Module 1

Integrated Water Resource Management and Governance of River Basins

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Introduction

The neo-Malthusian creed of "scarcity induces conflicts" as a generic way to explain conflicts over natural resources has been challenged globally[1]**.** As such, a state of conflict may exist within the human societies with nature acting as the stressor, while there might also be a state of conflict between the human society and nature: both ofwhich pose a threat on environmental security. The context of conflict within human societies for natural resources is well-evidenced and more or less well-understood. They can be evidenced from the various cases of water conflicts, conflicts over agricultural land-use, forest rights, and oil resources. The less understood part is related to human interventions in natural resource flows, and eventually disrupting ecosystem service flows for short-term economic gains in the name of "development". As an example, anthropogenic interventions in the natural hydrological flows have often proved counter-productive in the long-run, despite yielding short-run economic benefits, as has already been stated earlier. Such interventions have negatively affected human livelihoods further downstream by affecting ecosystem services (Bandyopadhyay and Ghosh, 2009). These are all concerns for environmental security. Dalby (2013 and 2016), however, has expressed that there remains lack of social-scientific evidence on the neo-Malthusian creed advocating environmental scarcity as a cause of conflict. The neo-Malthusian creed has also been challenged by the extensive body of work on "securitization"[2] by the Copenhagen School, mainly associated with the work of Barry Buzan and Ole Waever (see for example, Buzan and Waever, 2003; Booth, 2007). Empirically, the creed has also been proven to be invalid for the Himalayan river basins. The failure of the neo-Malthusian hypothesis in explaining conflicts and addressing water governance challenges can be witnessed from the cases of inter-state conflicts over the Ganges related to floods in Bihar (Ghosh, 2016), or from the case of the

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[1] For exposition to the hypothesis, please refer to Homer-Dixon (1991 and 1994), and Ghosh and Bandyopadhyay (2009).

[2] Securitization is a notion in the discipline of International Relations talking of the state actors viewing all subjects through the prism of security. Further details are given in the glossary.

development paradox of “ample water, ample poverty” of the Brahmaputra (Bandyopadhyay et al., 2016).

Therefore, the very traditional thinking that addressing water scarcity is akin to water governance does not hold for the governance of the Himalayan waters of the Ganges and the Brahmaputra. Globally, given the social, political and economic stresses that water creates at the various levels and in various contexts, water professionals and researchers have been thinking of new ways of managing the resource, thereby marking a shift from the existing modes of water resource development, resulting in a worldwide debate on paradigm change in this subject.

The fact that ecosystem services and food security are inextricably linked is being increasingly recognised within academic circles, even though it rarely finds reference in the developing world’s policy documents (Bandyopadhyay and Gyawali, 1994). In South Asia, this omission has led to adherence to the archaic notions of water management entirely based on the reductionist[3] engineering paradigm looking at short-term economic benefits, and that ignores long-term social and ecosystem concerns. This paradigm is essentially an integral component of the colonial legacy as this was introduced and formalised under colonial capitalism in South Asia leading to a ‘metabolic rift’ between human-nature relationship (Foster, 2003;Gilmartin, 1994 and 1995). The most critical concern that the reductionist engineering paradigm misses addressing is that the livelihoods of the poor in the developing world are reliant on ecosystem services. Essentially, because of the importance that ecosystem services render to the livelihoods of the poor, such services are often classified as “GDP of the poor” (Martinez-Alier, 2012). Unfortunately, south Asian policy documents and

[3] Please see glossary for explanation of reductionism. Here, it is used to emphasise that river basin governance is a complex multi-dimensional problem requiring multi-disciplinary thinking. Hence, a mono-disciplinary approach from engineering that reduces the solutions to water governance problem to supply-augmentation responses has been called “reductionist” here.

implementation plans rely on “arithmetic hydrology” rather than “ecohydrology”[4] and have ignored this linkage. They have also ignored the changing relation between water and food security, with the change being embedded in the new emerging paradigm of water management, also known as Integrated Water Resource Management (IWRM), which recognises the critical role of ecosystems. Under IWRM, water is treated as a multi-dimensional flow, rather than as a resource stock to be used for human consumption as per need. The complexity presented by the multidimensionality of the Himalayan river system, very recently described as the intricate dynamics of WEBS (Water, Energy, Biodiversity, and Sediments) by Ghosh and Bandyopadhyay (2018), cannot be addressed through the prism of the neo-Malthusian creed that inspires the reductionist engineering thinking. It is this integrated thinking that can bring about a change from the business-as-usual ways of managing and governing Himalayan waters to a more sustainable water management regime.

Context of the module

At the same time, while the interconnectedness of land, water, and other resources has long been ignored in water governance across the world, the acknowledgement of the interconnectedness brought a change in thinking in the ways water was managed, thereby marking a paradigm shift from a fragmented approach to an integrated approach to water management and governance. According to GWP (2000), “… Integrated Water Resources Management (IWRM) propagates this integrated approach and is defined as a process which promotes the coordinated development and management of water, land and related resources in order to maximise economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems”. Therefore, the central proposition of IWRM is a clear acknowledgement of

[4]Ecohydrology is an interdisciplinary domain of knowledge studying the interactive dynamics between water and ecosystems. It recognises the crucial interdependence between the two, thereby acknowledging the critical ecosystem functions and services of water. This is missed out by the doctrine often referred to as “arithmetic hydrology” that thinks of water as a stock of resource for human consumption, and misses out on the crucial ecological aspect (Hunt and Wilcox 2003; Sohel 2015).

the interdependence of land, water, ecosystem and socio-economic development (Falkenmarket al., 2004 and 2014).

It has now been widely recognised in policy (if not in practice) that water management principles need to reflect the fundamentally interconnected nature of hydrological resources, and IWRM is the accepted alternative to the sector-by-sector, top-down management style that has dominated the past. The basis of IWRM is that the many different uses of water resources are interdependent.

The challenges of governing the Himalayan waters emerged from a reductionistengineering paradigm promoting a fragmented approach to managing waters for myopic economic benefits without consideration of long-term ecosystem damages that can impair livelihoods by diminishing the provisions of ecosystem services. This has been aggravated by lack of knowledge about the ecosystemic processes, fluvial geomorphology, and the economy-ecosystem dynamics. That is why human intervention for economic benefits at one end has often led to problems at the other end that are linked to the ecosystem. Such cases are galore in the Ganges-Brahmaputra-Meghna basin, with conflicts arising at various levels, namely, the local, state, federal and international levels, and across sectors. Thechallenge apparently is with reconciling the trade-offs at two dimensions: space (upstream-downstream water conflicts at various levels: across spatial and sectoral boundaries), and time (short-run economic benefits vs. long-run ecosystem costs). Therefore, it is extremely important that the need for integrated approach to water governance be appreciated and undertaken in the mystic and vulnerable Himalayan system

At a broader scale, it is now increasingly recognised that the river basin needs to be the unit of management and governance, rather than the river system within a national or any other geographical boundary. From that perspective, an integrated approach will help in understanding the impacts of intervention at any point in the basin on the other parts of the basin, as also on the entire basin. In other words, an integrated approach at a river basin scale helps in understanding the trade-offs, and brings to the fore a holistic understanding of the costs and benefits of interventions. The understanding of IWRM principles for the Himalayan waters is therefore extremely important for basin level governance. This is what this module intends to do.

Learning objectives and outcomes of this module

With the background already provided, it becomes clear that a paradigm shift is needed in governance and policy thinking for the south Asian and more so for the Himalayan river basins. The policy documents, even the latest ones, despite allusions have failed to incorporate the holistic and integrated thinking (Ghosh and Bandyopadhyay, 2016). The learning objectives set against this backdrop are: -

- To sensitise participants on the importance of an integrated approach to water management, marking a paradigm shift from a fragmented sectoral approach;
- To sensitise participants on the importance of integrated approach to water governance at a basin scale.
- In the process, it is expected that there will be appreciation of IWRM and understanding its utility in the context of river basin governance among the participants. Therefore, at the end of the module, the expected learning outcomes are envisaged as:
- Participants will be able to appreciate the need for adopting IWRM as a founding principle for governance of river basins;
- Participants will be able to appreciate why a holistic and integrated approach is more equitable and sustainable than a fragmented sectoral approach,
- Participants will be able to understand how environmental security can be achieved at the basin scale through an integrated approach factoring in concerns of society, culture, and ecosystems in basin management.

In that sense, this module does not expect participants to be champions of IWRM and river basin governance. That is not possible given the limitations posed by duration of this module. But, the module definitely seeks to sensitise the participants to the needs for adopting IWRM as a guiding principle for river basin governance. This will help create the practicable framework for Integrated River Basin Governance (IRBG) over time.

