WATER SCIENCE POLICY BRIEF

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Floods as agents of vitality: Reaffirming human-nature synergies

Sayanangshu Modak[1]*, Surajit Ghosh[2] *corresponding author

[1]Observer Research Foundation, Kolkata, India, [2]International Water Management Institute, Colombo, Sri Lanka,

Email: sayanangshu@orfonline.org, s.ghosh@cgiar.org

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Disclaimer: The satellite observations used here have not been verified using field data. The authors do not make any warranties on the basin boundary. The brief is only indicative and decisions/actions taken based on it are strictly at the discretion of the reader.

THREE POLICY RECOMMENDATIONS:

- The policy response for flood governance should be based on the premise that floods in monsoon-dominated landscapes such as the Ganga-Brahmaputra-Meghna (GBM) basin are inevitable. Structural interventions to contain high flows in rivers often exacerbate the problem of flooding, overriding the ancient wisdom of floods as agents of vitality.
- An eco-hydrological perspective on floods demands a paradigm change in policy response from a reductionist 'flood control' to an integrated 'flood management' approach. This shift needs to be accompanied, in perspective and practice, from 'flood resistance' to 'flood tolerance'.
- By creating room for the river to expand and undertaking floodplain zoning and regulation, settlements can become less vulnerable to floods and benefit from a plethora of ecosystem services offered by connected riverine systems.

EXECUTIVE SUMMARY

Prevalent development on floodplains has increased exposure to high flows in rivers, shaping our understanding of floods as damaging. Flood response through structural measures severely undermines natural processes that are characterised by flows in a connected fluvial system. A new paradigm of flood governance needs to identify high flows as an intrinsic part of the fluvial system and strategically integrate this natural phenomenon within human habitations. A shift to adaptive management can reduce flood risk and enable riparian communities to reap the benefits of flows in a connected river system. These benefits include water security, replenishment of soil and river nutrients, groundwater recharge, seasonal influx of freshwater and biota into wetlands and soil formation among others.

BACKGROUND

The Ganga-Brahmaputra-Meghna (GBM) basin spans across emerging economies, including Nepal, India and Bangladesh. Areas of the GBM basin located within the middle and lower reaches of the Himalayan drainage systems experience flooding with clockwork regularity. Due to an exceptionally high population density, exposure to disaster is significantly greater than any comparable river basin globally. This makes a large section of the population vulnerable to flooding; vulnerability being a combined result of exposure, scale and probability of the hazard. Aside from the impact on lives and property, floods also strain government financial capacity, due to regular expenditure on flood mitigation and management activities.

The response to floods has been dominated by state-led structural interventions that largely borrow from colonial approaches toward 'flood control' (Kapuria & Modak, 2019). Counter-intuitively, embankments have only exacerbated the problem. The issue is best exemplified by the Indian state of Bihar, where major Himalayan tributaries of the Ganga debouch onto the plains. According to estimates, in the last seven decades or so, despite an expansion of embankments from 160 km to 3790 km, flood-prone areas have increased from 2.5 million hectares to 6.8 million hectares (Singh, 2020). Moreover, embankments have also created new concerns such as channel avulsion which were hitherto unforeseen. The Kosi channel avulsion of 2008 in Bihar is a grim reminder (Sinha, Sripriyanka, Jain & Mukul, 2014). Thus, constraining natural inundation caused by high flows intrinsic to Monsoon Asia is futile. Implementing nature-based solutions along floodplains is key to coexisting with high flows while deriving ecosystem services of the flood pulse (Bayley, 1991).

RESEARCH

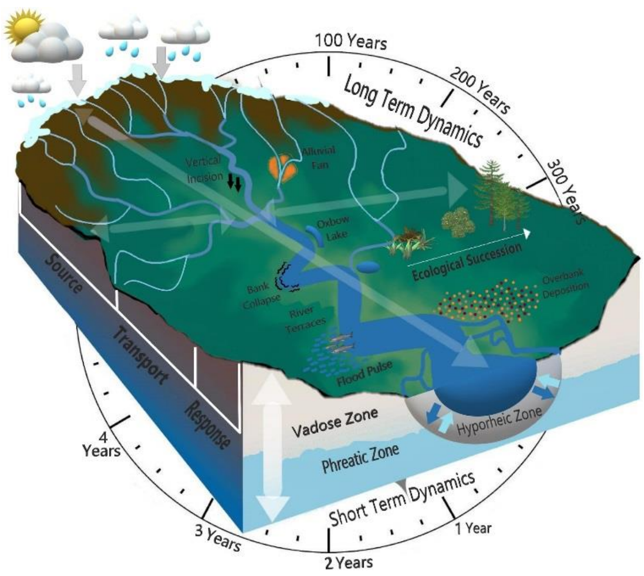

Figure 1. The interactive pathways of river-floodplain ecosystems – lateral, longitudinal, vertical and temporal. (Source- Author's Own)

