ORF ISSUE BRIEF

AUGUST 2019
ISSUE NO. 308

Towards A Synergy-Based Approach to River Basin Governance

JAYANTA BANDYOPADHYAY

ABSTRACT The need for integrated water resource management (IWRM) has been explored and articulated by many water professionals over the recent years. Today, such a holistic approach to the management of water systems has become even more imperative in the context of the global crisis in water for which no easy solution is yet in sight. This brief calls for the development and institutionalisation of the interdisciplinary approach of integrated water systems governance (IWSG). It proposes an initial framework for a synergy-based perspective to the governance of flows in river basins. This framework is based on the inclusion of water, energy, biodiversity and sediment as basic to the identity of water flows.

Attribution: Jayanta Bandyopadhyay, "Towards a Synergy-Based Approach to River Basin Governance", *ORF Issue Brief No. 308*, August 2019, Observer Research Foundation.

ISBN 978-93-89094-70-1

INTRODUCTION

'Water is the driver of nature.'

~ Leonardo da Vinci (1452-1519), Italian artist and engineer

River basin management has long been conducted from the perspective of reductionist engineering which sees rivers primarily as a stock of water to be diverted and used to satisfy human requirements. However, the effectiveness of this approach has reached its limit. It is increasingly proving inadequate in addressing the challenges facing humanity in terms of both quantity and quality of the world's water systems. These challenges have been recorded adequately in the United Nations World Water Development Report.[1]

The call for a more holistic perspective in addressing water-related challenges is not new. In 1977 in the UN Mar Del Plata Conference, such concerns were already discussed; the discussions would continue over the years, and reiterated in other occasions including the Dublin Conference of 1992. Such a new perspective is commonly known as Integrated Water Resources Management or IWRM.[2 3] A great deal of discussion has taken place on what IWRM should constitute and in many countries, water policy and governance have advanced with some degree of integration of the principles of IWRM.[4 5 6 7] Innovative steps have been taken in the institutional structures and techno-economic management of water as a product of nature.

To address the crucial challenges in water security from the local to the global levels, it is essential to articulate IWRM in fundamental and practical terms. The process of IWRM will have to elevate itself beyond management by engineering to internalise social, economic, political, cultural, and other dimensions of governance. In this process of evolution, a composite perception integrating the diverse bio-geophysical and chemical constituents of flow of water, in general, is needed as a first step for the articulation and delivery of the full potential of Integrated Water Systems Governance (IWSG). This brief offers an approach that goes beyond reductionism to a synergy-based composite identity of flows in river basins, so that IWSG processes can be more clearly identified and implemented.

In the reductionist perspective, the extent of flows in river basins is limited to the physical channels and excludes the flow of sub-surface water. Similarly, the flow is quantified as the volume of water passing by a specific point per unit of time along that course. With advances in many branches of natural sciences, including theoretical physics and water science, it has become imperative to generate synergetic perceptions that make use of interdisciplinary knowledge. In the case of flows of water, after the precipitation from the sky reaches the surface of the Earth, and small streams are formed, onwards to the creation of rivulets and rivers, all flows, notwithstanding their quantities, play many important ecological roles in shaping, evolving and altering the morphology of almost all parts of the related basins and in supporting the biodiversity that exists on them. There is no dearth of literature expounding on the role of streams and rivers in the creation of the socio-economic-cultural-demographic features in various river basins.[8]

Indeed, flows in river basins have helped shape the history of human societies. It will not be an over-statement to describe flows in river basins—whether the Danube in Europe or the

Ganges in South Asia—as the most important environmental influence in the shaping of the terrestrial landforms, biodiversity and related human societies. There is a need for a multifaceted perspective to understand what flows are, what they have been doing over the geological past, and what will be the appropriate mechanisms for governing them in river basins so that the ecosystem services offered by them are not at risk in the future.[9]

In spite of a growing global consciousness of the failures of the present reductionist perspective in engineering for river basins, a clear articulation of a synergy-based approach is yet to emerge. This brief outlines the key elements of such an interdisciplinary perspective by taking a composite view of some of the bio-geophysical constituents of flows. This perspective—abbreviated as WEBS[10] for Water, Energy, Biodiversity and Sediments—considers all these as constituents of flows. This is an initial and early step towards the making of a more synergy-based perspective of flows for water governance that would in the future ideally include the social, political, economic, and cultural dimensions of flows in river basins. In the ongoing global exercise for the assessment of allocation of flows for sustaining ecosystem services, this perspective can play a central role in deciphering environmental flows.