At the same time, one needs to keep in mind that the broader objective of good governance is environmental security. Environmental security is the position opposite to a conflict situation. In the debate on the posed hypothesis of addressing “scarcity” as has been traditionally done to explain conflicts, it has been found that the neo-Malthusian creed of promoting environmental security is not applicable for the Ganges-Brahmaputra-Meghna basin (see Bandyopadhyay et al., 2016; Bandyopadhyay and Ghosh, 2016 for greater details). This comes out aptly, when Bandyopadhyay and Ghosh (2009) describe the primary challenge of GBM basin governance as “ample water, ample poverty”. The GBM is amply endowed with water in terms of its annual flow and precipitation, but the compounded problems of dry season flows, upstream floods due to sedimentation resulting from large constructions, hydropower, floods, etc. have been issues of conflicts between federal states, as also between nations. Therefore, there needs to be a departure from the neo-Malthusian thesis while defining environmental security in the context of the GBM. It needs to be devoid of the “scarcity” dimension, but needs to take into account the dimension of “conflicts”. Therefore, following Ghosh and Khan (2012:5), “... environmental security is defined as a state of absence of conflicts in the complex and interconnected relations in and between the biological, social, economic and cultural processes of human societies and the natural environment. In the process, one may state that environmental security depends on the dynamics in the natural environment, population change, degree of access to the environmental resources, etc. Interaction between and among the determinants of environmental security sets the stage for addressing the environmental security challenges”.In this context, it is important to understand that environmental security is a broader umbrella notion and the aim of IWRM is not merely water security here. When we use the term “water security”, it has a much narrower connotation than environmental security. The idea here is that overall environmental security in a basin is a critical function of not merely water availability and access that go on to define water security, but of creation of enabling conditions of governance resulting in “a state of absence of conflicts”.There is no harm reiterating that conflicts may result from a host of other sources as described earlier, rather than merely lack of physical availability of water. Therefore, IWRM as a guiding principle for basin governance has been proposed in this module as a vehicle for promoting environmental security.

Topics covered in the module

The module1 was initially designed andwas tested in the pilot testing workshops in New Delhi, India and then in Dhaka, Bangladesh during October and November 2017. Experts from the respective nations were invited to deliver their lectures for various topics initially selected. The module was then modified based on feedback from participants and presented in the Regional Workshop in Bangkok, Thailand in December 2017, and then fine-tuned further based on comments received there. In the process, the module turned out to be a combination of instructors’ lectures, panel discussions and debates, and films. Aside from an introduction to relate the participants to the stresses created by complexities of water allocation problems, making water governance a complex problem across the world (with south Asia not being an exception), the topics covered in the module are now classified as given below.

Topic 1: Introduction to IWRM
Topic 2: Why IWRM?: Imperatives for IWRM
Topic 3: IWRM and Himalayan Rivers
Topic 4: Challenges of River Basin Management
Topic 5: Ecological Economics, IWRM, and Governing River Basins
Topic 6: Panel Discussion: The Dynamics of the Farakka Barrage: Is Engineering against an Integrated Approach?

Topic 7: IWRM for River Basin Governance: A proposed structure for Brahmaputra sub-Basin

Topic 8: Movie on "ICPDR: Sustainable Water Management in the Danube River Basin"

Topic 9: IWRM: Guiding principle or Empty rhetoric?: Panel discussion

The module is expected to last for around 4 hours in continuum. Breaks, as required, can be taken in between, based on need and discretion of the anchor. The topic-wise durations are being discussed in the following sections, as we summarily describe each of the topics in the following few sections.

Module 1: IWRM and Governance of River Basins

Introducing the module

The module is being introduced through the existing problems of governing waters. Agricultural expansions were essentially results of intervention in hydrological flows through constructions of large dams and storage and diversion mechanisms (Ghosh, 2009). No doubt, making more water available for irrigation allowed water-intensive crops to be grown and enabled land-use change but the latter has threatened the ecological foundation of the world food system. Agricultural expansion during the last century has caused widespread changes in land cover, watercourses, and aquifers, thereby degrading ecosystems, and restricting their ability to support some services including food provisioning. Interventions have also been caused for hydro-power, flood control, and in the form of diversion for navigation, and to a less extent for urban-industrial water use. All these interventions happened without understanding the long-term ecosystem implications, which further have negative impacts on fisheries, aquatic ecosystems, and also the downstream economy and human livelihoods.

Quite unfortunately, the management policy of many agro-ecosystems has essentially been based on the premise that they are delinked from the broader landscape. There has been scant recognition of the ecological components and the processes that support the sustainability of such agro-ecosystems. As a result, the carrying capacity of the ecosystem has been defied by traditional agricultural and water management regimes. Some ecosystems, therefore, were made to cross the ecological thresholds, leading to a regime change in the ecosystem and their concomitant services (Falkenmark et al., 2007). The resultant reduction in the ecosystem's resilience also restricts the sustainability of the ecosystem services. Unfortunately, beyond a point, even the water supply augmentation plans (through dam constructions), and land-use change (entailing bringing more land under agriculture by cutting down forests or filling wetlands), do not work and can have a negative impact on food security, with the impacts intensified by climate change. All these result in greater conflicts at all levels. Such a situation prevails because of myopic and fragmented approach to water resource management and governance.

The introductory topic entails an audio-visual session to introduce the audience to the topic and the imperatives to IWRM. The audio-visual shows the competing uses of scarce waters (often leading to conflicts) and why a sectoral and fragmented approach to water management needs to be replaced by integrated management approach.

Why IWRM? Imperatives for IWRM[5]

As we talk of the imperatives of IWRM, the objective is to relate to the paradigm shift from the traditional thinking of water as a resource to be harnessed and used for human consumption to a more holistic thinking of water management at its interface of ecosystem and society. The topic 2 has therefore been titled as "Why IWRM?" The paradigm movement has been defined as movement from a reductionist "hydrologic" paradigm to a "hydro-eco-social" paradigm. This implies that while the traditional thinking looks at water management from the perspective of hydrology only, the IWRM paradigm acknowledges that water is multi-dimensional and apart from its hydrological

[5] Portions of this section have been taken from Ghosh (2015).

dimension, its ecological and socio-economic dimensions are integral components of its flow regime. Further, the global water crisis needs to be redefined as the global water governance crisis. The objectives are very clear under this new thinking: securing water for humans, securing water for ecosystems, and securing water for food. At the same time, the gender dimension in governance of critical resources is becoming Acute.

Therefore, this topic talks of IWRM as a critical link to bridge the governance and the management gaps, albeit at a conceptual level. Eventually, the resource person will also talk of the tenets of IWRM under the following heads: Human Needs, Ecological Needs, Cooperative Understanding and Management, Multi-stakeholder Engagement, and Legal and Institutional Safeguards.

This movement to the new paradigm of IWRM from a traditional paradigm of supply-augmentation paradigm of water governance is not free from conflicts. The change has been accentuated by scientific analyses of past mistakes and availability of new information (Ghosh, 2015). With the dawning of the ecological concerns,the new paradigm recognises human socio-economic system as a component of the broader social-ecological system in which water is a key element (Falkenmark, 1997;Gleick, 2000;Falkenmark, 2003). Based on the various contending thoughts and ideas, the notion of IWRM has been conceptualised in the form of the following points and has been presented by Bandyopadhyay (2004) and later by Ghosh (2015):

a) Water is an inextricablecomponent of the global hydrological cycle, and not a stock of material resource to be stored and used as per human convenience: With the continued emphasis on the economic benefits of water, its ecological functions in sustaining ecosystem health, and thence human health, have been largely ignored. The “stock” concept of water emerges from treating water as purely a resource to be used for human consumption. The new paradigm treats water as a flow in the context of the global hydrological cycle, and acknowledges its critical role in sustaining ecosystem functions and providing ecosystem services to humans.The diversion and use of water for economic purposes, though yields short-run benefits, has long-run implications for the ecosystem and therefore on the human community reliant on the ecosystem services (Flessa, 2004). This aspect is recognised when one takes an integrated view of water management.

b) Ever increasing supply of water is not a prerequisitefor economic growth. Neoclassical and Keynesian economic theories that have prevailed upon development thinking have created the perception that economic growth is positively associated with resource availability. With water being one of the critical resources,its availability has traditionally been seen as an essential pre-condition for continuing economic growth (Bandyopadhyay, 2004). The new paradigm, however, delinks economic growth from water supply augmentation plans, and stresses upon shifting the focus to demand side management of water as one of the cornerstones of new ways of water governance (Gleick, 2000;Falkenmark et al., 2004).

c) Acknowledgement and clear prioritisationof competing demands for water, including those by ecosystems, is needed. By acknowledging the multidimensionality and competing demands for water, the interdisciplinary paradigm of IWRMtalks of clear prioritisation between the two classes of competing needs.The first is between the needs of the ecosystem and the needs of human society,and the other is among the needs of human societies themselves (Bandyopadhyay, 2004). An important component of current water resource management is setting the right priorities by understanding the involved trade-offs.

d) An integrated and comprehensive approach to assess interventions on hydrological flowsby considering the integrity of the hydrological cycle is of utmost need.The core of the new paradigm essentially entails creation of an interdisciplinary knowledge base through a multi-disciplinary team to provide comprehensive assessments of the rationales and footprints of supply-augmentation projects (Bandyopadhyay, 2004;Barbier and Thompson, 1998).

e) Creation of an interdisciplinary knowledge base and a trans-disciplinary framework is of utmost need to understand and appreciate the multidimensionality of hydrological regimes in the context of the social, ecological and economic roles played by them. The complexities of managing water-related problems include a real understanding of the nature of water resources and their complex links and interrelations with other systems. This means that single-disciplinary approaches will no longer work and new, innovative strategies will have to be developed for coping with water problems, involving multidisciplinary approaches (Falkenmark et al., 2004; Bandyopadhyay, 2004).

f) The so-called “disasters” in the traditional development thinking that unfold as floodsand “low flows”(droughts) should be contextualised in the broader framework of the hydro-meteorological processes associated with them, and should be viewed as integral components of the ecohydrological cycle.

g) There is a need to develop newer and more holistic social and economic instruments for assessment of projects and efficient, equitable, and sustainableutilisation of water resources as also for the reduction of damage to their quality from pollution. The new economics of water will definitely have to move in a direction that will be a clear departure from the reductionist neoclassical economic thinking. Ecological economics combining the social, ecological and broader ethical concerns need to be incorporated in the newly emerging instruments. This has also been discussed later in this module.

h) Old institutional frameworks need to be replaced with newer forms of institutions at multiple levels to promote a democratic structure of governance that will be equitable, sustainable and participatory.