High flows are characteristic of river systems within the Monsoon Zone where the hydro-meteorology is influenced by seasonal dynamics. In some instances, they become severe enough to cause harm to life and property. When that happens, a high flow is perceived to be causing floods, inland and riverine, thereby involving a 'flood-risk' for riparian communities. Human-induced transformation of and expansion on floodplains have increased exposure to floods, shaping the understanding of floods as a nuisance to growth and prosperity. This, in turn, has prompted us to devise ways of controlling the lateral movement of floodwaters through the construction of embankments. The movement of water along and within river channels has also been altered by constructing water retaining structures or diverting flows out of the system to reduce peaks in flooding. This dominant paradigm of 'flood control' in the GBM basin has severely undermined natural processes that are dependent on seasonal flows.

An eco-hydrological perspective of flood management considers rainfall-runoff and surface-subsurface interactions as vital in accommodating floods by design. These interactions within the river-floodplain ecosystem (lateral, longitudinal, vertical, and temporal) are facilitated by high flows and provide numerous ecosystem services (Fig. 1). Inculcating this knowledge of hydrological interactions in adaptive response to floods is critical. For example, this knowledge plays a role in integrating nature-based solutions, such as blue-green infrastructure, to manage recurrent flood hazard in the GBM basin.

VISIBLE HYDROLOGICAL INTERACTIONS

Lateral interactions occur along the breadth of the river corridor, comprising of the river, its floodplain, and the extended riparian zone beyond floodplains. Floodplains serve as an ecotone or transition zone between aquatic ecosystems (the river) and terrestrial ecosystems (the extended riparian zone). The lateral connection between these distinct ecosystems is critical for their functioning and integrity since water acts as a conduit for the exchange of nutrients. Ecosystem services derived from floodplains include water security, food security, water purification, soil formation and microclimatic regulation (Suchara, 2019). Floodplains also have recreational and cultural significance.

The transfer of sediment, nutrients and biota occurs essentially in two ways. When floodplains are inundated, soil nutrient concentration is regulated (Ogden & Thoms, 2002) and the exchange of nitrogen with the atmosphere is stimulated. This process enhances floodplain functions such as biomass production. It also facilitates the release of dissolved organic carbons, nitrogen and phosphorus from leaf litter and floodplain soils, making them available along with decaying plant matter to be transported back into the river channel during flood recession. This process influences the biogeochemistry of the river, enhancing the overall productivity of fluvial ecosystems (Robertson, Burns & Hillman, 2016).

An example through which the importance of lateral interactions can be observed is the the Kabartal wetland in Begusarai district of Bihar. The Karbartal wetland, declared (Singh, 2020) a Ramsar site in 2020, is located amidst a network of channels (Fig. 2). It is perhaps the last remaining lake of its kind that has been sustained by the lateral movement of high flows and flood pulses. It is an oxbow lake of the Burhi Gandak River, the course of which is about 10 km apart from the lake. The GBM has a number of such inland wetlands that face anthropogenic threats, even though some of them are enlisted as Ramsar sites.

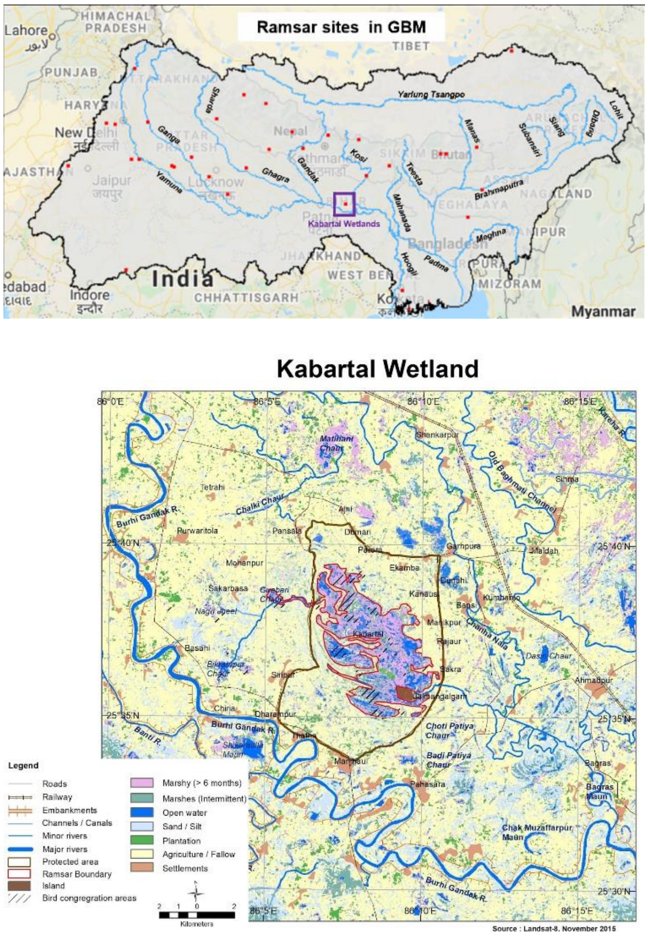

Figure 2: Ramsar Sites in the GBM (Authors' own) and Kabartal Wetland System (Source: Ramsar Site Information Service - modified)

