Environmental flow assessment of River Ganga – importance of habitat analysis as a means to understand hydrodynamic imperatives for a sustainable Ganga biodiversity

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Environmental-flow (e-flow) assessment is still at a rudimentary level in India. Among such assessment studies that have been undertaken for the Ganga River Basin, a large fraction is based on the use of simple, less robust methods where ecology has not received due attention. Owing to the ecological importance of the river, we propose the use of habitat analysis methods for assessing e-flows. Studies incorporating knowledge of river hydrology and hydrodynamic transport phenomena coupled with a knowledge of ecological preferences of indigenous species can provide robust and more realistic solutions. Limitations and difficulties in using these methodologies need to be documented and, hopefully, with their resolution.

Indian researchers have been evaluating various environmental-flow (e-flow) assessment methodologies that have been used worldwide to explore their feasibility for Indian rivers. The broad domain of e-flow assessment in India has evolved in response to its largest river basin, namely the Ganga River Basin becoming the focus of intense socio-cultural scrutiny. Ironically, simple hydrological methods are commonly adopted for this complex river system[1] for a variety of reasons that include, amongst others, (i) data are not available; (ii) suspect data integrity; (iii) disorganized data archival system resulting in data being irretrievable when required; (iv) intent-driven unwillingness to share data and (v) anachronistic and nebulous data release policies, etc. Studies using a combination of hydraulic and holistic approaches have been sporadic and therefore rare. In these latter studies, however, ecological compulsions and related requirements are shown to be incorporated, albeit with an overdose of subjective judgements and assumptions. While recourse to such subjective elements is indeed inevitable in ecology-based approaches, attempts to develop a rigorous scientific and technical framework to arrive at projections and/or predictions should be encouraged.

Ecological complexity of River Ganga cannot be overemphasized and is evidenced by the presence of a broad spectrum of terrestrial, riparian and aquatic biodiversity and species richness including reports of numerous unique and rare flora and fauna. Over the years, sadly, biodiversity and ecological richness of the Ganga system are widely believed to have become increasingly vulnerable, endangered or critically endangered. Relating terrestrial and riparian ecology to e-flows is an indirect approach where normal riverine processes like inundation, groundwater recharge and sediment transport, that are seen to be critical support for maintaining the quality of habitat of the endemic species, are evaluated based on linkages to flow conditions. Understandably, therefore, development of e-flow assessment methodologies is now centred on a comprehensive aquatic habitat analysis. Post their development in late 1970s and early 1980s, these methodologies became popular to rank second only after hydrologic methods and by 2003 rose to represent as high as 28% of the total global effort[2].

These aforementioned methodologies rely on the use of hydrodynamic relationships and their potential to support species habitat preferences to analyse both the quantity and quality of habitat for producing resultant outputs. These results are generally obtained in the form of suitable habitat versus discharge curves which offer the advantage that they quantify the changes to habitat suitability as a result of changes in natural flow regime, thus aiding the task of evaluation of alternative flow proposals[3]. Several habitat modelling tools have been developed worldwide, such as a pioneer habitat model PHABSIM developed in the US, while others based on similar components[4] are RHYHABSIM – New Zealand, RSS – Norway, CASiMiR – Germany, River-2D – Canada and EVHA – France. A common thread in these models is the use of 1D or 2D hydrodynamic models to link river hydraulics with habitat preferences. These habitat preferences are defined in terms of habitat suitability criteria (HSC) curves that link hydraulic parameters (flow depth and velocity) and channel conditions with corresponding measures of habitat suitability for a particular life stage of the target species. Suitability is marked on a scale of zero (unsuitable) to one (optimum) based on expert understanding that is developed through empirical and actual ecological surveys.

In the Indian scenario, selecting one of these models will be a challenge considering copious data requirements in the form of detailed river channel profiles, channel morphology and flow stage-discharge data along with ecological responses to their variations. However, to begin with, a model with attainable input parameterization may be selected and to address scant availability of ground observations, surrogate information may be used. While remotely sensed data in the form of digital elevation models and high-resolution land-use/land-cover information can be used to generate river channel profile and morphology; HSC curves can be developed using species habitat preferences cautiously studied from the available literature about target species.

A successful study plan for the Ganga River Basin is understandably expected to involve identification of river reaches suitable for species of importance identified as keystone, flagship or umbrella species. A sound and comprehensive understanding of demographics, life-history traits, distribution, migration, food habits, and reproduction patterns amongst other aspects, and how they

translate into quantifiable microhabitat requirements at various life stages of growth, including a verifiable understanding of the major threats to them is indeed imperative for a meaningful study. Institutionalizing systematic and long-term campaigns for collection of high-resolution, precise data pertaining to river hydraulics with verifiable adherence to the procedures and guidelines explained by worldwide developers and users is necessary. For these initiatives to have a reasonable chance of succeeding, hydrologists and ecologist, to the exclusion of compulsive activists, have to come together in a coalition of partners to address this complex and multidisciplinary challenge that spans across domains such as environmental sciences, eco-hydrology and eco-hydraulics.

This note is essentially an averment that the approach, as outlined above, if adopted, will ensure robust and defensible e-flow assessment with better prospects of long-term acceptance and sustainability. It is expected that such a study as outlined here has the potential to become a benchmark reference for future e-flow assessment initiatives that are likely to follow, as a socio-political and cultural imperative, for other Indian rivers.

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