Definitely, the above aremerely evolving, and in no way exhaustive. Refinements, augmentations, and additions to this list are happening as the challenges of water governance are getting more and more complex. Yet, there is no denying that the emerging paradigm of IWRM explicitly acknowledges that irrigation development has often come with a high environmental price tag (Molden and Fraiture, 2004). The costs range from degradation of aquatic ecosystems, fragmentation and desiccation of rivers, and drying up of wetlands. These costs have often been much higher than the benefits generated by irrigation systems (Barbier and Thompson, 1998;Acreman,2000). This aspect will not be realised unless an integrated approach is taken in impact assessment. Falkenmark (2003),emphasising on the concern of integration, calls forIWRM as the principle to integrate land, water and ecosystems to promote the three E's – two human dependent ones (social equity and economic efficiency), and one related to the ecosystem (environmental sustainability).

IWRM and Himalayan Rivers

The uniqueness of the Himalayan waters emerges from their significance as “water towers” of large parts of Asia. In terms of the number of people who depend on such "water towers" for their survival and well-being, the Himalayas are the most important. The Himalayan region, encompassing the Hindu Kush mountains and the Tibetan Plateau, spans an area of more than 4.3 million square kilometers andbordersmore than 10 countries, and impacts more than 1.5 billion of the population in and around the region including Afghanistan, Bangladesh, Bhutan, China, India, Kazakhstan, Kyrgyzstan, Myanmar, Nepal, Pakistan, Tajikistan and Uzbekistan (Yao, 2012). The region stores more snow and ice than anywhere else in the world outside the two poles, and thus ispopularly known as "the third pole”. The Indian summer monsoon and the East Asian monsoon interact in this environment to provide a large portion of the water supply of Asia. Ten major rivers emerge from the Himalayan region, making it a crucial ecological buffer. The scale of the ecosystem services that the Himalayas provide is almost without parallel in human history. The Himalayan river basins are home to about 1.5 billion people and supply water, food, and energy to more than 3 billion people. Human intervention in the flow of these rivers must be based on adequate knowledge of three vital constituents of the Himalayan rivers—water flow, sediment load, and energy potential.

However, the management of the Himalayan waters is still based on a reductionist engineering paradigm, which has worsened the effects of floods and droughts. In fact, it has also worsened the severe erosion of the rivers banks, and punctured the soil formation capacityby reducingthe sediment flux in the upper reaches of the rivers due to interventions in the forms of dams and water diversion structures. The topic on “IWRM and Himalayan Waters” talks of the various knowledge gaps and the need for a new interdisciplinary knowledge base that needs to be developed for implementing IWRM for the Himalayan waters.

One needs to understand here that in most cases the knowledge exists in a fragmented manner and in a piece-meal approach. They hardly appear holistically at the basin-scale to understand the impacts in their continuum. These gaps in knowledge, best expressed under the following heads, has been summarised from Ghosh (2015).

a) Gaps in ecohydrological knowledge on surface water systems: The critical gap in the ecohydrological knowledge on surface water flows of the Himalayan system poses a challenge. The livelihoods of millions are dependent on the myriad of ecosystem services offered by the basin from its origin at the upland watersheds to its sink in the delta and estuaries. These were hardly taken into consideration in the initial phases of constructionist interventions on the hydrological flows. As the long-term environmental impact of altered flow regimes are expressing themselves, serious degradations of the downstream ecosystem services are becoming apparent. In the country of origin of large dams, the United States of America (USA), approach to large dams has now changed fundamentally considering their basin-scale impacts. However, the new concepts are not being easily internalised in the formal water governance in south Asia (Bandyopadhyay, 2007). Further, there are crucial knowledge gaps in relation to the fluvial processes, as also on issues related to environmental flows (e-flows).

b) Gaps in ecohydrological knowledge on groundwater systems: Severe knowledge gap exists with hydro-geological component of the Himalayan system that is rich in groundwater, both static and dynamic. Arsenic toxicity in groundwater has affected major parts of the Basin, especially Bangladesh and southern West Bengal (Chakraborti and Saha, 1987; Acharya and Shah, 2010). Whilethere has been good documentation on the various problems caused by arsenic pollution as far as human health are concerned (Das et al., 2008; Samanta et al., 2007), documentation on the impacts of arsenic pollution on ecosystem health with its consequent effect on human livelihoods, is indeed scarce. Again, literature on institutional issues, especially with respect to property rights status of groundwater is not substantial, due to local level of the existing conflicts. This gap needs to be bridged through research that would transcend disciplinary foundations of engineering geology and soils sciences and extend to sociology of local water institutions and environmental law (Bandyopadhyay, 2007).

c) Gaps in knowledge of flood management: The traditional engineering thinking brought about by the British engineers prevails in Indian water technocracy till today. This leads to the perception thathigh-flow inundations during monsoons (that are regular features) are still being described as “flood disasters”, without recognition of the ecosystem services offered by them.“Flood damages”, till now, has a relief-dominated response, rather than a pro-active approach to long-term solution.The damages have aggravated with extensive changes in land-use and land-cover due to human settlements in the floodplains. A fragmented approach of flood management in the basin, and clear non-recognition of the ecosystem processes and services associated with floods is a crucial concern of environmental security, and much in contravention with the principles of IWRM.

d) Gaps in knowledge of social dimensions of water systems use, local governance and water conflicts: The “metabolic rift” between man and nature was accentuated during the British era with the dominance of engineering solutions for problems of water management. The age-old traditions of water use and management of the Himalayan system remained in folklores, and got lost in the montage of engineering interventions. As Bandyopadhyay (2007) notes in the context of South Asian Rivers in general, “… For nearly a millennium, water in south Asia was managed by community-based organisationswhich were as diverse, as are the water endowments and physiographic characteristics of the specific areas. In the past few decades non-governmental initiatives have established effective and revitalisedinstitutional structures for such local water management. Various activities related to water are also divided between the two genders”.

e) Knowledge gap on diverse demands and requirements of water: The need for understanding and prioritisationof diverse water demands is an important hallmark of IWRM. Sound knowledge of the diverse demands including that of the ecosystems is of utmost importance for more informed decision-making on interventions, and ex-ante and ex-post assessments. This becomes even more pronounced when the national governments in basin are committed towards the fulfilment of the Sustainable Development Goals (SDGs).

f) Gaps in knowledge in emerging technological and practice-oriented options in water systems management: Across the world, technological and practice-oriented innovations have been taking place for promoting water-use-efficiency in irrigation, while new technological options globally have been sought to resolve urban water problems. The core of the problem with the transboundary waters of the Himalayas is related to agriculture, with 85% of the water being consumed in this sector. On the drinking water front, Uche et al.,2006 have given a detailed account of the potential of the desalination technologies. Again, there is still a gap in the knowledge on re-use of water and innovation of related technologies. System of Rice Intensification (SRI), as a practice-oriented innovation, has been proposed as an intervention reducing water use for rice production. However, the efficacy of such innovations is yet to be inferred with conviction without more field level experiments in the Himalayan floodplains.

g) Knowledge gaps on the Himalayan components: Void in knowledge on Himalayan ecosystem has inhibited objective and professional assessments of large projects, thereby casting questions on their viability. Gaur (1993), Bandyopadhyay and Gyawali (1994) and Bandyopadhyay (2002) have identified these gaps under the following heads: i> the mechanism of the generation and draining out of flood waters in the Himalayan foothills and floodplains; ii> the dynamics of the generation, transportation and deposition of sediments all along the course of the Himalayan rivers; iii> the nature of seismic risks associated with high dams in the Himalaya; iv> the impacts of structural interventions in the Himalayan rivers, like dams, barrages, and embankments; and v> the impact of the four points above on the economic feasibility of water development projects. Again, the data gaps on the Himalayan components have been noted officially by the NCIWRDP (1999a, b).

h) Gaps in knowledge in the relation between water and food security: Food security in large parts of south Asia has so far been perceived of as a positive function of water availability. Recent literature, however, refutes such a relation (e.g. Förare, 2008; Molden and Fraiture,2004; Ghosh and Bandyopadhyay, 2009). The ecosystemic approach and definitionof food security is neither understood nor acknowledged and there hardly exists any knowledge created in South Asia in this domain. The importance of floods and the ecosystem services of sediments in making the Gangetic floodplains the "rice bowl" of the region is hardly being recognised in an era dominated by constructionist engineering thinking.

i) Lack of detailed hydrological data in public domain: Sensitive flow data have not been made available in the public domain by the national governments. Non-availability of data at public forum on transboundary hydrological flows, and some other associated important variables in the basin has totally restricted independent and non-partisan assessments of hydrological projects and livelihoods issues on the basin. It is important to have transparency in information dissemination among the various nations, with data being made available to the scientific community for independent scientific assessments. Such lack of data has created a void in knowledge on some of the important transboundary issues like floods (Bandyopadhyay et al., 2016), droughts (Brammer, 1987; Shahid and Behrawan, 2008), ecosystem services (Danda et al., 2011), as also for implications for conflicts (Ghosh, 2015), -- all of which are crucial issues for environmental security.

j) The threat point of Climate Change: One needs to keep in mind that the most crucial threat to environmental security in the ecosystem can be posed by climate change. This is because Ganges and Brahmaputra are essentially mountain rivers, and though largely snow-fed, the summer monsoons (June to September) provide a significant portion of the region's annual precipitation within a period of only four months. Any deviation of the seasonality of the monsoon can create severe problems of water availability in the region. The Intergovernmental Panel on Climate Change (IPCC) third assessment report (IPCC-TAR) has indicated the possibility of greater frequency and intensity of the extreme events related to water (IPCC 2001). The impact of global climate change on precipitation, stream flow and water availability have been major areas of global research (see for example, Erda et al., 1996; Milli et al., 2005, ICIMOD, 2015).

