Environmental flow assessment for Indian rivers: the need for interdisciplinary studies

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Environmental flow requirements of a river are often defined as a suite of flow discharges of certain magnitude, timing, frequency and duration. These flows ensure a regime capable of sustaining a complex set of aquatic habitats and ecosystem processes, and are referred to as 'environmental flows', 'environmental water requirements', 'environmental flow requirements', 'environmental water demand', etc[1–3]. Flow is considered as the master variable because it exerts great impact on aquatic habitat, river morphology, biotic life, river connectivity and water quality[4]. Environmental flow requirements of a river depend on the properties of the aquatic ecosystem, development stage of the area and the societal requirements[5]. The flow regime is regarded by many aquatic ecologists as the key driver of river and floodplain wetland ecosystems[6], responsible for appearance, establishment and spread of different life forms. Hence, any disruption of the natural flow regime of a river can alter entire river ecosystems and the socio-economic activities that depend on them[7]. The assessment of water requirements of freshwater-dependent ecosystems represents a major challenge due to the complexity of physical processes and interactions between the components of the ecosystems[8].

The altitudinal and geographical variation, vast and varied catchments, vegetation cover and influx of numerous tributaries of the rivers have formed varying substratum and micro-habitats in the rivers[8]. Accordingly, the habitat diversity enabled evolution of diverse biotic forms in a particular river stretch. The variations are properly reflected in the form of diverse biotic assemblages and fish diversity. Among the available aquatic resources, the rivers are highly prone to anthropogenic stressors because of diverse drainages traversing through varied catchments, extremely populated banks and area of maximum developmental activities. Besides being the lifeline to human beings, rivers are also known as the original abode of hundreds of native fish species. These vast and varied river systems of the country harbour rich fish fauna comprising 930 species belonging to 326 genera[9]. Keeping the importance of environmental flow, there is need to estimate and release the flow on the basis of the complex need of various stakeholders of the downstream stretch to maintain downstream ecology and fisheries. A global review of the status of environmental flow methodologies revealed the existence of some 207 individual methodologies, recorded for 44 countries[10]. These methods are based on various criteria, including hydrological, hydraulic rating, habitat simulation and holistic methodologies.

India is currently facing large shortages in base and peak electricity[5]. As of 2014, the country has 255 GW of installed generation capacity out of which thermal-based projects account for 178 GW, nuclear sources 4780 MW, renewable 31.7 GW and 40.8 GW is contributed by hydropower plants (http://www.cea.nic.in). Hence, serious actions are underway to harness the available green source of electricity from potential regions. The Himalayan rivers are preferred for hydro-power development because of assured perennial flow, steep gradients and gorges with stable rocky banks. Owing to these attributes, the rivers and their ecological assets in the mountain states of Uttarakhand, Jammu & Kashmir, Himachal Pradesh and Arunachal Pradesh, including fisheries resources are under severe threat[11]. The present methods in vogue to construct barrages for the generation of hydroelectric power need the release of environmental flow to safeguard downstream ecology, biota and stakes of the holders. Though preliminary study on environmental flow assessment in relation to fisheries has already been attempted on River Sone[8], comprehensive and interactive attempts are still lacking in the Indian rivers because of the dearth of a sufficient eco-biological database.

I have noticed in many of events wherein experts suggest that holistic methodologies like building block methodology (BBM)[12,13] or downstream response to imposed flow transformation (DRIFT method)[14] should be used for the estimation of environmental flow. The holistic methodologies, several of which are scenario-based, address the flow requirements of the entire riverine ecosystem, based on explicit links between changes in flow regime and consequences for the biophysical environment[10]. Recent advancements include the consideration of ecosystem-dependent livelihoods and a benchmarking process suitable for evaluating alternative water resource developments at basin scale, in relatively poorly known systems[10]. No doubt, both the methods are holistic, interactive and involve participation of all stakeholders and their claim for water requirements in the respective stakes and the flow trade-offs are made accordingly on the basis of the sum of the quantities staked by different holders, hence predicted to solve the problem. However, in the Indian scenario (even elsewhere too), most of the stakeholders are not aware of sound scientific water requirements of their respective activities. Let us take the example of fisheries sector. As already mentioned, the Indian rivers harbour immense fish diversity. A few studies listed 143 species from main trunk of River Ganga[12], 112 from Yamuna[13], 89 from Ken and 81 in Betwa[14] and 89 species from River Sone[8]. Hence it is a gigantic task to estimate the flow for each and every species of a river stretch. However, the flow may be estimated targeting certain keystone species of a river or a particular stretch. We may target *Schizothorax richardsonii* and *Tor putitora* for Himalayan stretches, Indian major carps for Indo-Gangetic Plain rivers and *Tenualosa ilisha* for estuarine rivers. Till date, there is no scientific documentation of *in situ* water requirements of any of the fish species in relation to their spawning, nursery caring, feeding, migration (if any) and other life stages in any of the river systems. The environmental flow estimation should not only be done by fisheries scientists alone, but to estimate water requirements of any species (for example, Indian major carps), there is a need to study (*in situ*) the complete life cycle of the species in relation to the water requirement

(quantitative and qualitative), including physico-chemical parameters, sediments, substratum characteristics, river depth, width, flow rate, etc. Information is often available on life cycles of many of the species (though sometimes it is fragmentary), but the life-cycle studies are not viewed at all related with hydrological regimes. Similar information on mahaseer and snow trout in the upland rivers may also be available. In this situation, it is not possible (at present) for a fishery scientist to precisely suggest the water requirements of total fishery or particular species in a river stretch. Therefore, there is an urgent need to prioritize the studies to unravel the issues with the help of interdisciplinarily experts from ecology, geomorphology, hydrology, biology and other stakeholders such as socio-economics and local community.

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COMMENTARY

When will Indian universities open their doors to international students?

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At a recent international education conference in Pune, the Association of Indian Universities (AIU) revealed that Indian universities and colleges have the potential to host almost five lakh foreign students per year on their campuses. However, they are able to attract only 32,000 students. As if to give a 'quick fix' solution to this problem, the Union Minister of Human Resources Development, responded by saying that 'institutions must "strategize policies" in such a way that intake of foreign students is utilized to full capacity'. Actually, the Government of India has to evolve a strategy on how it wants to attract international students, as part of its much awaited National Education Policy. Developed countries like Germany, Japan, the UK, etc. are setting targets for 2020 to considerably increase the intake of international students and laying down strategies on how the government could help in this process. India needs to do the same. Let us first understand why it is necessary for our universities to bring in more international students and then analyse why they are not able to do so. Based on these analyses, some measures will be suggested for the consideration of the Government.

India takes pride of its demographic dividend and claims the ability to provide skilled manpower to different parts of the world – both developed and developing. For this, we must produce manpower that is acceptable and employable in the diverse world culture. Our own national employability reports have highlighted that a majority of our graduates are considered unemployable even in the domestic market. How can we then assume that what is not suitable for the domestic market will be acceptable abroad? Indian universities are not able to impart skills that are required in the real-life world of the employment market. The skills development report shows that our institutions primarily impart 'specialized domain' expertise to our students, who form only a quarter of the diverse skill requirements of the employment market. Skills such as adaptability, cultural understanding and communication skills are seriously lacking in our graduates. The process of testing the capabilities of the graduates, further produces unfit graduates. Interpersonal skills, learning agility, integrity and values are some of the other soft skills that are expected by the employers which are not part of a 'degree-giving' education system. Logical ability and problem-solving approach are seriously missing. Some of these skills are learnt not necessarily in the classrooms, but by meeting