

High level visits and meetings

Study tour by MoWR, BWDB and WARPO, April 2012 (including Additional Secretary, MoWR, DG WARPO and DG BWDB)

Visit to Canberra by Senior Secretary Ministry of Water Resources, and ED IWM in Dec 2012

MoWR and WARPO delegation led by the Senior Secretary in Sep 2016

MoA and MoWR delegation in September 2018

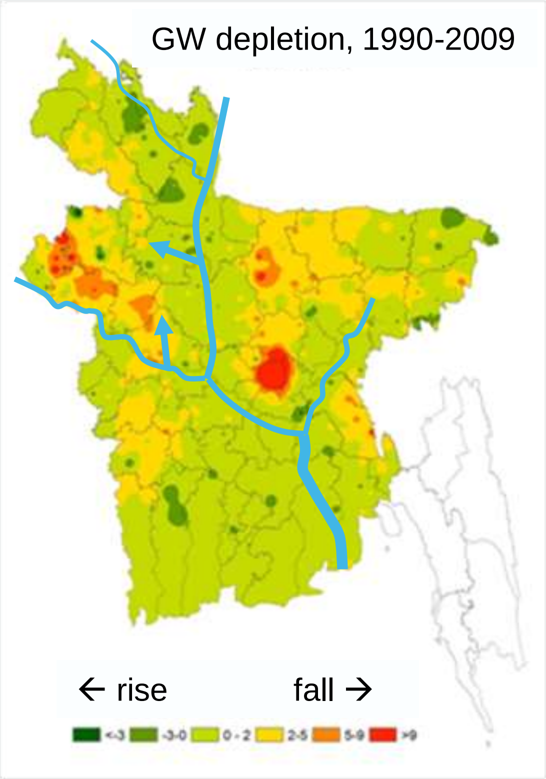
BIWRA project identified regional hotspots for detail study

Most pressing issue in northwest is **groundwater overuse**, solving the issue is of major national importance.

Coastal zone developments in agriculture potentially solve other problems. But problems with **water storage**, **floods** and **salinity**.

Dhaka water use is **unsustainable**

Surface water pollution by industrial waste and other pollutants is a huge issue



Study on the hot spots - coastal zone

Cropping system intensification in the coastal zone of Bangladesh and West Bengal (2015–2025)

Partners:

Australia: CSIRO, Murdoch University

Bangladesh: BARI, BRRI, IWM, Khulna University, Shushilan

India: ICAR – CSSRI, BCKV, TSRD

Funded by ACIAR and KGF Honourable Minister visited our project activities in Dacope on 12 March 2020

Study on the hotspots – Sustaining groundwater in the Northwest region

Two projects

Project 1 (Field scale)
Understanding water use and water productivity at the field level (2014-2019), funded by ACIAR.
CSIRO, University of Southern Queensland, BRRI

Project 2 (Regional scale)
Sustaining groundwater irrigation for food security in the Northwest Region of Bangladesh
Regional study funded by DFAT (2016-2021)
CSIRO, BMDA, WARPO, IWM, BARI, BAU
We had a meeting in Nov 2016 with the Honourable Minister and Secretary at that time.

Aims and major components

The aim is to **define the sustainable level of water (particularly groundwater) use for irrigation** and their i**mpacts on the socio-economy and livelihood**

3 major components of the project

Water availability assessment

- Groundwater level trend analysis
- Surface water modelling and water balance
- District scale water balance
- Groundwater modelling
- impacts of climate and land-use changes on surface water and groundwater

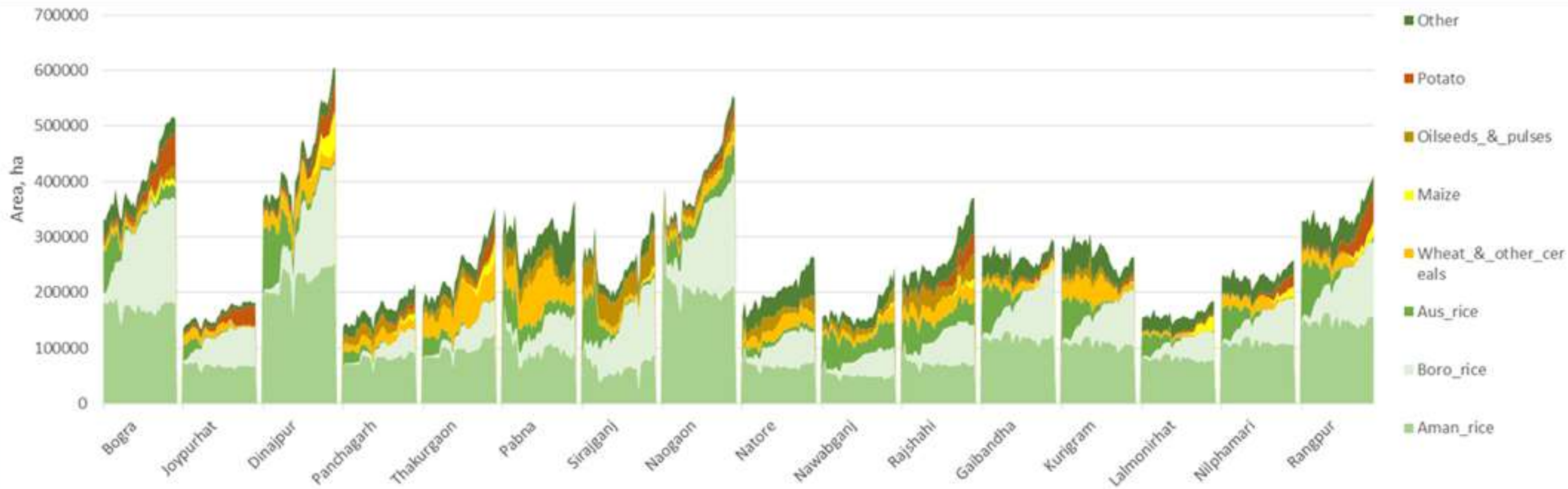
Demand assessment

- Long-term water use using RS and GEE
- Spatiotemporal dynamics of land cover and land use

Economic and livelihood impacts

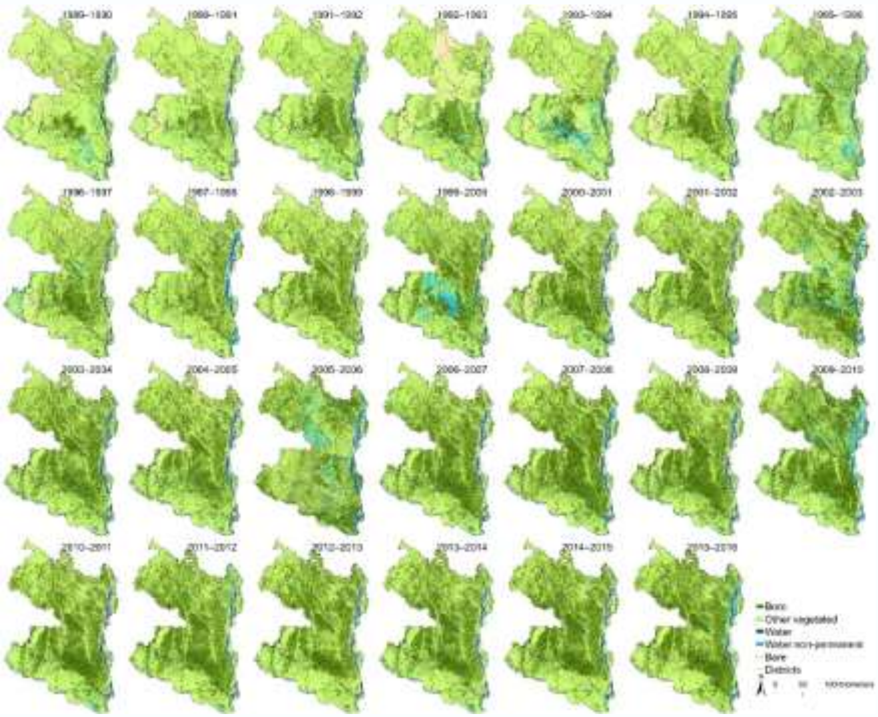
- Cost and benefit of dry season crops
- Gender involvement of decision making process

Expansion of Boro rice has slowed or even stopped in the last decade ...