The possibility of increasing intensity of such events has also been documented, and the additional impact of nature's variability is expected in lower Ganges sub-basin comprising the Indian Sundarbans Delta (Hazra, 2002). On the other hand, preliminary observations indicate that in addition to the reduction in the snow and ice cover in the Himalaya, water scarcity and extreme events in the region may be accentuated, thereby posing a threat on the environmental security further downstream in the context of the transboundary water relations between India and Bangladesh (Hosterman et al., 2009; Bandyopadhyay, 2007). Initial forecasts also suggest that changes in climate will further exacerbate the existing variability (Cruz et al., 2007). In the Ganges basin, climate change is expected to increase temperatures, resulting in the retreat of glaciers; increase variability in precipitation, resulting in increased magnitude and frequency of droughts and floods; and lead to sea-level rise (Hosterman et al., 2009).

A very recent study by Mohammed et al. (2017) finds that the frequency and magnitude of floods in the Brahmaputra are likely to intensify in the future. On the other hand, both the frequency and intensity of hydrological droughts are projected to diminish. Further,the average timing of both the events is projected to shift to an earlier period as compared to the present hydrological regime (Mohammed etal., 2017).

With this accepted premise of climate change in the GBM basin, the uncertainty still remains with the precision of various climate change predictions. On the other hand, there still remains a blurred idea of the possible impacts of climate change on food production and other ecosystem services. However, no research so far has been able to draw up the critical impacts that climate change might have on the critical ecosystems-livelihood linkages. There is a chance that with the alterations in ecosystems services caused by changes in climate, livelihood processes might get negatively affected, and as a result newer modes of adaptation have to follow.

Given these, Bandyopadhyay and Ghosh (2009), Ghosh and Bandyopadhyay (2016), and Bandyopadhyay et al. (2016) propose a combination of three perspectives for generating a new interdisciplinary knowledge base. These entail the following: i>Ecological perspective of understanding the ecosystem service–livelihood linkage; ii> Institutional Perspective for development of river basin organisations and water markets; iii> the perspective of ecological economic valuation for holistic understanding of the trade-offs through estimation of costs and benefits.

Challenges of River Basin Management

River basin management challenges are getting more and more complex over time. This has been discussed earlier. This topic is incorporated to relate to the challenges of river basin governance, and eventually creates the case for adopting IWRM as a guiding principle to combat these complex challenges. This topic is therefore supposed to talk of the various tenets of Integrated River Basin Management or IRBM, and then move on to the problems of fragmented approach to river basin governance in India. The dominant "arithmetic hydrology" paradigm that characterisesrivers as "surplus" and "deficit" basins, the debate over the definition of environmental flows, and the missing ecological economics have been some of the critical gaps in this discourse. While this topic alludes to the two cases of the Farakka barrage case, and the Cauvery water dispute, both being examples of fragmented approaches to river management, the idea is that in subsequent sessions, these cases are going to be debated and discussed in further details.

While IWRM has become the key mantraof water management globally, it is thought that the river basin should be considered the spatial unit of riverine management. This led to the development of the notion of Integrated River Basin Governance (IRBG), leading to a paradigm shift from the earlier reductionist notion of project based approach to river basin management. The primary tenet of IRBG is that naturally functioning river basin ecosystems, including any wetlands and groundwater are an integral part of the water system. Hence, while the entire river basin is treated as an ecosystem, management of the river basin has to include maintenance of ecosystem functions and services so as not to cause destructive impacts on the ecosystem services (Boelee, 2011;Mattas et al., 2014). This 'ecosystem approach' is the key idea as far as the Convention on Biological Diversity (CBD 1992) is concerned.

Interestingly, over time, many policy documents began acknowledging ecosystem concerns without really understanding how to interpret them. The National Water Policy of India also acknowledges this notion, but shows little application of it. For example, in the 2007 Award by the Cauvery Water Tribunal, certain quantities of water are stated as being "unavoidable escapages to the sea" (sic.). In many cases, there is a clear misinterpretation of the notion of environmental flows without much understanding of the ecohydrological processes associated with it. Environmental flows describe the quantity, timing, and quality of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems; through the implementation of environmental flows, water managers strive to achieve a flow regime, or pattern, that provides for human uses and maintains the essential processes required to support river ecosystems at an agreed sub-pristine level. However, most policy documents in South Asia place an ad hoc quantity or percentage as "flows" that have very little eco-systemic and scientific basis. This becomes clear in the National Water Policy 2012, Govt. of India, which states, "…A portion of river flows should be kept aside to meet ecological needs ensuring that the low and high flow releases are proportional to the natural flow regime, including base flow contribution in the low flow season through regulated ground water use" (MoWR 2012: 4). However, recent policy documents especially the National Framework Water Bill 2016 and the Report entitled A 21st Century Institutional Architecture for India's Water Reforms makes substantial effort to create an integration of various fragmented issues.

A systems approach to river basin management can be considered as an improved alternative, -- often referred to as "Pareto Improvement6" in economics. River basins are sensitive over space and time; any single intervention has implications for the system as a whole. Activity taking place in a part of the basin (e.g. disposal of waste water, deforestation) will have impacts downstream. A vivid example of this was the cyanide spill in the River Tisza (a tributary of the Danube) from a mine in Romania in January 2000. The highly toxic chemical swept downstream through Hungary, devastating aquatic life along the course of the river and contaminating the drinking water of hundreds of thousands of people (WWF, 2002). The other example is the construction of the Farakka barrage in 1975 on the lower Ganges in India. The idea of constructing this barrage was to divert water to resuscitate Kolkata port. However, over

[6] Pareto improvement is a situation when at least one individual is better off without compromising the well-being of any of the others.

time excessive sedimentation in the barrage led to stream-flow depletion further downstream along the natural course of the Ganges, especially in the estuarine zones (Rudra, 2004; Bandyopadhyay, 2012;Danda et al., 2011). There have been ecosystem losses in the form of mangrove depletion and other species loss, as also to livelihoods (Bandyopadhyay and Ghosh, 2009; Bandyopadhyay, 2012).

While today's best practices in water resources planning entail integration of water quantity and quality management for both groundwater and surface water, there remains a need for a comprehensive understanding of how the natural environment and the resident population of a basin are impacted by various levels of interventions in the rivers or by adoption of new policies, land use as well as land and vegetation management. This is best done in a highly participative way, involving all the major stakeholder groups, and in a way that achieves a balance between the level of economic development and the consequent impact on the natural resource base of a river basin as agreed to by the stakeholders. This participatory and comprehensive approach is what is generally referred to as good integrated river basin governance (IRBG) (Bandyopadhyay et al., 2016).The various tenets of IRBG has been summarised as the following:

- Incorporation of community and stakeholder participation into the planning and management processes.
- Drafting a long-term river basin vision, through the process of a consensual agreement among all stakeholders: There should also be an integrated natural resource policy agenda and clear financing and budgeting systems for the range of basin-wide activities.
- An integrated approach toward policy making, decision-making, and cost-sharing across various sectors including industry, agriculture, urban development, navigation, ecosystems, taking into consideration the poverty reduction strategies.
- Decision-making at a macro river-basin-scale should also take into consideration concerns at the sub-basin or local levels.

- **Adequate investment by governments, the private sector, and civil society organisations in capacity for river basin planning and participation processes.** There needs to be adequate investment and cost-sharing by all relevant stakeholders in the system, thereby making them more responsible for the success of such a system.
- **A comprehensive foundation of knowledge of the river basin and the natural and socio-economic forces that influence it:** One needs to note here that one pre-requisite is good knowledge of the condition and behaviour of the social-ecological system of the basin.
- **Establishment of a monitoring system:** There needs to be a detailed, ongoing monitoring and auditing process to openly assess if the basin-wide institutional arrangements are achieving the goals and objectives set by governments.