ELEMENTS OF A SYNERGY-BASED W.E.B.S. PERSPECTIVE OF FLOWS IN RIVER BASINS

Water

Flows of water in the river basins are integral parts of the global hydrological cycle. Rivers (together with streams, lakes, wetlands, land, and aquifers) play the most important role of transporting water after its precipitation from the atmosphere, to their final discharge into the oceans via their passage through the terrestrial landmass. Water flowing in the streams or rivers is never chemically pure, even at the pristine stage of precipitation. As precipitated water travels through the atmosphere, it absorbs suspended particles and gaseous materials, a process seen in the formation of acid rain. As the precipitated water finds its way through the terrestrial landmass, its content gets further modified by land and land cover, as much as it also alters the physiography of that land itself. During the journey through land, the flow dissolves organic and inorganic materials. Thus, water of each stream or river gets its characteristic chemical composition, which further evolves as the flowing water moves along its downstream course.

On the basis of the physical structure and chemical composition of the river bed, as well as the temperature of the water, the biological life in the water bodies emerges and evolves. A segment of the biological life in river flows, especially in the form of fish varieties, can be economically significant. Thus, water flowing in a river is not just H_2O, but a complex mixture of chemical and biological contents. In the case of river basins with large temporal variations in flows and extensive floodplains, the inundation of the floodplain areas results in the regeneration of both surface and groundwater as well as biodiversity in the floodplains, even if the spots are away from the main course of the river.

Flows of rivers, especially when they temporally vary extensively, have both advantages and disadvantages especially for human well-being, by generating floods and lean flows. Since about more than five millennia, flows of rivers have been blocked and diverted for meeting the needs of human settlements, including irrigation and moderation of the impacts of floods. Examples of human-made structures on the Nile, Yellow, Indus, or Tigris-Euphrates can be given in this regard.

In the past 200 years, engineering interventions into the flows of water have also increasingly been made for promoting navigation, generating hydro-electricity and meeting urban-industrial demands. As a result of diversion of flows from the rivers by interventions made with a reductionist perspective, downstream flows have declined in amount, changing their ecological status and services. In many instances, such diversions were large enough to cause stoppage of outflows to the ocean and destruction of fishery economies. The example of the Yellow river in China is an important one as for several years, its flow did not reach the oceans through the Bohai Sea.

In the WEBS perspective, flows of water in river basins integrate all parts of the basin from the stage of precipitation to the point of confluence with the oceans. Thus, flow of water in river basins need to be perceived as a continuum and described through the contents and not a stock to be stored, transferred and used independent of externalities. This perception will enforce changes in water science and engineering towards a larger degree of interdisciplinary understanding and governance.

Energy

Water from the surface of the Earth (oceans, rivers, lakes, wetlands, soil, vegetation) gets heated and its vapour lifted by solar energy. It returns to the surface of the Earth as precipitation, in the form of liquid water, snow or ice, falling both on land and the oceans. Depending on the altitude at which it falls on the terrestrial surface, the precipitated water embodies a potential energy. After deducting the water that goes back to the atmosphere as evapotranspiration and goes down through the process of percolation to fill groundwater aquifers, the remaining precipitated water flows as surface run-off, initially as small streams, which finally join together to form rivers. Under the pull of gravity, the water moves downstream, transforming the potential energy to kinetic and creating the river flows.

Energy is an essential constituent of river flows that makes its downward journey, all the way from the headwaters to the mouth, coastal areas and beyond. This is why upland and mountain areas have traditionally been most suitable for the use of the flows for generating mechanical and electrical energy. In the upland parts, where the slope of the river bed is higher, the kinetic energy in the flows generate bed loads and suspended sediments by causing erosion of the river bed and the banks. In the mountain areas, the flows can be powerful enough to carry even large boulders.