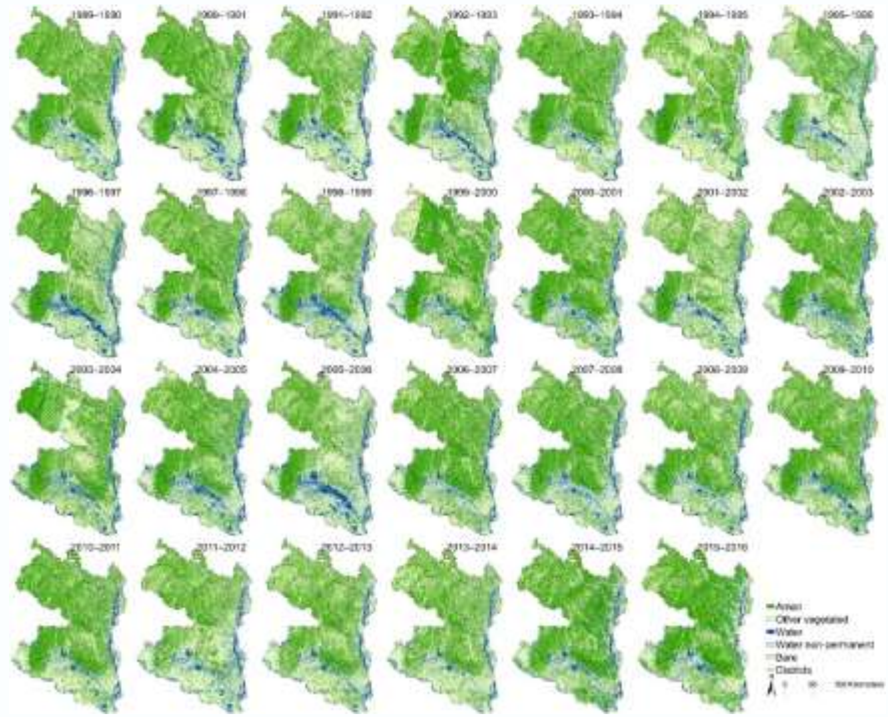


- Boro rice replaced Aus
- No expansion of area in the last 10 years particularly in the Barind region
- Significant increase of maize in Dinajpur, Lalmonirhat and Thakurgaon
- Potato has increased in Bogra, Joypurhat, and Rangpur

Expansion of Boro rice has slowed or even stopped in the last decade



Historical maps for the Boro cropping (dry) season in northwest Bangladesh from 1989 to 2016



Historical maps for the Aman cropping (wet) season in northwest Bangladesh from 1989 to 2016

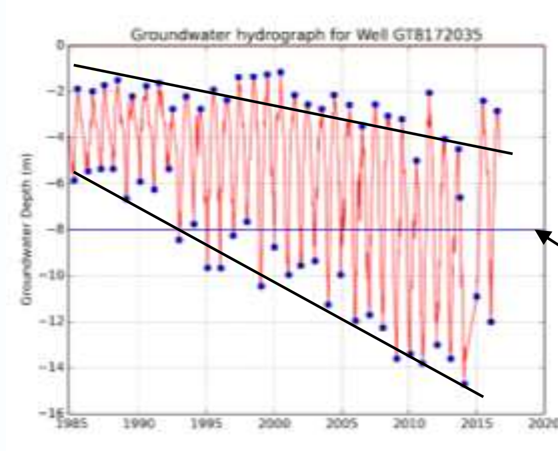
Groundwater levels are not declining everywhere ...

Analysed groundwater level data for 1985-2016

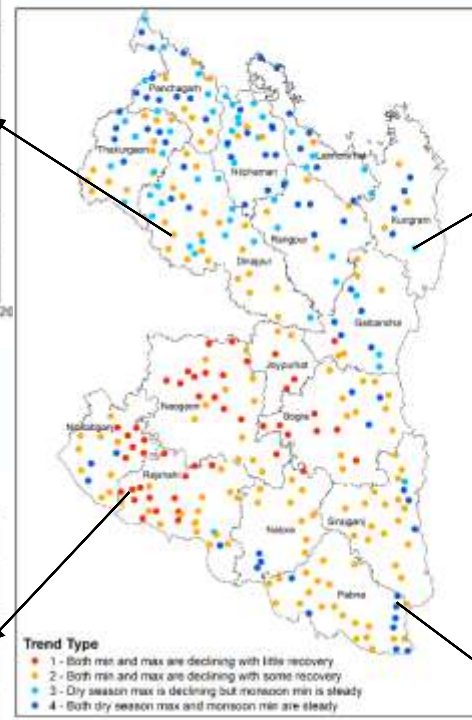
Defined 4 types of patterns

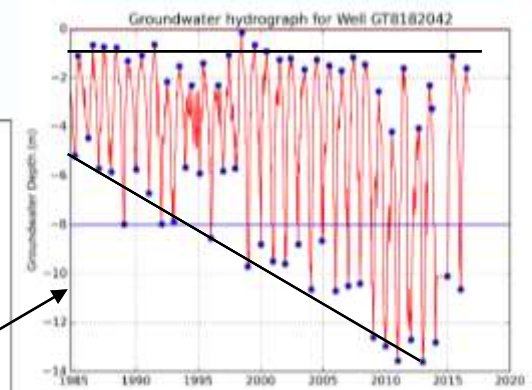
Total number of wells: 437

Selected wells: 328



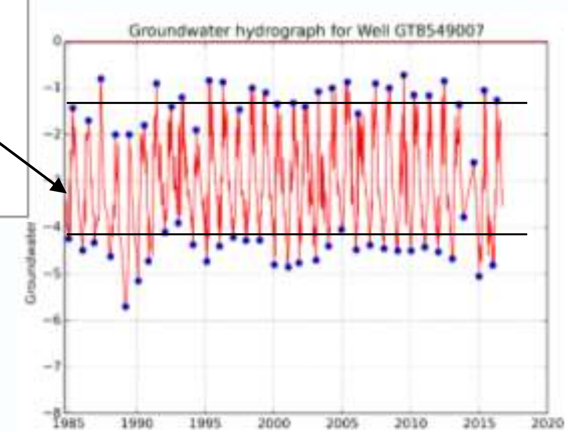
Type II – yellow dots





Type III – Blue dots

Type I – Red dots



Type IV – Navy blue dots

Groundwater levels are not declining everywhere ...