Figure 1 reveals the Integrated River Basin Management framework with its economic, social, and environmental pillars. This depends on promoting economic efficiency, distributional equity, and environmental sustainability. Figure 1 further suggests that at the centre of promoting IRBG is creation of the right institutional framework, which in later parts of the volume will emerge as the River Basin Organisation (RBO) for the Brahmaputra sub-basin. It is the institution that will essentially bring about the enabling environment and the management processes for promotion of IRBG.

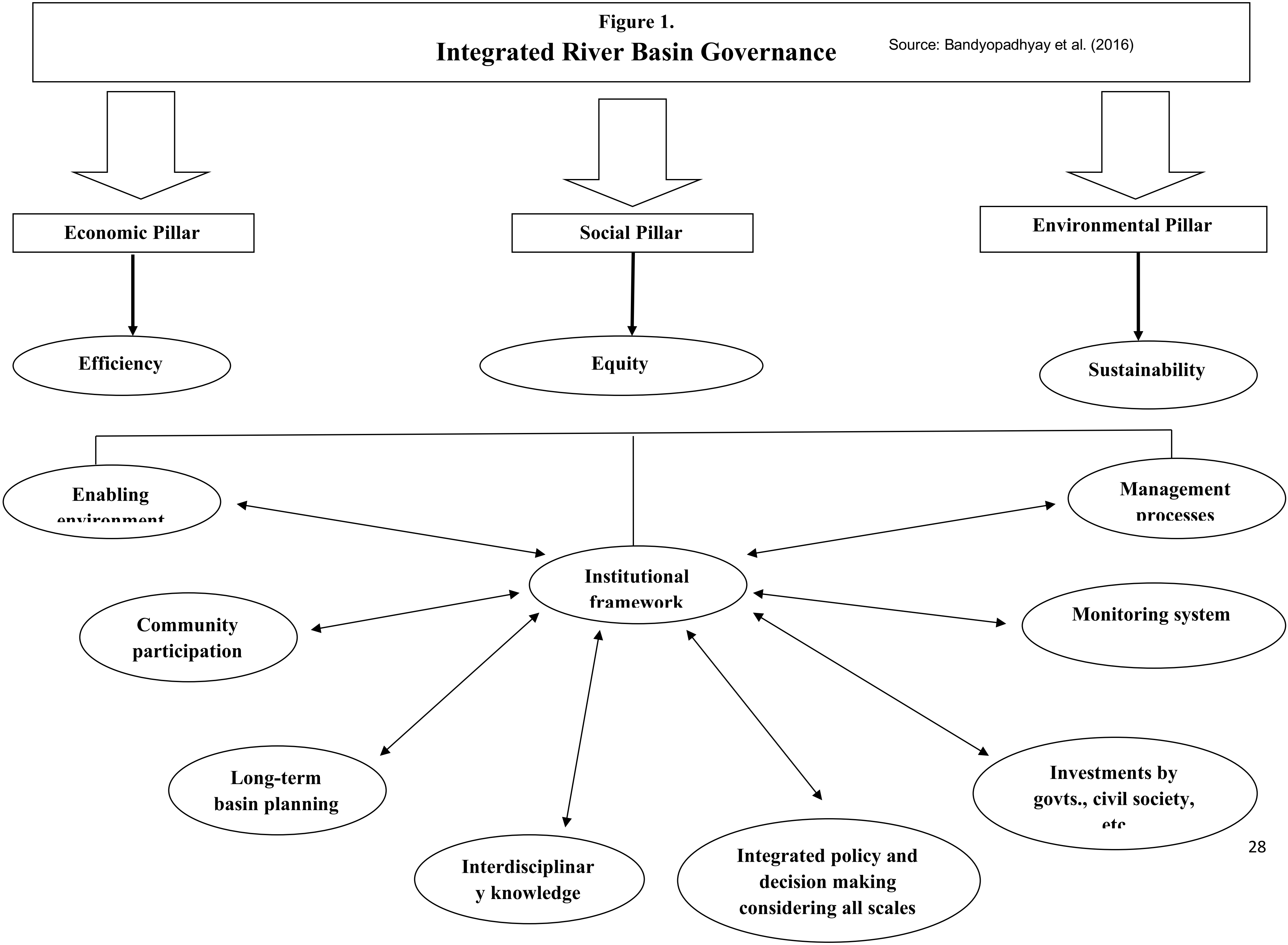
Figure 1.
Integrated River Basin Governance
Source: Bandyopadhyay et al. (2016)
Economic Pillar
Social Pillar
Environmental Pillar
Efficiency
Equity
Sustainability
Enabling environment
Management processes
Institutional framework
Community participation
Monitoring system
Long-term basin planning
Investments by govts., civil society, etc.
Interdisciplinary knowledge
Integrated policy and decision making considering all scales

Ecological Economics, IWRM, and Governing River Basins

This module envisages Ecological Economics as one of the mainstays of IWRM for river basin governance. The topic on "Ecological Economics, IWRM and Governing River Basins" introduces the participants to this crucial aspect. Unfortunately, this very critical cornerstone has so far been ignored in the global discourse of river basin management. The important entry-point to ecological economics is created by the very thinking that supply-augmentation plans proposed by construction engineers can proceed ad infinitum. The assumption that technology can overcome any hurdle and that there is no limit to growth still looms large in policy making in many parts of the developing world. But the very limits to growth and constraints on achieving sustainable development goals are posed by depletion of "natural capital", and the ecosystem services provided by them. This remains to be acknowledged in the policy practice of water governance so far. Ecological economics can help bridge this critical knowledge gap. The 2016 report from the Ministry of Water Resources, River Development, and Ganga Rejuvenation, Government of India, titled A 21st Century Institutional Architecture for India's Water Reforms authored by the committee headed by Dr. Mihir Shah adequately acknowledges the importance of a multi-disciplinary framework with ecological economics being an important cornerstone.

In the last two decades or so, there has been useful expansion of research and publications on the ecosystem services of water and their economic implications. To a large extent, the recognition by the Millennium Ecosystem Assessment (MA) (2005) was very important for this growth. The MA classified ecosystem services into four categories, namely, provisioning services (such as the provisioning of food and water), regulating services (such as the control of climate and disease), cultural services (such as spiritual and recreational benefits) and supporting services for biodiversity. Monetary values of ecosystem services, though very approximate and indicative, are useful for policy making and advocacy. This is where the criticality of ecological economics of water comes in. Valuation of water from the perspective of its ecosystem services is an emerging field of research that is gaining popularity over time. Ghosh and

Bandyopadhyay (2009) have carried out a detailed survey on valuation of ecosystem services of water.

The ecological economics of water is important from the perspective that the very discipline of ecological economics looks at the human society as an integral component of the broader social-ecological system. For its own sustenance, the system generates forces in the forms of actions which intervene into the ecosystem structure and functions, and in the process, this action impacts the ecosystem services. Generally, ecosystem services are associated with the ecosystem structure and functions. With human actions, which are generally economic in nature (in the form of logging, fishing, agriculture, water diversion, etc.), the integrity of the ecosystem structure and functions might be compromised, and this may affect the ecosystem services, thereby creating a dent on human well-being. This scheme of things is ignored by the neoclassical environmental economic thought process, which, in its reductionist mode of thinking, looked at water as a stock of resource to be used for human extraction for meeting short-term economic goals. Further, environmental economics as an offshoot of the neoclassical economic framework looked at human actions as resulting in externalities like pollution or depletion, and talked of internalisation of the externalities through some short-term mode of monetary valuation of the loss. This reductionist thinking hardly takes into consideration the broader social-ecological impacts in the long-run that will affect human society. As it is, microeconomic theory bases its theorisationon pre-conceived assumptions about human behaviour.

In the context of water resources, neoclassical economic theory has dealt with the resource in two ways. One is the body of literature put across by natural resource economics that deals with water as a stock of resource that might be depleting (if the rate of extraction is higher than the rate of regeneration) and yields economic value through agricultural production, drinking and sanitation purposes, energy, etc. The approach has primarily been to look at this resource as a stock appearing in the argument of a production function. Environmental economics approaches are no different either, and as stated earlier, is concerned with externalities, and pre-conceived assumptions of optimality. None of these theories really looked at water as an integral component of the broader ecohydrological cycle.

This is where ecological economics comes into the fore. On the one hand, there is an extensive emerging literature on valuation of ecosystem services, though the concerns are less specific to water bodies. The importance of valuation of ecosystem services has adequately been recognised by MA (2005) and TEEB (2010). When it comes to water resources, water has an extensive contribution to the human society in many ways. First, it provides various provisioning services in the form of agricultural crops, seafood, aquatic species and plants, other food, fisheries, etc. Second, it provides supporting service to terrestrial ecosystems including forests that again play important regulating functions. Third, it plays important roles in cultural services.

While at the interface of the human society and the ecosystem, a few of the services are visible and documented, ecological sciences have merely hit the tip of the iceberg in unearthing the range of services provided by the ecosystems. This is more so because the ecosystem structure and the consequent functions are not well understood till date.

