Modelling the risk of water pollution impacts on ecosystem services in the Ramganga Basin, India

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Research Questions

Q1: What is the spatial distribution of the exposure risk to water quality impairment in the Ramganga catchment?

Q2: What is the likely outcome of different management interventions on public health, fisheries and food security?

Methods

This project aimed to understand the likely impact of water quality on ecosystem services, including risk to health and food security (crops and fisheries) within a risk-based framework.

Risk = Hazard * Vulnerability

Hazard was derived as likely exposure to pollution, using available data on land cover[1]; industry location[2]; fertiliser application[3]; irrigation, sewage treatment and population density[4].

Vulnerability was mapped as mean capital scores using the Sustainable Livelihoods Framework[4], based on the 2011 census data[5]. We hypothesised that populations with high access to natural capital and low infra-structure (physical capital) will be more susceptible to pollution.

A **Bayesian Belief Network** was constructed to conceptualise the framework and was informed by literature, data and expert opinion of the study area by the project investigators.

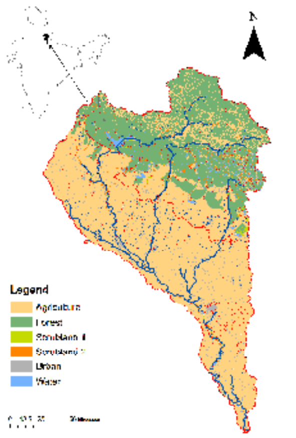

Fig. 1: Land use in the Ramganga basin. Red lines show state boundaries. The study focused on the village communities in the southern state of Uttar Pradesh where census data was available.

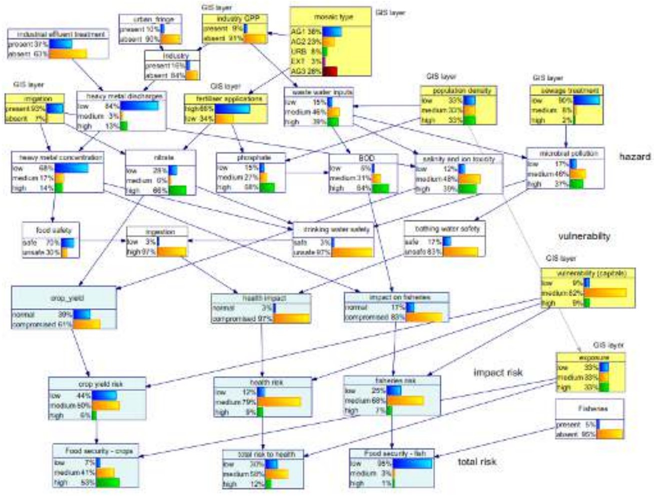

Fig. 2: Bayesian Belief Network showing the relationship between drivers, pressures, impacts and responses. The bars indicate marginal probabilities of different states for an **hypothetical example**. Yellow boxes show variables informed by spatial data, blue boxes show impact and risk nodes.

Selected Results

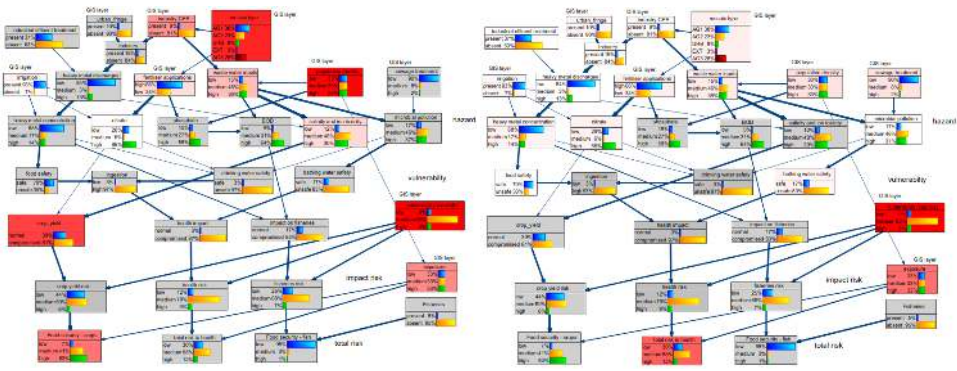

Fig. 3 Sensitivity analysis showing most important variables influencing risk to ecosystem services a) crop food security b) health risk. Shades of red show the most important parameters – the deeper the colour, the more influential is the variable.

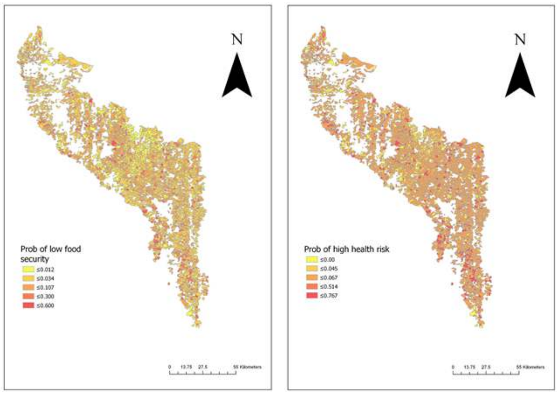

Fig. 4: Spatial mapping of risk to ecosystem services in the Ramganga basin shows differentiated risk levels and spatial pattern for a) risk to crop food security and b) risk to health

- Conceptual model summarises current understanding of key risk drivers
- Vulnerability and exposure important controls on risk
- Physical variables more important for food security risk while health risk is mainly influenced by vulnerability and exposure

- The BBN allows to model the likely effectiveness of different water quality mitigation interventions and can be used to quantify uncertainties associated with both the model and the data.

References

1. Land use – International Water Management Institute http://waterdata.iwmi.org/applications/espa/
2. Industry locations – Central Pollution Control Board
3. Fertiliser application rates – Fertiliser Association of India
4. DFID 2003 Sustainable Livelihoods Approach and its Framework http://www.glopp.ch/B7/en/multimedia/B7_1_pdf2.pdf
5. Census data 2011 and Statistical Report 2015 http://www.censusindia.gov.in

Conclusions

- The risk-based framework provides a blueprint for a holistic understanding of the complex socio-ecological system in the Ramganga basin.
- Going forward, the Sustainable Livelihoods capital mapping will be extended to urban areas using a separate census data set and ground-truthed with stakeholders in the study basin.
- The Bayesian Belief Network model structure and conditional probability tables need to be validated with the involvement of stakeholders in the Ramganga basin.
- Further model improvements can be realised when more detailed spatial land cover data becomes available (e.g. including different crop types).
- Ultimately, this work will aid local authorities in developing a water quality monitoring strategy and prioritise mitigation measures based on pollution risk and human vulnerability.

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