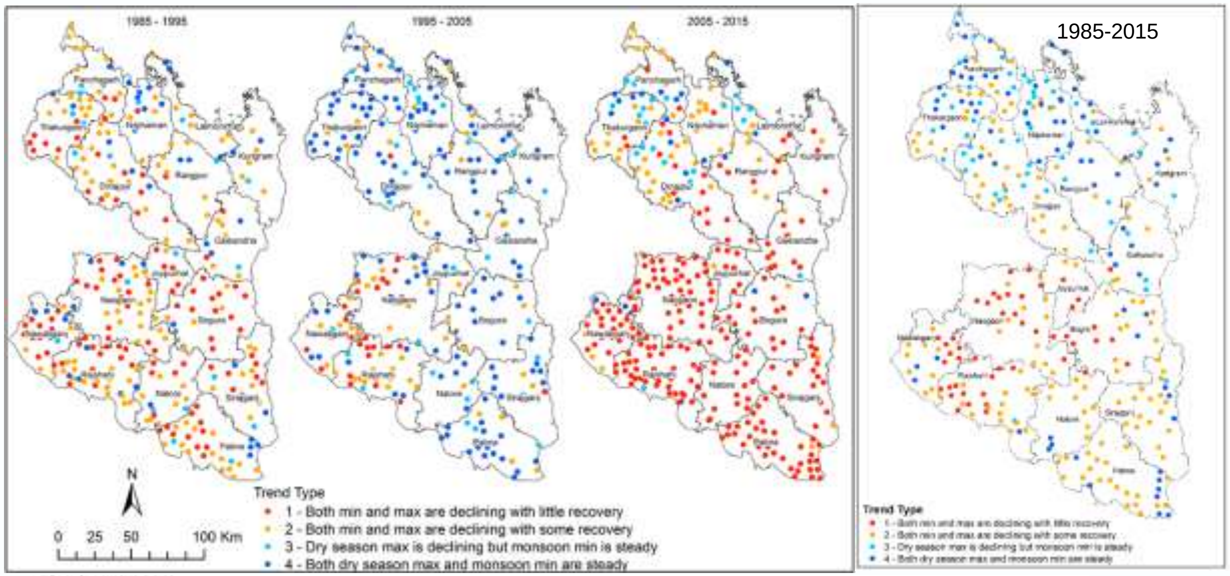
Climate is an important factor

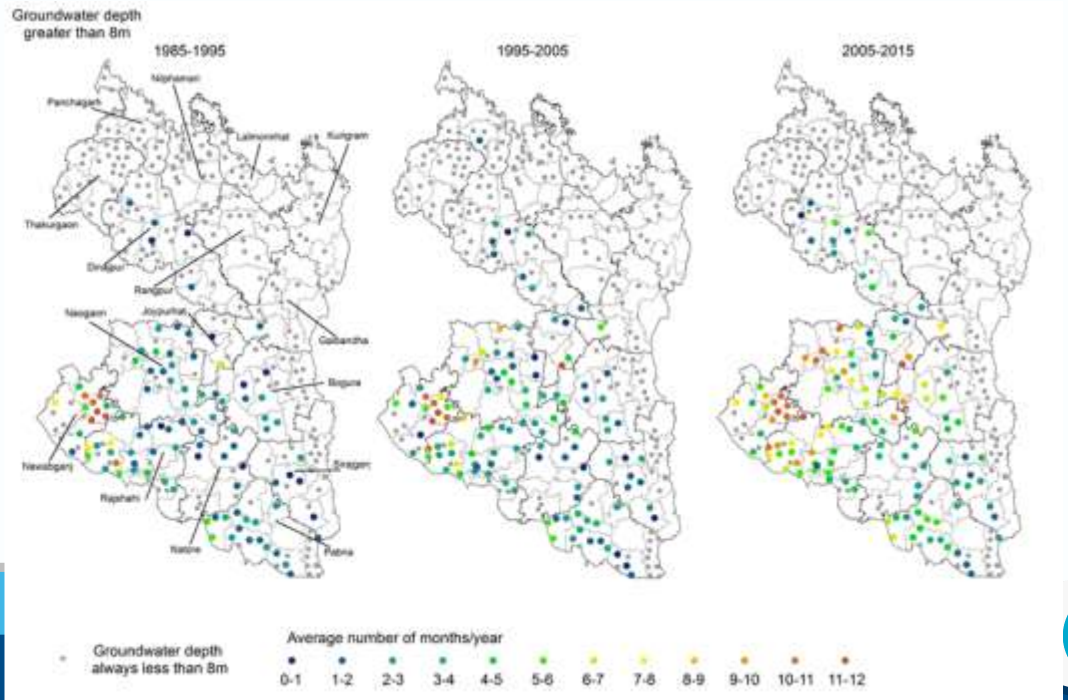
1985-1995 period witnessed an average rainfall and groundwater levels that were similar to the long-term trends

In the wetter decade (1995-2005) the dry season maximum water level either remained steady

The climate was relatively dry during 2005-2015 and both the minimum and maximum groundwater levels failed to recover in most cases

Falling groundwater levels can disrupt domestic water supply for household purposes, which in rural areas is usually sourced from hand tubewells (suction pumps)



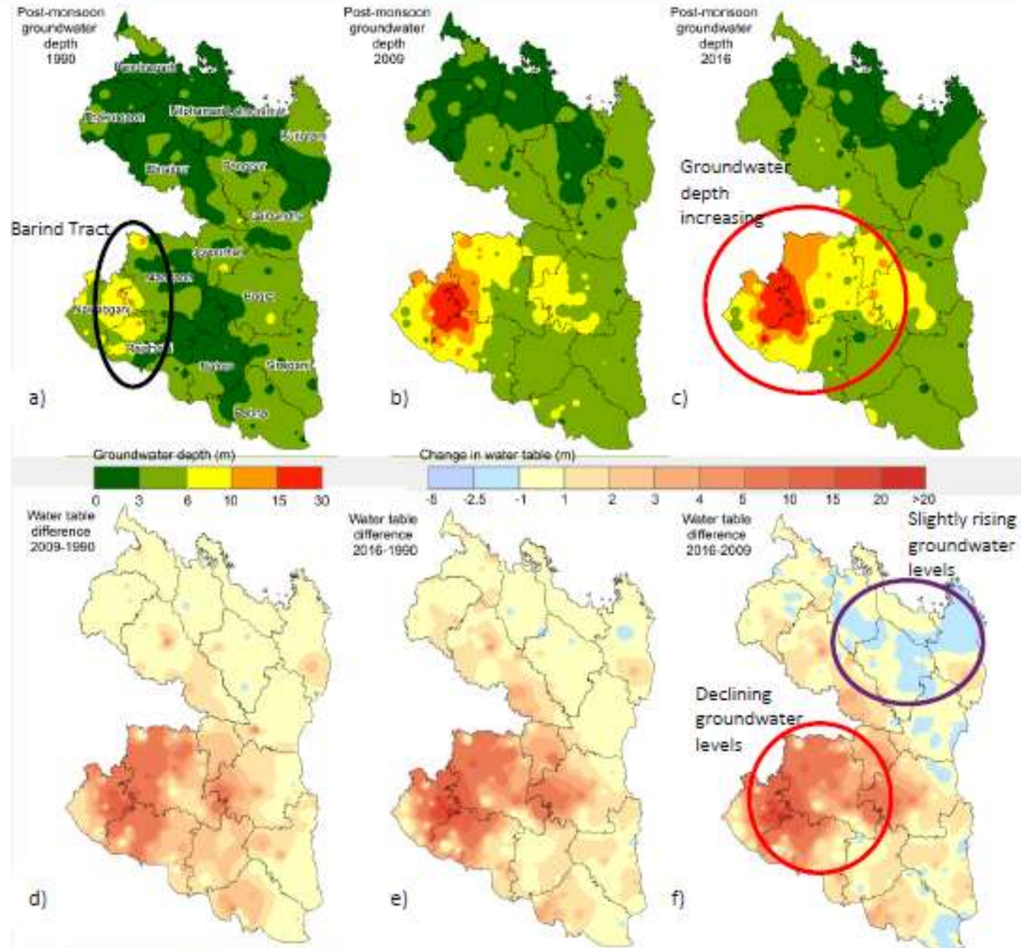


Groundwater levels are not declining everywhere

Groundwater elevation surfaces and water table difference showed increasing groundwater depth across larger areas over time (Figure a, b and c) and declining groundwater levels in the difference maps (d, e and f).