The energy that endows river flows with the ability to erode the banks and the bed, generate boulders, gravels, sediments, and silt, also transport the eroded materials further downstream. As a stream or river comes out of the uplands and enters the flat plains and then the delta, which have much reduced slope of the bed, the gravitational pull also declines. Wherever the flow slows down their capacity to generate or carry sediments also declines. In turn, the flows increasingly perform their role of deposition of the sediments. The deposited materials contribute to the growth of sand bars, riverine islands, and finally the delta. The level of energy in the flows also determines whether the river, after passing through the upland areas, would follow a braided course or form a meander.

Early forms of navigation and transportation, like floating of felled trees, were efficient users of the energy that is an integral part of this natural downward flow of rivers. Energy in the flow of rivers has been used by humans for millennia for running water mills in the upland areas, for grinding of food grains, and to run simple machines. In the last two centuries the scale of extraction of energy from flows in rivers in the upland areas has rapidly increased, in particular, as hydro-power in the industrially advanced countries. Thus, in recent times, large quantities of energy in the flows of rivers have become an important provisioning ecosystem service.

In many mountain areas, energy from flows in rivers has become the main source. At the same time, extraction of energy from the flows impact the ability of rivers to maintain other ecosystem services, like generation and transportation of sediments, thus disrupting the ecological linkages along the longitudinal course of rivers. This affects the aquatic habitats and biodiversity based on them. It is therefore important to see the energy in flows of streams and rivers as integral part of the totality of flows without which description of the flows will remain incomplete and assessment of hydro-power projects will remain misleading.

Sediments

During the downward journey from the mountainous and upland parts of a basin to the floodplains to the delta and further to the coasts and submerged delta, flows of rivers generate, transport and deposit solids of various sizes. In many instances, such as the Eastern Himalaya which receives highly intense summer monsoon precipitation, the energy content in flows may be enough to roll down boulders more than a meter in size. On the other extreme, such flows also carry clay with particle size less than 0.002 mm. The solid content of river flows plays a crucial role in shaping the physiography of the basin, fluvial geomorphology, and the formation of habitats for biodiversity, in all parts of the river basins.[11] Newson and Large has recorded the growing need of recognising the sediments and the role of fluvial geomorphology in restoration activities for river basins.[12]

On the basis of the primacy of the three processes of erosion, transportation and deposition, in general the basins of rivers are divided in three segments: the uplands, the floodplains and the delta. In the event of sharp changes in the slope of a river bed, the dominant sediment process would change accordingly. Most of the erosion processes occur in the uplands. As the flows cross the foothills and reach the floodplains, the slope of the bed drops, causing a marked reduction in its ability to erode. At this stage, the flows start dropping boulders and larger particles as sediments.

In the floodplains, the flows mainly transport finer sediments and in situations where the river periodically extends over large areas of the floodplains, they deposit sediments that may range from sand to clay, depending on the energy content of the flows. Such processes leave the landscape in the basin area, either rejuvenated by deposition of fertile soil or damaged by deposition of sand. Such ecosystem services occur extensively in basins of the Nile, Ganges-Brahmaputra-Meghna (GBM) and others and play a central role in supporting the agricultural economy in the basins. However, catastrophic natural events like earthquakes or human interventions not informed by ecology in the basins, often create conditions in which sand gets deposited on fertile topsoil, to the detriment of agriculture.

As a river flows further downstream and enters the delta region, its energy level declines, and so does its capacity to transport sediments. Here it starts to deposit even the finer sediments transported from the upstream areas. While most of the sediments are suspended in the flows, a smaller part also gets transported as the bed load which is rolled or dragged by the flow along the river bed. Beyond the point of confluence of the rivers with the oceans, the transportation and deposition of sediments continues, with the formation of submerged delta and thus, continues the outward growth of the delta. Such a submerged delta, in the case of the Ganges-Brahmaputra-Meghna basin, which has an annual sediment load of 2,179 Million Metric Tons[13] has a length of about 3000 km and a width of 1000 km.

The synergy of water, energy and sediments are basic and closely related identities of flows and changes in the status of one directly impact on the other two. Their systemic link supports the diverse habitats in the basin and related biodiversity.