However, the significance of valuation of ecosystem services arises on various counts. Firstly, value attached to the ecosystem services is a testimony of the importance of the underlying resource to human society. When expressed in monetary terms, it upholds the significance of the services that ecosystem renders to the human society. Secondly, valuation of ecosystem services can raise awareness of the market and the policy-makers on the importance of the ecosystem services under consideration. Thirdly, valuation can help legal proceedings determine damages where a party is held liable for causing harm to another party, e.g., when pollution from upstream areas affects the downstream ecosystems negatively thereby affecting the downstream ecosystem services. Therefore, to deal with compensation policies properly, the economic value of the harm so caused needs to be assessed to obtain the extent of the negative externalities. Fourthly, valuation of ecosystem services can help revise investment decisions. The most probable of these decisions might be related to large infrastructure like dam constructions that might otherwise ignore the related harm expected to be caused to the natural environment and consequent loss to the ecosystem services.

Fifthly, valuation helps designing of efficient management mechanism. Sixthly, since livelihoods in poor areas of the developing world are inextricably linked to these ecosystem services, the values generated by the ecosystem services and goods are often referred to as “GDP of the poor”.

On the other hand, there is a large body of literature acknowledged in the domain of ecological economics that deals with institutions (Ostrom, 2009). This aspect essentially tries to understand the working of institutions that can help in management of water keeping in view its integration with the broader socio-ecohydrological cycle. As it is, the role of institutional rules and structures in framing of action situations within which individuals or groups make choices on the basis of the incentives and disincentives, and jointly affect each other as also the outcome of the interactive process, as also the development of a general framework for analyzing sustainability of Social-Ecological Systems (SESs), have essentially affected the study of ecological economics, rather than a more reductionist domain of environmental economics. This is where ElinorOstrom envisaged a different perspective of institutions, which is beyond the self-optimisingbehaviours. Ecological economics further accepts the complementarity of the two approaches (valuation and institutions): this is also because while values affect development of institutions, it is institutions that determine values.

In the context of water management, therefore, ecological economics is important from both perspectives. The canonical definition of traditional economics is “canonical of scarce resources among competing ends”. Ecological economic theories, however, are not really based on scarcity, as it recognises the ecohydrological cycle. The issues of property rights and governance structures are critical issues that deserve to be taken up as important cornerstones of discussions in this context.

There is another critical aspect of research emerging here. This is the economics of environmental flows. In a recent work, Ghosh et al. (2017) creates a framework to reveal the trade-offs between achieving E-Flows. The values associated with flow regimes provide an objective instrument to prioritise between which demand management option needs to be followed for the best possible results. As an example, they argue that through a combination of agricultural water demand management approaches, it is possible to restore environmental flows in the Ganga. They further estimate that the highly conservative estimates of the annual value of ecosystem services offered by the river at the current rates and current state of health are INR 873.89 billion. If one considers the entire investment for the Namami Ganga project which is to the tune of INR 200 billion for five years, there is every reason to put across such an amount when even maintenance of a small stretch of the river yields four times the amount annually.

As such, the literature on valuation of flow regimes is extremely limited, and so far, we have not been able to find any paper or study in peer-reviewed forums on valuation of environmental flows, except one by Karanja et al. (2008). The ecological economic cost-benefit analysis is an important contribution for creating a replicable framework for evaluation of changing institutions, technology, and practices through placing monetary values to various scenarios. Here lies the importance of ecological economics in river basin governance.

The Dynamics of the Farakka Barrage: Is Engineering against an Integrated Approach?

The Farakka barrage stands as a classic case of how fragmented approach to water management has led to problems of governance at various levels. This topic has been incorporated in the module as a moderated debate to sensitise participants to the different varieties and opposing views related to the construction of the Farakka barrage. While Farakka barrage has been a matter of contention between Bangladesh and India, lately the government of Bihar, a federal state in the eastern part of India, also blamed the barrage for causing floods in Bihar in the upstream of the Farakka barrage. This has subjected the barrage to a “two-level” game. Some experts from West Bengal do not agree to this thesis of Farakka barrage being responsible for upstream floods. Even the recent CWC report refutes the claim (Ghosh, 2016).

As such, national governments often get engaged in a "two-level game" when dealing with transboundary waters. They have to deal with their domestic water regimes, and almost simultaneously get into international transboundary water negotiations, keeping in view their domestic objectives. On the other hand, international agreements also affect domestic hydro-political conditions. Therefore, a move in one game will typically have implications for the outcome of the other. The lower Ganges (flowing through India and Bangladesh) exemplifies this hypothesis, with the Farakka Barrage being the point of contention.

Bihar Chief Minister Nitish Kumar’s call for removal of the Farakka Barrage has created rolls in the ongoing debate on the utility and/or disutility of the Farakka Barrage. The barrage, located in the Indian state of West Bengal, roughly 16.5 kilometres from the border with Bangladesh, was planned to enhance the flow of Bhagirathi-Hooghly branch to resuscitate the port at Kolkata (then Calcutta), located downstream. While the Farakka Barrage has been blamed for reducing the streamflow, causing salinity ingression and drying up the Sundarbans delta, the problem with the management of sediments has lately taken an ugly turn with the floods in UP and Bihar. While the Central Water Commission (CWC) asked for the opening of the barrage gates to release water, large parts of the Malda district in West Bengal on the north of the Farakka Barrage got flooded.

As such, the Government of Pakistan and, after 1971, the Government of Bangladesh had been critical of the project as it was apprehended that by enhancing the flow into Bhagirathi-Hooghly, the barrage would reduce the dry season flow of the Ganges/Padma into Bangladesh. In fact, the voices within Indian technocracy, who opposed the project from the perspective of sheer sustainability, like the ones of Mr. Kapil Bhattacharya, were singled out and marginalised. As such, even today, the construction of the Farakka Barrage has been historically the most crucial factor affecting the India-Bangladesh hydro-political relations and the perceptions of transboundary environmental issues.

The Farakka Barrage stands as a classic example of the constructionist thinking based on the reductionist engineering paradigm that looked at short-term economic benefits, ignored the long-term sustainability concerns, and created the 'metabolic rift' between human and nature. This paradigm, promoted by the British colonial legacy, was also formalised under colonial capitalism in South Asia. This reductionist knowledge of water management spread across engineering colleges in India over time. This "half-baked" reductionism keeps on dominating Indian water engineering scenario even after Independence, and has created situations of enhanced damages, livelihoods losses and eventually conflicts at both international and inter-state transboundary levels.

With the existing paradigm being devoid of the knowledge of the complex ecohydrology and the fluvial geomorphology of Himalayan rivers like the Ganges and Brahmaputra, the possible negative impacts of the construction of the Farakka Barrage were not perceived at the design stage. Most importantly, the British constructionist regime neither understood peak and lean flows, nor the sediment dynamics associated with the flows. This is the most significant knowledge gap and an important consideration in the present discourse that links upstream floods with the Farakka Barrage. Further, without consideration of the sediments, the India-Bangladesh treaty of 1996 on the sharing of the dry season flows at Farakka turned out to be merely an arithmetical exercise.

For years, Bangladesh has perceived the Farakka Barrage as a symbol of India's evil intent toward their nation, as India's failure to consider the downstream consequences of the project left space for the assertion that the prime utility of the barrage was not merely to ensure flow to the Kolkata port, but to cause harm to Bangladesh (then East Pakistan). Even if this myth may have subsided, the myth of Farakka Barrage's potential to cause flash floods in Bangladesh through the release of water stored behind the barrage remains alive. However, this myth does not hold true as the barrage is unable to store more than trivial quantities of water, far too little to have a significant effect on floods in Bangladesh. Even recently, the Indian Government made a press release to that effect to clarify this myth.

Notwithstanding the international hydro-political dimension, the flood issue in UP, Bihar, and West Bengal needs a different mirror to reflect at. Flooding in UP and Bihar is an annual phenomenon and is an integral component of the global ecohydrological cycle. It is reductionist engineering that has perceived flood as "unmixed bane". British engineering knowledge hardly understood that when floodwater recedes, the rich silt and sediments that are left behind have made the Gangetic plains the "rice bowl of South Asia." The tradition of ignoring this critical ecosystem service that can be classified as supporting function continues even today.

However, the recent call for Farakka removal is driven more by the perspective of the "man-made floods" due to the construction of the Farakka. This contention seems to have been based on the backwater effect hypothesis, caused by the sedimentation in the Farakka, and consequent cascading of the sediments in the upstream of the barrage. With the sediments acting as obstructions, the water deposits the carried sediments, and take a diversion towards Malda district in West Bengal, where in the narrow channel, it causes bank erosion and flooding.

It is a fact that without obstructions caused by Farakka Barrage and consequently by the accumulating sediments in the upstream of the barrage, the river would have carried the sediment and flushed them out to the Bay of Bengal. But, the present obstructions might have resulted in the water to flow back and cause upstream floods. It may be from this point of view that recent floods in Bihar have been linked to the Farakka Barrage.

On the other hand, the Bengal delta is geo-morphologically dynamic and is built on the huge sediment load carried by the Himalayan rivers, namely, the Ganges and the Brahmaputra. The barrage seems to have incapacitated the river's potential to perform this function. At the same time, going by this logic, the barrage and the subsequent lack of sediment separation technology seem to have punctured the "soil formation" service of the ecosystem further downstream. However, even the avowed purpose of resuscitating the Kolkata port has not been satisfied (Ghosh, 2016).