In Figure f an area of rising water tables was observed for the period 2009−2016 which was deemed a response to higher rainfall and/or flooding phenomenon.

This demonstrates that while groundwater abstraction is influencing long term water table trends, climate impacts both short and long term also play an important role in the observed depth to groundwater tables.



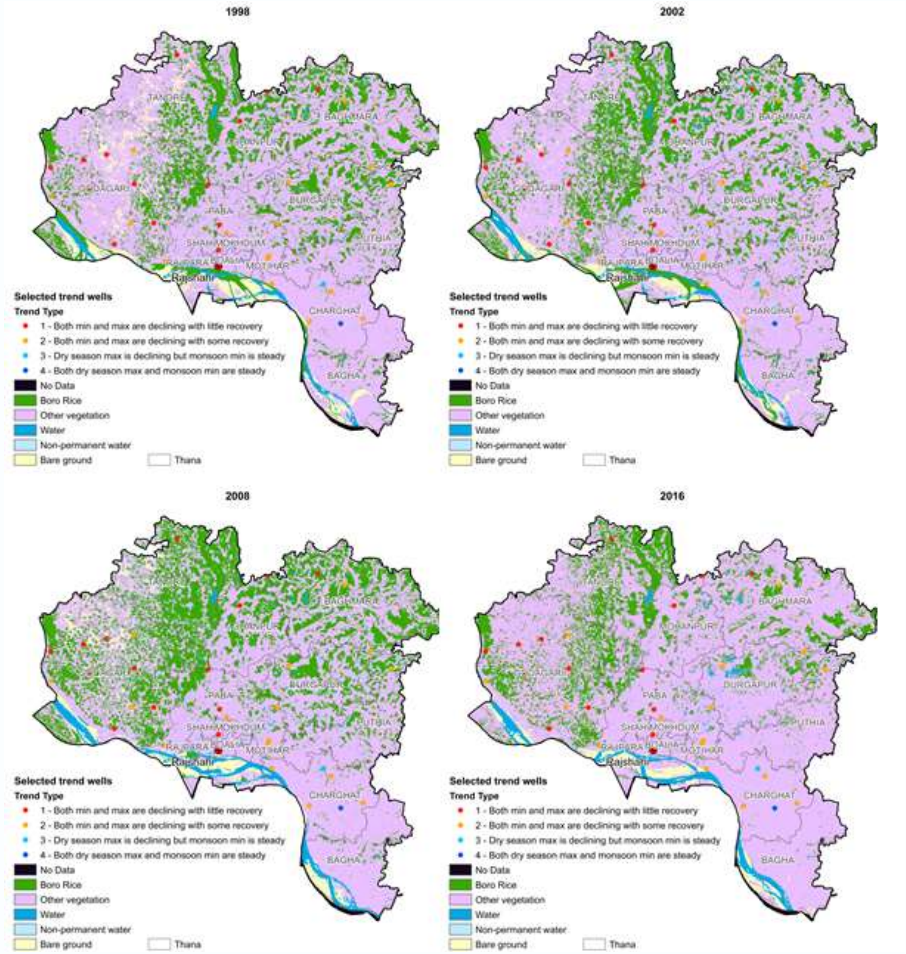
Post-monsoon depth to GW table (a) 1990, (b) 2009, (c) 2016, (d) 2009-1990, (e) 2016-1990, (f) 2016-2009

Overexploitation is not the only cause of groundwater decline: there are other factors ...

Over-exploitation of the groundwater in the Barind Tract does not necessarily mean that groundwater use has increased with increasing Boro rice area.

The extent of Boro rice during the dry season in the Rajshahi district for the years 1998, 2002, 2008 and 2016 derived from satellite imagery was 572 km^2, 609 km^2, 775 km^2 and 448 km^2, respectively.

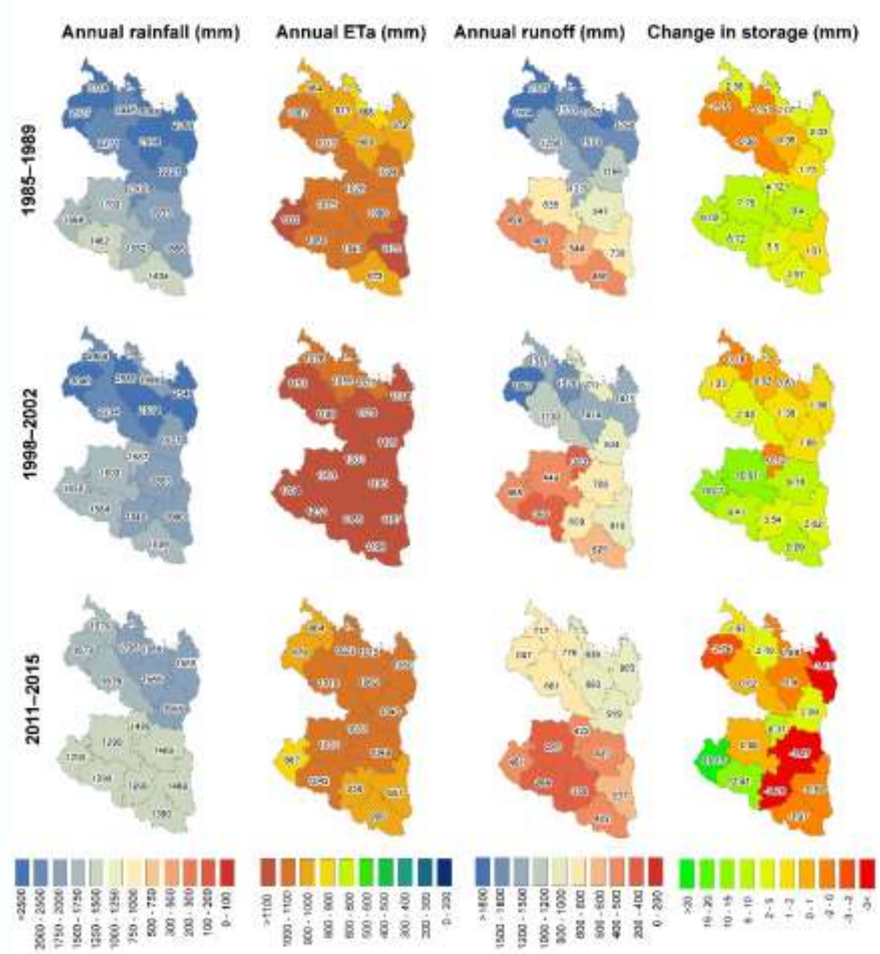
The increase in Boro rice production appears to have peaked around 2008 and slightly declined since then



The extent of Boro rice cropping in 1998, 2002, 2008, and 2016 in Rajshahi district with wells showing groundwater level trend types (1985−2016)

Overexploitation is not the only cause of groundwater decline: there are other factors