The generation of sediments in flows of rivers can be the result of a purely natural process, like tectonic activities or landslides. In the last several decades, the processes of sediment formation and transportation has been substantially influenced by human interventions, including the building of roads and railways, dams, barrages, embankments, as well as afforestation. With large parts of the sediments getting trapped in the artificial storages that are built, there has been a great change in the processes and amounts of sediments being carried by the flows in rivers of the world to the oceans. This has affected the ecological status of many rivers, large and small. Conversely, as in the case of the Yellow river, human intervention has reduced the outflow of sediments. It is thus important to recognise and assess the sediment as an integral element of flows in river basins which needs to be used in the assessment of all engineering interventions for river basin governance.

Biodiversity

From their headwaters in the mountains and uplands to their confluence with the oceans, water, energy and sediments constitute basic contents of flows and generate a great variety of habitats. These habitats, in turn, support a rich biodiversity starting from micro-organisms to simple algae to large fish varieties weighing tens of kilograms. Giller and Malmqvist have provided an important account of the biological life around flows in streams and rivers.[14] Biodiversity in river basins is closely linked with the chemical composition, acidity level, and temperature of flows in rivers and the nature of the vegetation and animals on the banks or in the rivers. Fish from the rivers have remained the food for both humans and animals since the beginning of civilisation. The aquatic biodiversity of flows in river at specific parts has undergone rapid changes resulting from both natural processes, and more recently, human interventions leading to changes in river flows and their courses. Various varieties of fish in rivers move from the oceans to the upstream parts for breeding in freshwaters and then return to downstream directions, as part of their annual migration. Salmon in Europe and Hilsha in South Asia offer examples of fish varieties that make such migratory moves.

The large number of ponds, lakes, wetlands, and creeks in the floodplains of rivers provide cheap sources of protein in the form of small fish varieties that grow in open access aquatic bodies, including wetlands. The state of biodiversity in the flow of a river is an indicator of the environmental status of the flow. Therefore, it is a basic description of that flow. Restoration of ecological status of flows in rivers has become an essential part of their integrated governance. In these activities, biodiversity becomes a primary indicator and tool in the restoration process which has deep implications for global water security.[15]

In this way, biodiversity becomes a signature of flows in rivers and a crucial element for their governance. The large and rapidly urbanising population in many parts of the world in the coming decades would generate higher and more diverse demands for water, energy and food, raising important challenges in the governance related to allocation of water across time, space and sectors.[16] This is related in particular to the issue of sustaining the ecosystems to maintain their natural functioning and ensuring the continuity of their ecosystem services. In doing so, a crucial and new starting point will be the generation of a perception of river flows not simply as a quantity of water but as consisting of an inter-related combination of water (with dissolved contents), energy, biodiversity and sediments.

In the above backdrop, an elementary interdisciplinary perspective of flows in river basins is identified as Water-Energy-Biodiversity-Sediments or WEBS. This preliminary perspective needs to be further expanded and refined in the future to include other relevant parameters. Nevertheless, the WEBS perspective will serve as a starting point for the understanding of the basins of rivers across the world.

CONCLUSION

The current global water emergency indicates a serious crisis in the natural environment as a whole. The widely discussed need for the holistic governance of water systems, is indeed a global necessity. To move towards the much needed interdisciplinary governance of water in the future, it is urgent to reorganise perceptions of water as a system. The predominant framework of water engineering that is reductionist needs to be replaced by a composite and synergy-based one. There is a large body of literature on such integration. Molle has described the path of thoughts on the emergence of river basin as the spatial unit for such integration.[17] Falkenmark and Folke have tried to integrated ecosystem services in the framework of IWRM.[18]

This brief offers initial steps towards evolving a synergy-based perception of flows in river basins in the form of the WEBS perspective. It calls for the internalisation of four constituents of flows in river basins: water, energy, biodiversity and sediments. Not only from the point of interdisciplinary water science but also holistic water engineering, in the present context of large-scale human interventions into flows of rivers, the synergy among these elements is of great importance. For example, any intervention to store the flows and transfer them would impact the sediment dynamics, water quality and biodiversity. Hydro-power projects look at the flows only as a source of energy and are often unconcerned about their impacts on water quality, sediment dynamics and state of biodiversity.