Longitudinal interactions occur along the length of the river comprising of the headwaters at the source, the zone of sediment transportation and the estuary (Fig. 1). The continuous gradient of physical conditions from the headwaters to the mouth elicits a series of responses as adjustments within the river's constituent population of plants and animals, resulting in a biological continuum.This results in varying patterns of loading, transport, utilisation and storage of organic matter along the length of the river. Thus, changes in biophysical characteristics are never abrupt and follow a certain continuum as expounded by the river continuum concept (Vanotte, Minshall, Cummins, K. W., Sedel, J. R., & Cushing, C. E., 1980).

Commercially important aquatic species such as fish are attuned to the continuity of flow conditions between the river reaches. Their upstream migration for spawning is a tell-tale indication of the importance of a longitudinally connected river system. In the monsoon-dominated parts of Asia, high flows in rivers and heavy discharge of freshwater to the seas act as cues for fish species such as the Hilsa to migrate upstream.

Additionally, the geomorphic function of rivers and streams is magnified with the onset of monsoons as the landscape and streams spring back to life. Thus, numerous geomorphic functions such as erosion, transportation and deposition along the river's length and even beyond the estuaries occur during this time of the year. Longitudinal connectivity is essential for maintaining the riverine habitat and providing a passageway for the flow of matter and organisms. In the GBM, flow connectivity extends well into the Bay of Bengal and is instrumental in fueling the primary productivity on which marine species are dependent.

INVISIBLE HYDROLOGICAL INTERACTIONS

Vertical interactions occur between precipitation-derived surface water and groundwater. This occurs in the hyporheic zone comprising of water-filled spaces between the grains of unconsolidated sediments beneath and adjacent to streams. This zone is another characteristic ecotone between surface and groundwater (Fig. 1). In this zone, microbial activity and chemical transformations are stimulated by percolating water (Culver & Pipan, 2014). The fluxes of water, solutes, oxygen, nutrients and organic matter triggered by these exchanges influence the functioning of the stream ecosystem (Zarnetske, Haggerty & Baker, 2011).

Water, along with nitrates and dissolved organic carbon, is retained in this zone during the monsoons, and released to sustain base flow during dry periods. Streams may gain water from an unconfined aquifer or lose water to it, depending upon the water table. Therefore, any excessive withdrawal of groundwater over time alters this dynamic exchange in ways that are detrimental to the productivity of the system. Similarly, unregulated sand mining destroys this critical zone and exposes the bedrock.

Temporal connectivity is the fourth type of hydrological linkage. Time is a critical factor to consider in managing river systems as various physical, chemical, and biological interactions occur through this dimension. It encapsulates both short-term (such as months or years) as well as long-term dynamics (such as decades or centuries). Within a short period, the overflowing of water allows for hydrological connectivity to be established. Episodic surficial connectivity is essential for the exchange of nutrients, organic matter and living organisms across the diverse ecosystems within the riverscape.

The long-term dynamics are crucial for the bio-complexity of riverscapes. They lead to fairly predictable and orderly changes in the composition or structure of an ecological community. This can be identified as the process of ecological succession, which may be initiated either by the formation of new, unoccupied habitats (creation of new river bars) or by some form of disturbance (floods) of an existing community (Amoros & Bornette, 2002).

Picture 1: Livelihood of fishermen is dependent on riverine connectivity – as seen in one of the tributaries of the Brahmaputra River in India's Assam state. (Photo by Rohan Reddy on Unsplash)

DISCUSSION

It is certain that a global temperature rise of 1.5 - 2 °C by the end of the 21st century will lead to increased flood-risks in the GBM basin (Uhe, P. F., Mitchell, D. M., Bates, P. D., Samson, C. C., Smith, A. M., & Islam, A. S., 2019). Extreme rainfall and melting Himalayan glaciers are contributing to erratic flows in close proximity to burgeoning urban areas. Therefore, a long-term vision with adaptive planning that allow rivers to move laterally will go a long way in mitigating flood-risks. This approach can also allow for scarce public financial resources to be used more judiciously in recurrent flood-affected areas.