Annual rainfall time-series (blue solid line) from January 1985 to December 2015 and associated trend line (red dashed line) for the 16 districts



Annual surface water balance for the 16 districts of northwest Bangladesh for the three evaluation periods

Other factors contributed to decline:

- Significant decline in rainfall
- Change in rainfall intensity
- Changing land use conditions
- Low permeability of soil due to plough pan
- Reduction in wetland areas, recharge areas
- Low flows in the rivers in the dry season

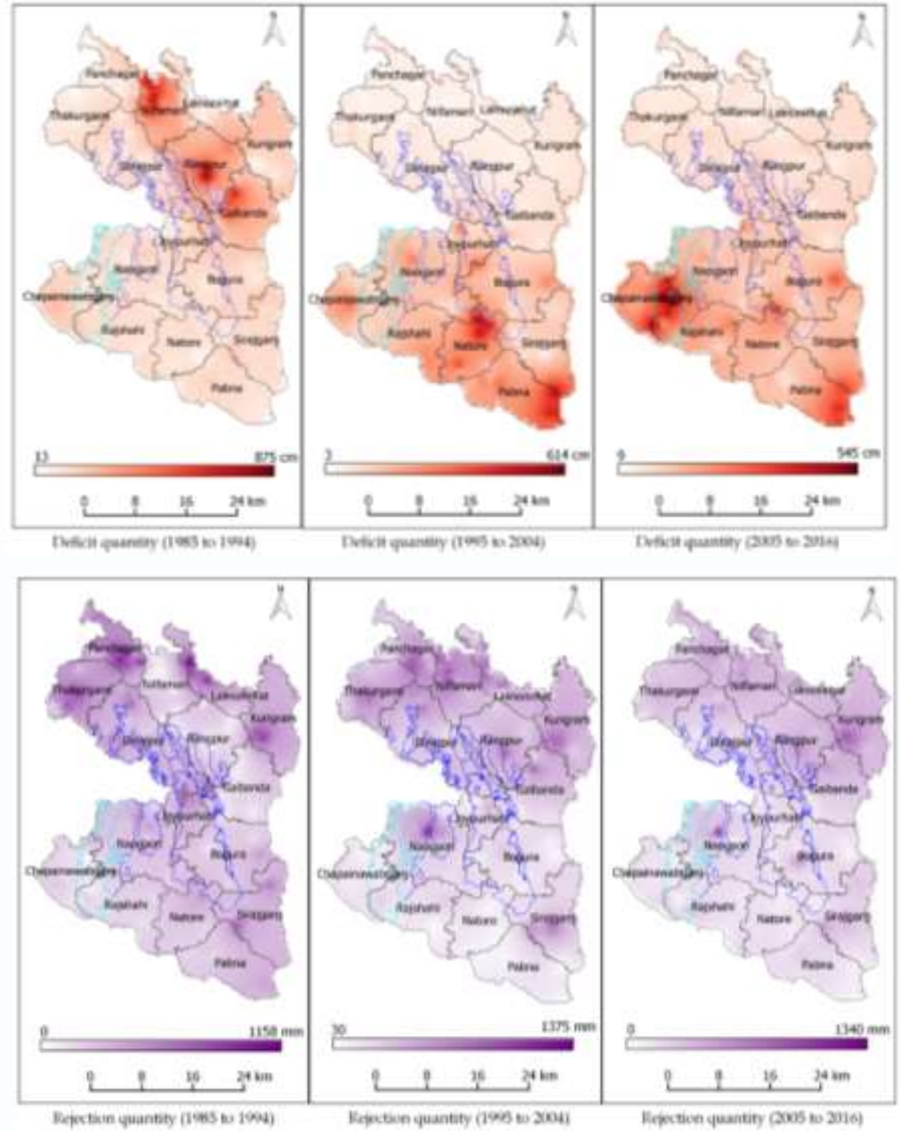
Recharge deficit occurs in some years and rejection in the others

Analysis of weekly total rainfall and weekly groundwater level data of 137 monitoring wells for 3 time spans (1985–1994, 1995–2004, and 2005–2016) for 3 sub-regions (High Barind, Level Barind and Other area)

Recharge deficit and rejection in the other years at all monitoring well sites; both quantities greatly varied spatio-temporally, revealing non-uniform development potential of the aquifers.

Recharge deficit

Recharge rejection



Increased pumping with decreasing rainfall does not deplete groundwater level significantly everywhere

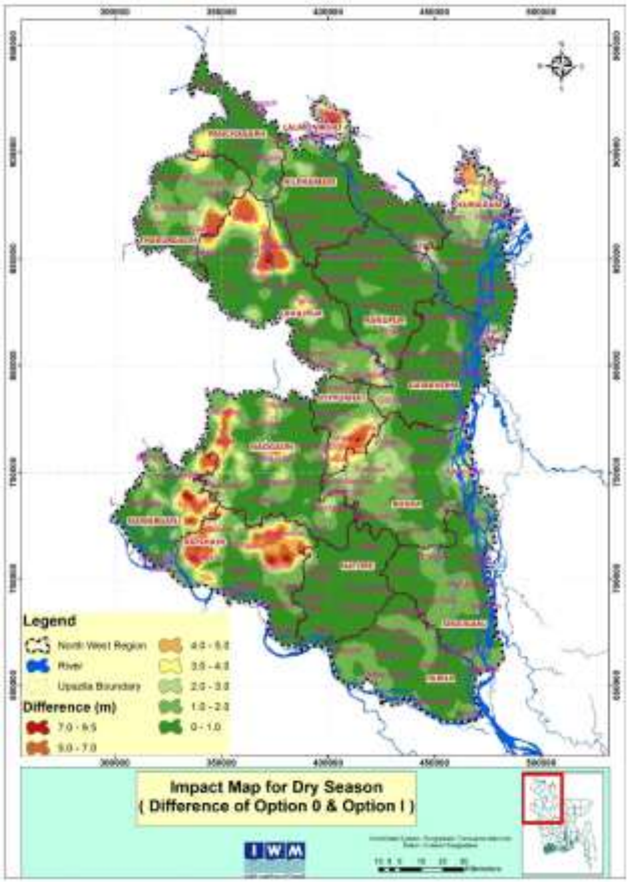
Option 0: current condition

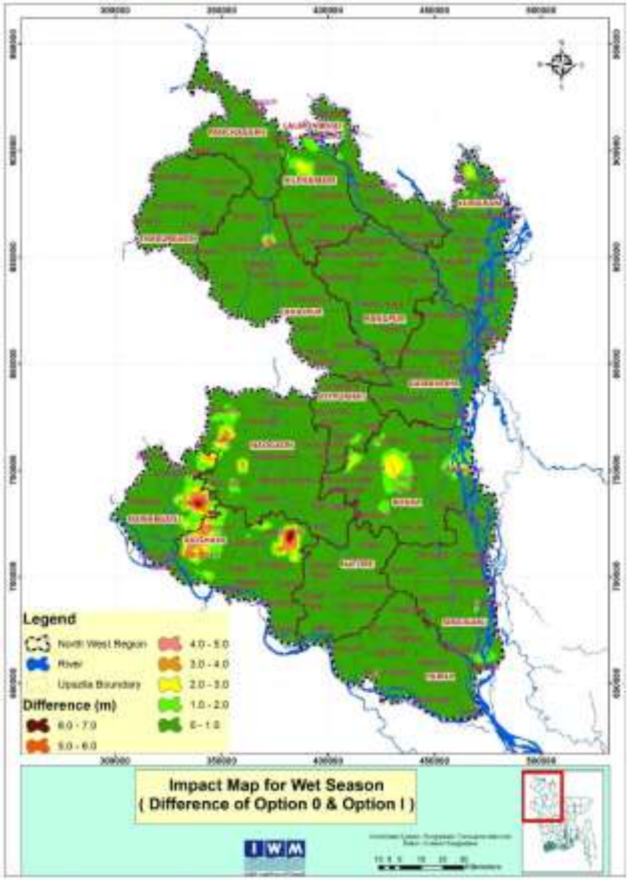
- Existing cropping
- Average (50% dependable) rainfall
- Existing domestic and industrial demand