Again, the entire contention of Farakka Barrage removal is not going to solve the problem, but further escalate the conflict between the states. There is no doubt that the unintended benefit of the barrage is amelioration of the water problem during lean seasons in the downstream, in the densely populated areas of West Bengal, due to the flows through the Bhagirathi-Hooghly channel. As such, the drinking water and sanitation problems of the burgeoning Kolkata metropolis seem to have been resolved because of the barrage, which has not only resuscitated the surface water flow in the channel, but may have also ensured groundwater recharge. Removal of the Farakka will definitely negatively affect the populace and ecosystem services in this part of the state (Bandyopadhyay and Ghosh, 2016).

The sole reliance on the traditional British engineering while constructing the Farakka Barrage has already created problems at a minimum of two levels: international and interstate. On the other hand, China has developed its own set of ecologically informed engineering while designing its dam on Yangtze (Ghosh, 2015). The design helps in flood control, and also uses the peak flow to use the sediments effectively for downstream floodplain cultivation. Sediment is an important variable, and such scientific understanding of sediment management needs to be developed in India as well. This "two-level" game can be managed more effectively with a transboundary river basin organisation that can promote IRBG, but it will require a better resolve from all the nations involved (Ghosh, 2016).

IWRM for River Basin Governance: A proposed structure for Brahmaputra sub-Basin

The idea behind including this topic in the module is to showcase a situation on how an integrated approach may help resolve the existing and potential management problems of a river basin. The Brahmaputra sub-basin—spread over Bangladesh, Bhutan, China and India and part of the Ganges-Brahmaputra-Meghna basin—has historically been abundant. Yet the populations who live in the region have not benefited from the natural wealth of the sub-basin; the levels of poverty are high. Traditional development theory makes a direct correlation between scarcity of natural resources and poverty. In the case of the Brahmaputra sub-basin, however, the paradox is clear: "ample water, ample poverty". The situation is not expected to improve in the future, and the governance of the Brahmaputra will continue to be a huge challenge.

It is here that the critical concerns of environmental security and human well-being in the sub-basin unfold. Environmental security has been defined in this volume as a state of absence of conflicts in the complex and interconnected relations in and between the biological, social, economic and cultural processes of human societies and the natural environment. In the process, one may state that environmental security depends on the dynamics in the natural environment, population change, degree of access to the environmental resources, etc. Interaction between and among the determinants of environmental security sets the stage for addressing the environmental security challenges (Ghosh and Khan, 2012).

The environmental security concerns have been driven in the Brahmaputra sub-basin by a lack of ecosystems perspective that has created the governance challenges. The four-fold governance challenges for the Brahmaputra sub-basin are: 1> floods, bank erosion, and shifting of rivers; 2> hydropower projects within Indian boundaries creating conflictual situation, and the hydropower projects in the Tibetan (or Chinese)boundaries; 3> water transfer projects entailing interlinking of rivers; 4> the concerns of global warming and climate change. This lack of ecosystems perspective has created threats at the social-economic-ecological interface of human existence, through the critical ecosystems-livelihoods linkages (Bandyopadhyay et al., 2016).

It has been found that the existing institutional mechanisms within national boundaries are inadequate to address regional-level challenges at the basin scale. This necessitates the setting up of a trans-boundary organisation that will have a bird's eye view of the challenges, understand and correlate the micro-level nuances in the cross-section of the sub-basin, and take a systems approach to combat the issues.

In view of this, and in an attempt to promote IRBG, the Organisation for Governance of the Lower Brahmaputra Sub-basin (OGLOBS) has been conceived of as a trans-boundary river basin organisation. The idea of a river basin organisation in lower Brahmaputra (excluding upstream China) has been conceived of for two reasons: a>Given the present political and the strategic considerations of the Brahmaputra basin nations, it is better to have a river basin organisation with Bangladesh, Bhutan, and India; b> though 55% of the length of the Brahmaputra mainstream lies in the Tibetan boundary, more than 85% of the hydrological flows of the basin emerge in the boundaries of Bangladesh, Bhutan, and India. OGLOBS is proposed as a trans-national body, autonomous in character, and with responsibilities to chalk the guidelines for water systems management, create the master-plans for basin-level development, and with powers to impose penalty on those players who do not adhere by the set guidelines. The powers can be vested to this Organisation on the basis of an Agreement by the three nations of the lower Brahmaputra sub-basin, i.e., Bangladesh, Bhutan, and India. Therefore, these three nations can be called the member nations of the OGLOBS. The volume then talks of the objectives, institutional responsibilities, financing mechanisms, and a broad organisational structure and composition of the OGLOBS. The volume presents the tentative broad skeleton that needs to be reviewed, reshaped, and meat needs to be placed at the right place on the bones. A bigger discussion and more detailed and dedicated research are needed for that. In the case of the Brahmaputra sub-basin, the issues are complex not only because of the complex nature of hydro-political relations between the nations, but also because of a very complicated and not yet properly understood social-ecological interactive system, and the complex management challenges.

Box 1: *CASE STUDY: ICPDR: Sustainable Water Management in the Danube River Basin*

In the context of transboundary river basin organisation, one of the successful cases happens to be the one of International Commission for the Protection of the Danube River (ICPDR). In the pilot testing sessions, these were presented as an audio-visual session to relate the participants to a case on an approach to Integrated River Basin in the Danube river basin.

The International Commission for the Protection of the Danube River (ICPDR) is an international organisation with its permanent secretariat in Vienna, and was established by the Danube River Protection Convention, signed by the Danube countries in Sofia, Bulgaria, in 1994. The commission became active in 1998, and has grown into one of the largest and most active international bodies of river basin management expertise in Europe. The commission, being a river basin organisation, takes a basin approach for management and governance with the basin being defined as encompassing more than 300 tributaries and the ground water resources.

The ICPDR has fifteen contracting parties: Austria, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Moldova, Montenegro, Romania, Slovakia, Slovenia, Serbia, Ukraine, and European Union.

The key objectives of the ICPDR are:

1. Ensure sustainable water management
2. Ensure conservation, improvement and rational use of surface waters and ground water
3. Control pollution and reduce inputs of nutrients and hazardous substances
4. Control floods and ice hazards.

IWRM: Guiding principle or Empty rhetoric?

The module is concluded with the debate on the theoretical foundations and practical applications of IWRM. IWRM has given us a few guiding principles for water management and governance. There is no doubt that it has received sufficient global traction in policy statements of international donors and advocacy, and of national governments.

Yet, the criticism against IWRM has been intense. It has been stated that "… the current monopoly of IWRM in global water management discourse is shutting out alternative thinking on pragmatic solutions to existing water problems" (Giordano and Shah, 2013). Biswas (2004) has long opined "… While at a first glance, the concept of IWRM looks attractive, a deeper analysis brings out many problems, both in concept and implementation, especially for meso- to macro-scale projects. The definition of IWRM continues to be amorphous, and there is no agreement on fundamental issues like what aspects should be integrated, how, by whom, or even if such integration in a wider sense is possible. The reasons for the current popularity of the concept are analysed, and it is argued that in the real world, the concept will be exceedingly difficult to be made operational".

As such, even in certain policy corners, the practicability of IWRM has been questioned. As stated by Saravanan et al. (2009), the biggest challenge of IWRM is with integration of discourses. In that sense, the call for integration had remarkable appeal worldwide in getting traction among all stakeholders. " … However, critics argue that the domain of water resource management is a political process of contestation and negotiation; the emphasis is on complexities, contextuality, power dynamics and the importance of analysing real world situations. They demonstrate 'how integration cannot be achieved' given the power dynamics in social interactions. These apparently contradictory discourses draw on different theoretical paradigms and polarise the discourse on IWRM, without offering constructive alternatives".

On the other hand, the other contention remains that IWRM is not supposed to be an operational doctrine, but a few guiding principles that mark the broad contours of an emerging discipline of water governance. Therefore, various policy documents define the operational governance issues under the broader umbrella guiding principles provided by the notion of IWRM. This is exemplified by two important state-of-art documents place in public domain in India, namely, the Draft National Water Framework Bill 2016, and A 21st Century Institutional Architecture for India's Water Reforms, both under the chairmanship of Dr. Mihir Shah. The realisation of the need for a holistic mode of water systems governance has been reflected in several new policy formulations globally, like Water Framework Directive in the EU. In some other countries, for example, South Africa, Australia and Russia, serious attention has been given to the social and ecological concerns expressed by people and scientists on the traditional reductionist approach to water governance. However, the broad common principle that is acknowledged is the need for a systems approach to water governance in general, and river basins in particular. River basins are integrated and all parts are linked to changes in others, over space and time. Such changes may be part of either natural processes or human induced ones.

Concluding Remarks

In a nutshell, the following set of messages become important in the context of the sustainability of the ecosystem, water, and food nexus that needs to be embedded in IWRM. First, ecosystems are crucial for providing long-term food needs of the human society, and this needs to find explicit recognition in policy documents. Food security is not a linear function of water use, and there needs to be more emphasis on demand-management of water rather than supply augmentation. Second, an integrated management approach is needed for land, water, and the ecosystems at the basin level to enhance the multiple benefits, and minimise the detrimental effects on the ecosystem services. Third, there is an urgent need to develop institutional and economic measures to prevent ecosystem degradation, and encourage changes in the practices of business-as-usual. Valuation of ecosystem services associated with water systems is important here. Fourth, policy documents need to explicitly recognise that the relation between water and food is not necessarily linear. Rather, irrigation development projects (like large dams) might even have detrimental impacts on food availability and livelihoods in the long-run. Fifth, solutions to the problems of food security need not be sought in water supply-side management alone, but more emphasis needs to be placed on distributional and the demand-side aspects as well. This can help in a more integrated approach to water management, while considering the release of pressure on the ecosystems. Sixth, this also goes well with the emerging literature on environmental flows that ask the question of how much water the river needs. A river basin approach is needed to promote the needs of the ecosystem keeping in view the ecosystem-livelihoods linkage. Seventh, IRBG needs to be taken up as the doctrine governing the management of water, and adequate institutional arrangements should be put in place to promote the paradigm in practice. Eighth, promotion of environmental security should be the broader goal of IRBG.