River restoration initiatives invariably try to revive the lost synergy or distorted links among water, energy, sediments and biodiversity. To exemplify the gaps in the present engineering approach, many structures can be taken, like the large-scale hydro-power development in ecologically fragile mountains like the Himalaya. In a further developed stage, such a perspective would be useful in generating a more comprehensive, realistic and interdisciplinary vision for the use of flows in rivers, especially for reforming the reductionist assessment processes and facilitating the integrated governance of flows in river basins. This would help open the path for avoidance of conflicts and crisis situations involving the stakeholders, foremost of which is the environment itself.

ABOUT THE AUTHOR

Jayanta Bandyopadhyay is a Visiting Distinguished Fellow at Observer Research Foundation-Kolkata, and an adviser to the Water Diplomacy Program at Tufts University. He holds a PhD in Engineering from IIT Kanpur. He may be reached at jayanta@iimcal.ac.in.

ENDNOTES

1. United Nations World Water Assessment Programme, "The United Nations World Water Development Report 2018: Nature-Based Solutions for Water," 2018.

2. "Integrated Water Resources Management," TAC Background Paper No. 4, Global Water Partnership Technical Advisory Committee, Stockholm, 2000.

3. "The Guide to Hydrological Practices," WMO No. 168, Commission of Hydrology, 1994, 770.

4. Malin Falkenmark, "Water Management and Ecosystems: Living with Change," TEC Background Paper No. 9, Global Water Partnership Technical Committee, 2003.

5. Jayanta Bandyopadhyay, *Water, Ecosystems and Society: A Confluence of Disciplines* (India: SAGE Publications India, 2009).

6. Peter Rogers, "Water Governance, Water Security and Water Sustainability," in *Water Crisis: Myth or Reality*, eds. Peter P. Rogers, M. Ramon Llamas and Luis Martínez-Cortina (London: Taylor and Francis, 2006), 3–36.

7. Martin Griffiths, "The European Water Framework Directive: An Approach to Integrated River Basin Management," *European Water Management Online* 5 (2002): 1–14.

8. Nick Middleton, *Rivers: A Very Short Introduction* (Oxford University Press, 2012).

9. Ibid.

10. Jayanta Bandyopadhyay, "Why We Need a New Perspective on Rivers," *The Third Pole,* 25 July 2018, https://www.thethirdpole.net/en/2018/07/25/why-we-need-a-new-perspective-on-rivers/.

11. Leo C. van Rijn, *Principles of Sediment Transport in Rivers, Estuaries and Coastal Seas* (Amsterdam: Aqua Publications, 1993).

12. Malcolm D. Newson and Andrew R.G. Large, "'Natural' Rivers, 'Hydromorphological Quality' and River Restoration: A Challenging New Agenda for Applied Fluvial Geomorphology," *Earth Surface Processes and Landforms* 31, no. 13 (2006): 1606–1624.

13. Joseph R. Curray and David G. Moore, "Growth of the Bengal Deep-Sea Fan and Denudation in the Himalayas," *Geological Society of America Bulletin* 82, no. 3 (1971): 563–572.

14. Paul S. Giller and Bjorn Malmqvist, *The Biology of Streams and Rivers* (Oxford University Press, 1998).

15. Charles J. Vörösmarty, Peter B. McIntyre, Mark O. Gessner, David Dudgeon, Alexander Prusevich, Pamela Green, Stanley Glidden et al., "Global Threats to Human Water Security and River Biodiversity," *Nature* 467, no. 7315 (2010): 555.

16. Olli Varis, Marko Keskinen and Matti Kummu, "Four Dimensions of Water Security with a Case of the Indirect Role of Water in Global Food Security," *Water Security* 1 (2017): 36–45.

17. François Molle, "River-Basin Planning and Management: The Social Life of a Concept," *Geoforum* 40, no. 3 (2009): 484–494.

18. Malin Falkenmark and Carl Folke, "How to Bring Ecological Services into Integrated Water Resources Management," *AMBIO: A Journal of the Human Environment* 29, no. 6 (2000): 351–353.

ORF OBSERVER RESEARCH FOUNDATION

Ideas • Forums • Leadership • Impact

20, Rouse Avenue Institutional Area, New Delhi - 110 002, INDIA
Ph. : +91-11-35332000 Fax : +91-11-35332005
E-mail: contactus@orfonline.org
Website: www.orfonline.org