Option I: Future scenario

- 90% area under Boro rice
- 80% dependable rainfall
- Future domestic and industrial demand

Groundwater level in Option I returns to its original position during the peak time of the monsoon in major part of the region except some part of Rajshahi, Naogaon, and Nawabganj Districts





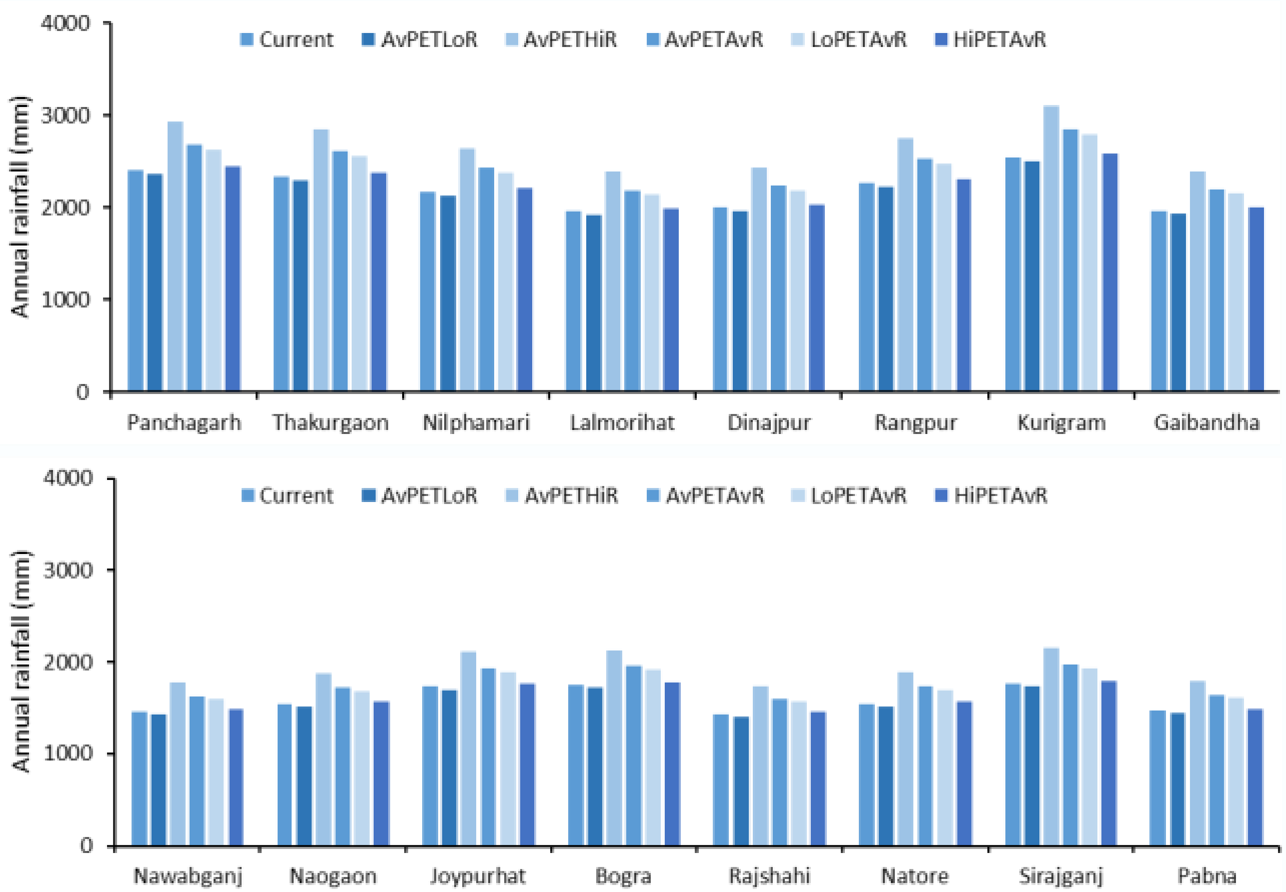
Impact map (Option 0 - Option I) of maximum depth to groundwater table for the dry season (left) and wet season (right)

Climate change is likely to impact water balance and groundwater availability ...

Climate change is expected to impact both rainfall and plant water use (evapotranspiration), but the direction and amount of change are uncertain.

Rainfall could increase or decrease, more likely to increase.

Evapotranspiration is expected to increase, but the rate is uncertain and small.

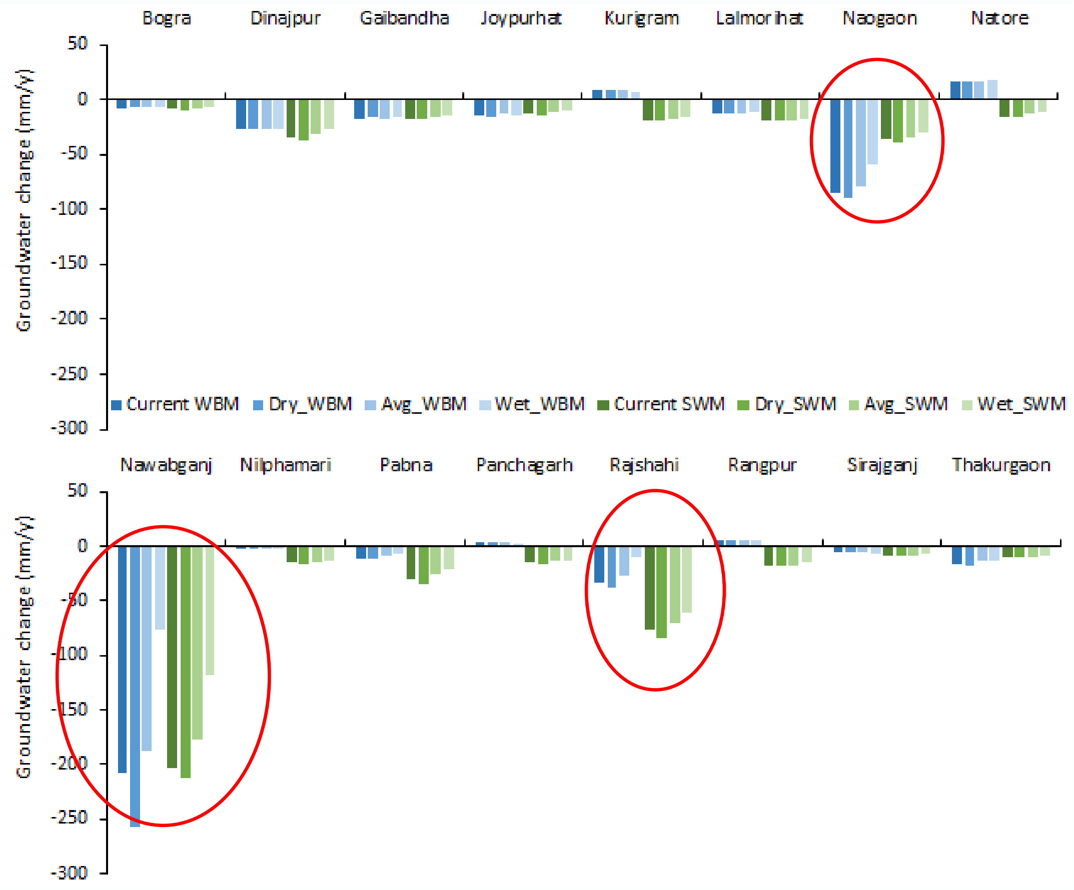


Mean annual rainfall for the 16-northwest districts under different climate change scenarios

Climate change is likely to impact water balance and groundwater availability

Climate change is projected to impact the rate at which groundwater level falls significant only in Nawabganj, Naogaon and Rajshahi. In the other districts, are not of great significance.