A new paradigm of flood governance in the GBM basin, and the monsoonal region at large, needs to identify high flows as part of the fluvial system that has traditionally benefited communities living on the floodplains (Mishra, D.K., 2001).

The hydrological interactions discussed in the previous section are fundamental to the understanding and appreciation of rivers as agents of vitality. Even today, despite large-scale alterations of river systems, some of these interactions remain intact (Fig. 3).

For example, the flood pulse in the Meghna system and the resultant seasonal expansion of waterbodies supports the Haor Wetland System and dependent fisheries in Bangladesh. Similarly, the Brahmaputra river from Sadiya to Goalando remains unshackled, replenishing and revitalising the Kaziranga forest and a number of beels or natural wetlands in its middle reach. It also provides the bulk of sediments to the GBM delta. The Hooghly and Madhumati-Gorai rivers, both distributaries of the Ganga, balance the salinity in the delta-estuarine complex through the seasonal fluxes of freshwater. Even in the state of Bihar, one of the most flood-ravaged parts of the basin, high flows continue to sustain agriculture.

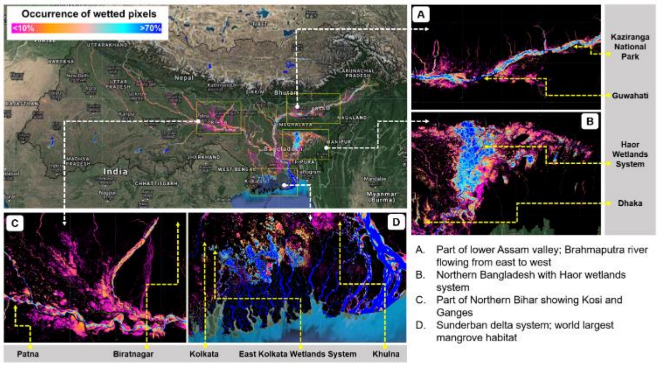

Figure 3: Maps of occurrence of 'wet pixels', generated from JRC Global Surface Water Mapping Layers (v1.2) which contain Landsat 5, 7, and 8 acquired between 16 March 1984 and 31 December 2019. Each pixel was individually classified into water / non-water classes and collated.

Realising this potential of high flows will also require critical design interventions to create 'room for the rivers' and undertake floodplain zoning and regulations at the subnational and local levels (Modak & Kapuria, 2020). However, integrating land and water governance in India is hindered by a lack of political will and absence of integrated governance. The union government of India circulated a Model Bill for Flood Plain Zoning in 1975 and reaffirmed it in a set of guidelines for flood management in 2008 (Sharma & Richa, 2018). However, land being a state subject in India, the onus to enact land regulations rests with the country's federal constituents. None of the regularly flood-affected states located within the GBM basin, such as Bihar, West Bengal and Assam, have taken proactive steps towards floodplain zoning. The two main reasons they have cited as constraints are (1) evacuation of people who occupy the floodplains; and (2) resettling them elsewhere. This is not to say that urban areas, such as Patna, Guwahati, Kolkata and Khulna should be vacated. However, other stretches of the floodplain need to make more room for controlled flooding and adopt an agro-economic system that utilises the bounties of high flows. Urban areas, especially those in the deltas and abutting estuaries need to consider their locational setting in urban planning and development. Urban wetlands should be preserved, and the expansion of impervious surfaces should be reconsidered. Similarly, natural drainage lines need to be reclaimed from encroachment and preserved despite the seasonal nature of flows. This will allow for the quick and efficient conveyance of water. A harmonious co-existence with the monsoon high flows will reduce the losses and contribute to the well-being of the riparian communities through various ecosystem services obtained from a connected riverine system.

THREE MAIN RECOMMENDATIONS FOR POLICY REFORM

1. Despite ample progress in technology for mapping and modelling flood-risk, the bottleneck for realising floodplain zoning and regulation in the GBM is essentially political. Strong political will is needed to look beyond the established status quo of flood relief which has worked well to galvanise political support within short-term electoral tenures. Decisive, long-term and adaptative measures such as floodplain zoning will require continued support from across the political spectrum.

2. Floodplain zoning and creating room for the river would also involve displacing people from the floodplains. Normatively, it will necessitate compensating those displaced, their rehabilitation and enabling alternate sources of livelihood – a challenge in itself in a densely populated region where land acquisition is a contentious subject.

3. The existing paradigm of flood-control, as expressed in the functioning of line departments and the expectations of the larger populace that is attuned to quick fixes and short-term needs, has its own inertia. Countering it will require strong effort in generating scientific evidence on ecosystem services of hydrological interactions and carrying out policy advocacy across multiple scales.

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