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Annexures

Annexure 1: List of Learning Resources

Books

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“Protecting Water Quality and Ecosystems in the Danube River: International Cooperation under the ICPDR”, https://www.youtube.com/watch?v=C5i9SYt4OJM&t=145s

Annexure 2: Glossary of key terms

- **Arithmetic Hydrology:** The hydrological management or governance approach that attempts to reduce everything to a single number for convenience of decision-making, but in the process loses out on critical variables thereby resulting in subsequent management problems is being called "arithmetic hydrology". The term is often used in contrast to "integrated approaches", "holistic ecohydrology", etc.
- **Convention on Biological Diversity (CBD):**The Convention on Biological Diversity (CBD) is a multilateral treaty with the objective to develop national strategies for conservation of biodiversity and sustainable use of natural resources. The Convention has three main goals including: the conservation of biological diversity (or biodiversity); the sustainable use of its components; and the fair and equitable sharing of benefits arising from genetic resources. The Convention was opened for signature at the Earth Summit in Rio de Janeiro on 5 June 1992 and entered into force on 29 December 1993.
- **Ecohydrology:** Ecohydrology is an interdisciplinary domain of knowledge studying the interactive dynamics between water and ecosystems. It recognises the crucial interdependence between the two, thereby acknowledging the critical ecosystem functions and services of water (Hunt and Wilcox 2003; Sohel 2015). This is missed out by the doctrine often referred to as "arithmetic hydrology" that thinks of water as a stock of resource for human consumption, and misses out on the crucial ecological aspect. In that sense, ecohydrology is considered more comprehensive, and is an important cornerstone of IWRM.
- **Ecosystem Services:** Ecosystem services are the goods and services provided by the ecosystem through its natural functioning to the human community for free.

These benefits are often integral to the provisioning of clean drinking water, the decomposition of wastes, and the natural pollination of crops and other plants. According to the Millennium Ecosystem Assessment, ecosystem services are classifieed into four broad categories: *provisioning*, such as the production of food and water; *regulating*, such as pollution control, and climate regulation; *supporting*, such as nutrient cycles and crop pollination; and *cultural*, such as spiritual and recreational benefits.

- **Ecosystems approach to Water Governance:** This approach treats water body or a river basin as an ecosystem, and devises management mechanisms and governance principles on the basis of that. This is a clear departure from the traditional approach of water governance through engineering solutions by looking at water as a stock of resource to be used for storage and human consumption.
- **E-Flows:** Environmental flows describe the quantity, timing, and quality of water flows required to sustain freshwater and estuarine ecosystems, and the human livelihoods and well-being that depend on these ecosystems. In that sense, this is a negotiated flow regime that attempts to replicate the pristine or natural flow regime, but is not the natural flow regime, as all river systems are compromised.
- **Environmental Security:** Environmental security has been defined by Bandyopadhyay et al. (2016) as ... *a state of absence of conflicts* in the complex and interconnected relations in and between the biological, social, economic and cultural processes of human societies and the natural environment. Therefore, environmental security depends on two critical elements: a>On the dynamics in the natural environment, population change, degree of access to the environmental resources, etc., b>Interaction between and among the determinants of environmental security sets the stage for addressing the environmental security challenges. Therefore, environmental security has to take into consideration multiple uses and users' perspectives, and need to reconcile between them.
- **GWP:** The Global Water Partnership (GWP) is an international network especially motivated to promote an integrated approach to manage water (IWRM). Its vision is for a water secure world. The Partnership operates as a network, which is open to all

organisations, including government institutions, agencies of the United Nations, bi- and multi-lateral development banks, professional associations, research institutions, non-governmental organisations, and the private sector.

- **Harmon doctrine:** This is one of the extreme doctrines to define property and user rights over water use. In simple words, this doctrine states, "… If water falls on my roof, it is mine". A notorious theory in international natural resources law, on the basis of the argument of Attorney General Judson Harmon issued a hundred years ago, the doctrine holds that a country is absolutely sovereign over the portion of an international watercourse within its borders. This gives the country the absolute right to divert all of the water from an international watercourse, thereby completely depriving the downstream.
- **Historical doctrine for property rights:** This is also called "prior appropriation" doctrine. This doctrine states that the first person to take a quantity of water from a water source for "beneficial use"—agricultural, industrial or household—has the right to continue to use that quantity of water for that purpose.
- **Hobbesian doctrine:** This doctrine states the property right arrived at through the process of negotiations is optimal, and should be the most accepted one.
- **Hydrograph:** A hydrograph is a graph that shows the discharge over a specific time unit (daily/ monthly/ yearly) at a specific point in a river, or other channel or conduit carrying flow. The rate of flow is typically expressed in cubic meters or cubic feet per second.
- **ICPDR:** International Convention for the Protection of the Danube is an international river basin organisation dealing with the governance of the Danube river basin.
- **IRBG:** Integrated River Basin Governance or IRBG are principles and practices to be put to effect for governing water systems at the scale of basins.
- **IRBM:** Integrated River Basin Management or IRBM, as a principle, considers the river basin as the unit of management, and calls for an integrated approach to manage land, water, and resources so as to reconcile between the equity, efficiency,

and sustainability goals at the basin level. It often talks of setting up of a basin-level organisation for better governance.

- **IWRM:** Integrated Water Resources Management or IWRM is a systematic process for the sustainable development, allocation and monitoring of water resource use in the context of social, economic and environmental objectives. Global Water Partnership (GWP) defines it as "a process which promotes the coordinated development and management of water, land and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems".
- **Metabolic Rift:**The term “metabolic rift” was coined by John Bellamy Foster. Metabolic rift is a Marxian notion envisaged in *Capital, Vol III* and refers to the "irreparable rift in the interdependent process of social metabolism", which again is defined as the set of flows of materials and energy between ecosystem and society, as also within and between different societies. According to Marx, the capitalist production and consumption processes are supposed to create a rupture in the metabolic interaction between human socio-economic processes and the natural ecosystem thereby leading to the lack of acknowledgement that the human processes are embedded in the broader ecosystem.
- **Millennium Ecosystem Assessment (MA):** The **Millennium Ecosystem Assessment** (popularly called MA) is a major assessment of the anthropogenic interventions on the ecosystem. It was called for by the erstwhile UN Secretary-General Kofi Annan and was published in 2005. It popularised the term ecosystem services, the benefits gained by humans from ecosystems, and provided a better classification to it.
- **Neo-Malthusianism:** "Neo-Malthusianism" concerns itself with the hypothesis that overpopulation may increase resource depletion or environmental degradation to the extent of unsustainability, and will accentuate conflicts over resources.
- **Normalised Melt Index:** NMI is the index varying between 0 and 1, reflecting on the percentage contribution of snow and glacial melt in the total flow of a river channel.
- **Reductionism:** Reductionism is the practice of analysing complex phenomena in terms of its simple or fundamental constituents, on the assumption that it provides a

sufficient explanation. Reductionism can be applied to any phenomenon that may entail objects, explanations, theories, concepts, etc. It is often stated that in the initial development of a theory or concept, reductionism is helpful. However, a complex phenomenon, deserving a multi-disciplinary approach, might not be helped by reductionist explanations.

- **Securitisation:**Securitisation is a notion in the discipline of International Relations talking of the state actors viewing all subjects through the prism of security. Buzan et al. (1998) define the scope of securitisation as a body of knowledge that aims to understand "who securitises (Securitising actor), on what issues (threats), for whom (referent object), why, with what results, and not least, under what conditions"[7].

- **SES:** The social-ecological system (SES) presents the interactive dynamics of the bio-geo-physical unit with its ambient social actors and institutions. Socio-ecological systems are complex and adaptive and delimited by spatial or functional boundaries surrounding particular ecosystems and their problem context.

- **Systems approach:**Systems theory entails the interdisciplinary study of system, defined as a cohesive accumulation of intertwined components. Due to this interconnectedness, any perturbation in one part of the system affects other parts and the whole system. In case of the natural ecosystem or a river basin, any perturbation on one part can cause extensive changes that might not be realised in the short-run, but makes itself visible in the long-run with its consequent impacts.

- **Valuation of Ecosystem Services:** Since ecosystems provides the human community various benefits in the form of free of cost services, the importance of the ecosystem services are often not properly understood and appreciated by the human economy. Hence, economic valuation techniques are often used to place monetary values to certain services to make the public understand the importance of the biodiversity, which is often called the “natural capital”.

[7] Buzan, B., O. Wæver, and J. de Wilde (1998): *Security: A New Framework for Analysis* (Boulder: Lynne Rienner Publishers)