However, in those districts, groundwater levels are projected to fall slower than at present if climate change results in more rainfall.



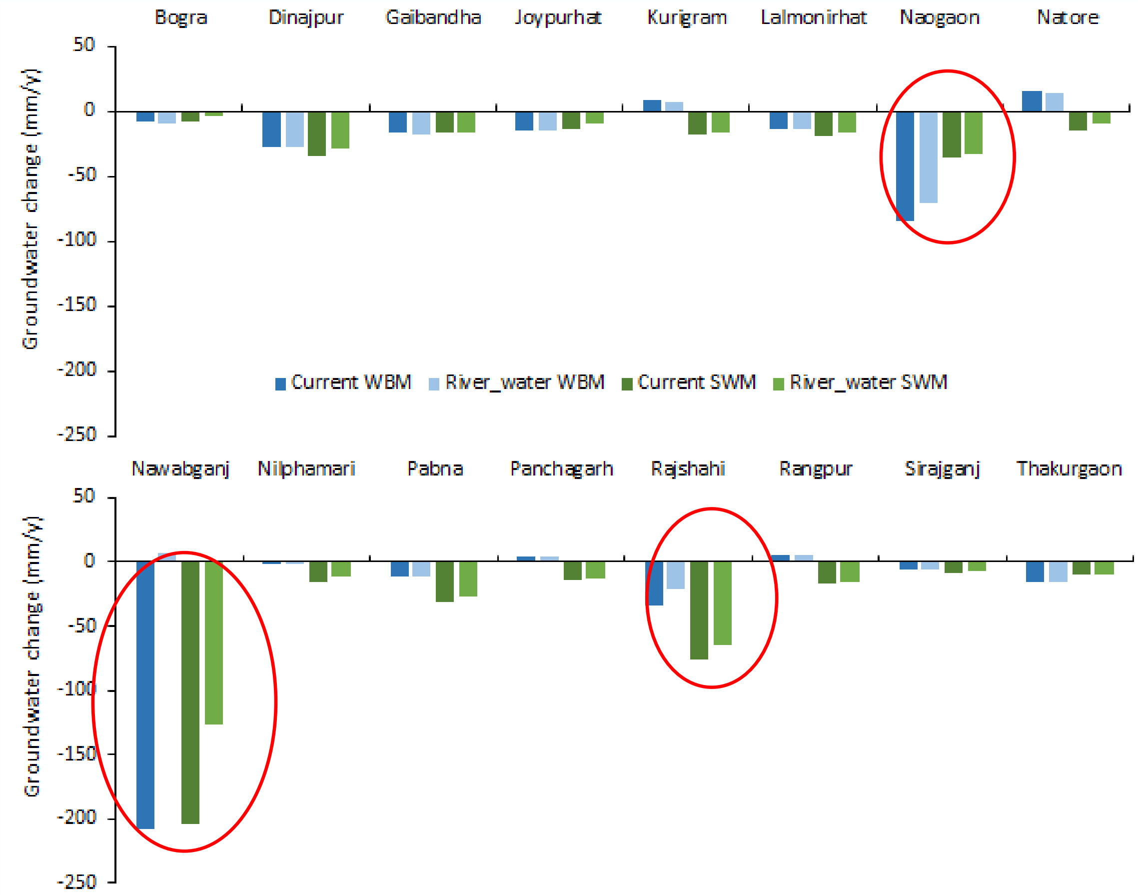
Estimated falling rates of groundwater with current management and under a dry, average and wet future climates based on a water balance model (WBM) and a surface water model (SWM)

Sourcing some irrigation water from surface supplies improves groundwater sustainability

Using river water (20%) in place of some of the groundwater leads to a substantial improvement

The beneficial impact of using river water is most dramatic in Nawabganj, followed by Rajshahi and Naogoan

In the other districts, groundwater is falling less rapidly, and the impact of using river water on groundwater decline is less dramatic



Rates at which groundwater is calculated to fall with current management and with 20 % of groundwater replaced by river water, according to a water balance model (WBM) and a surface water model (SWM)

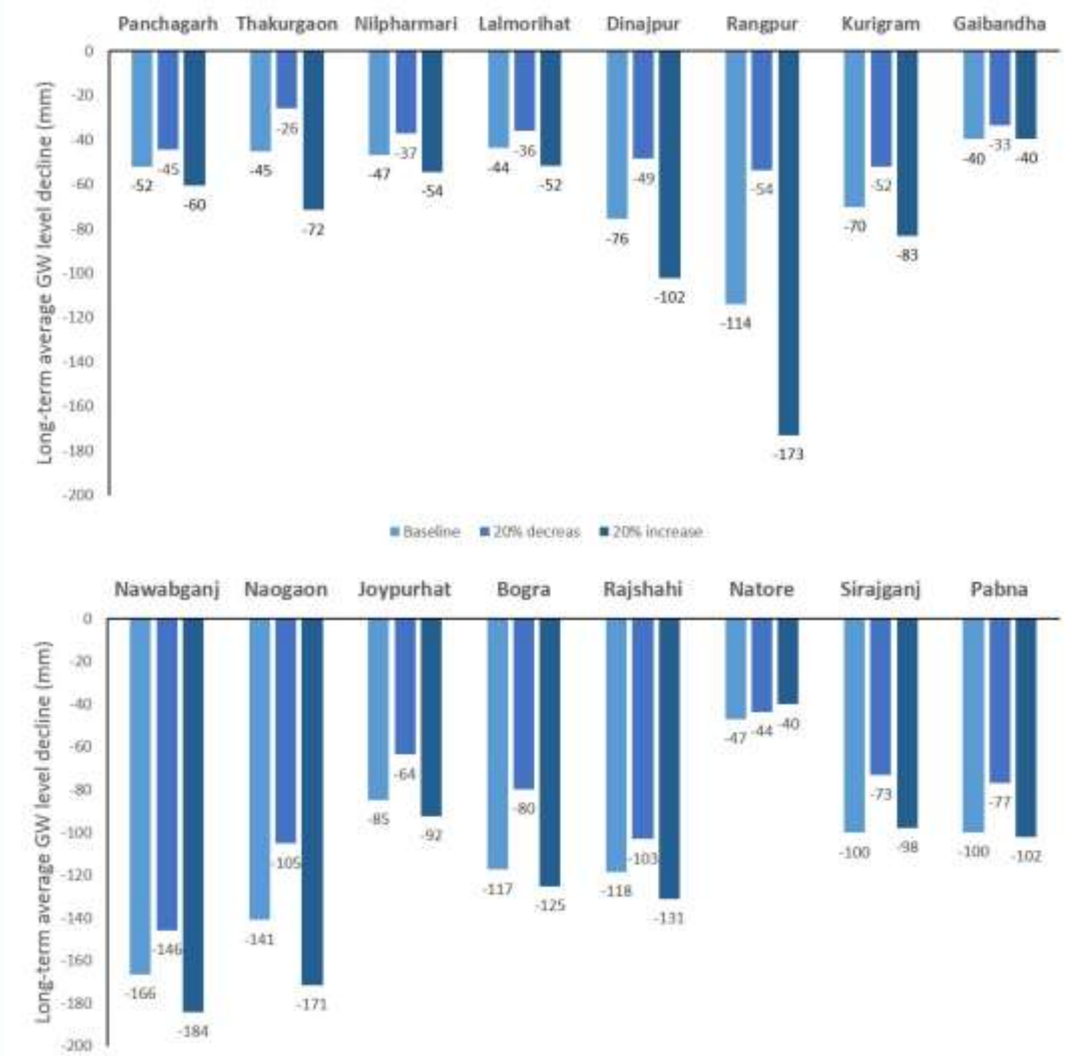
Surface water and groundwater must be managed together

The aquifer receives water from and loses water to the river depending on the water level changes in the river and the aquifer.

A 20% increase in groundwater use may result in an increased long-term decline of groundwater level.

20% less groundwater use can reduce the long-term declining trends in groundwater level.

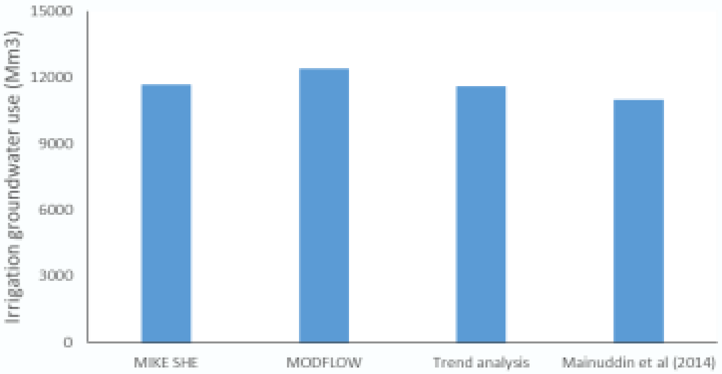
More localized studies are necessary.

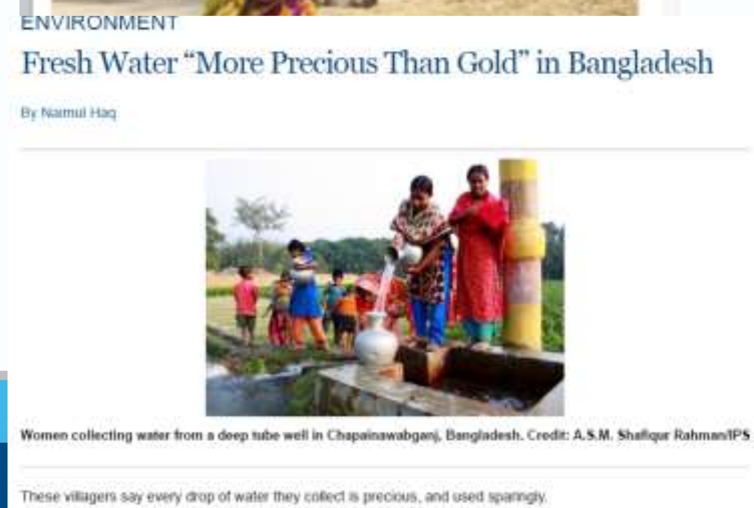


Long-term changes in groundwater level due to conjunctive management of surface water and groundwater

Conclusions

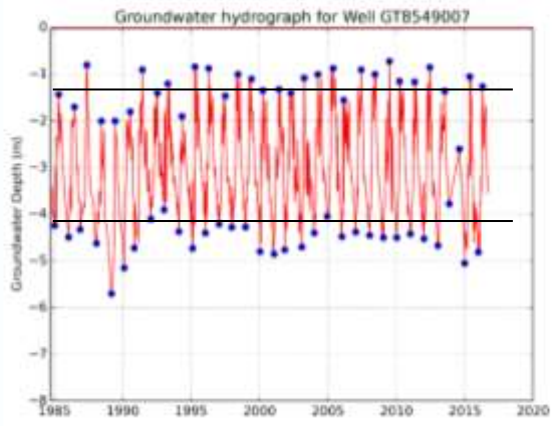
- Most comprehensive study to our knowledge
- There are misconceptions about groundwater use and consequences
- This is driven by sensational news due to domestic water supply problems in the dry months (March-April) in few areas
- General perception that farmers oversupply water is not found in the field
- Farmers are efficient in applying water to the field
- Percolation from rice field is not a loss – it recharges the aquifer
- Conservation agriculture or AWD save cost and reduce GHG emission but has no impact on sustainability of groundwater

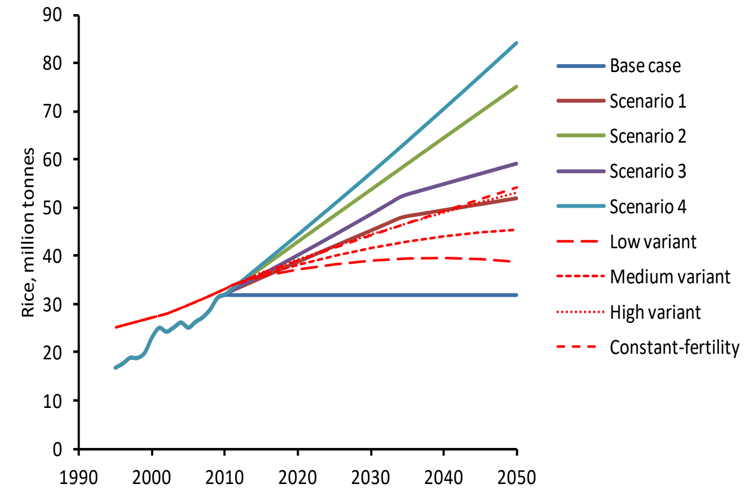




Conclusions ...

- It is normal that water levels decline due to pumping but, in most areas, they recover after wet season
- That decline can disrupt domestic water supply in some areas for a short period – this can be addressed and BMDA are already doing this
- Groundwater levels are not recovering fully, only in some parts of the Barind Region
- Multiple factors are causing this, not only net pumping
- Self sufficiency in rice production has been achieved because of growing Boro rice using groundwater
- Population is projected to increase to 202 million by 2050. This will require additional 14 million tons of rice
- Sustaining groundwater irrigation is essential for future food security and livelihood of the people





Comparison of projected production of rice for different scenarios (Base case to scenario 4) with the consumption requirements for different population projection scenarios (low variant to constant-fertility)

Conclusions

- Obviously, we need to manage water sustainably considering both surface water and groundwater
- BMDA has been working on increasing surface water storage and use. This will reduce pressure on groundwater and increase recharge to the aquifer
- Current focus for sustainability of groundwater is mostly on the pumping or demand management
- **We need to focus on increasing recharge to aquifers to increase storage**
- There are natural ways of increasing recharge (e.g. water storage, keeping water in the field in the wet season for long period) in addition to managed aquifer recharge (MAR)
- **Policies should not be generalized – rather targeted. There are significant variation within the region**
- Information generated in this study can be helpful for policy and actions

Thank you

CSIRO Land and Water
Mohammed Mainuddin

t +61 2 6246 5929
E mohammed.mainuddin@csiro.au
w www.clw.csiro.au/