



E-Flows in Indian River Basins – Methodologies, Issues, Indicators and Conditions: Learnings from the Hasdeo Basin

‘Making our rivers free-flowing again’ – Environmental flows approach in river basin planning’

Water for sustaining and regenerating ecosystems, culture and livelihoods seems to be the last priority in water use. The technocratic and conventional approach in management of river basins in the country, which believes that ‘every drop of water that flows into the sea is a waste’, has led to the degradation of a majority of the large river basins in India. Many of our river basins are now termed ‘closed’. There has been a tremendous destruction of river ecology and riparian habitats, loss of livelihoods, severe pollution, and adverse impact on deltas, like increase in salinity of the soil and seawater intrusion, as the rivers are no longer able to transport sediments. This approach has also led to numerous water conflicts. Through this policy brief, the E-flows Thematic Group of the Forum for Policy Dialogue on Water Conflicts in India (henceforth, the Forum) has tried to put together some of the important concepts, methods and concerns related to the implementation of the e-flows approach in India. It draws from existing literature and experiences of e-flows assessments in India till date and the Forum’s own work in the Mahanadi basin, the Hasdeo sub-basin in particular. In the Hasdeo sub-basin, the Forum’s E-Flows Thematic Group has been working to understand how a process of e-flow assessment would be implemented in the basin. At the same time, this work also offers important broader learning for implementation of e-flows elsewhere.

What are Environmental Flows?

The most widely accepted definition of environmental-flows (e-flows) was the one adopted at the conference in 2007 in Brisbane, Australia, which was attended by more than 800 scientists, economists, policy makers, research and resource managers, and a conference to which the first author of this report and policy brief was a signatory. The Brisbane declaration defined e-flows as ‘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’ (International Water Centre, 2007).

Maintenance of spatial and temporal patterns of river flows i.e., the flow variability, is the most important criteria for e-flows. Thus, e-flows cannot be termed as natural flows but those flows that are maintained in the river and will mimic the natural flow pattern of the river. However, it is important to understand that e-flows have limited capability and their objectives can be achieved only if human activities like land use changes, effluent discharges etc. are effectively controlled. Allocation of e-flows is ultimately a societal decision.

Environmental Flow Assessment in India

The Ministry of Environment Forest and Climate Change (MoEFCC), Government of India, has been giving environment clearance to all the river valley projects since 2007-08 under the condition that certain ‘minimum flows’ have to be maintained in the river at all times of the year. The proposed minimum flow requirement was 10 per cent of the observed minimum flow which was later revised in 2010 as 20 per cent of the average flow observed in the four lean season months at 90 per cent dependability. In 2011, the Expert Appraisal Committee (EAC) of the MoEFCC for the river valley projects, stipulated maintenance of higher flows during monsoon in addition to the minimum flows (Thakkar, 2012). Environmental flows assessment became a mandatory part of the Environmental Impact Assessment (EIA) for obtaining environmental clearance for river valley projects since then. Several studies were carried out by a number of government and non-government organisations and institutions to assess e-flows, especially in the Ganga and the Brahmaputra river basins. A review of these studies brought out a variety of concerns and limitations of e-flows assessments in India and raised various issues on how e-flows are perceived in river basin planning in the country.



Issues and Concerns on E-flows Assessment in Indian River Basins

- Determination of e-flow is ultimately a societal choice. Therefore, the most critical issue regarding e-flows assessment and also perceiving environmental flows in the context of river basin planning, is 'objective setting'. Prioritisation of the objectives in terms of how we use the river water, will determine how well the river will be able to perform its ecological, socio-economic, cultural and livelihood functions. There are several approaches to assess environmental flows but for all of them, setting the objectives or the purpose which the flows are meant to serve, is the most critical as it will determine the essential roles and functions that the river will serve. However, currently, there seems to be no clear objective setting in the e-flows assessment done in India.
- The MoEFCC in the 'Terms of Reference' (ToR) for new river valley projects has prescribed e-flows to be: '20 per cent of the average four lean months of the 90 per cent dependable flow and should be released during the lean season 30 per cent of the monsoon flow during the monsoon season.' During the post-monsoon months, the flow shall be decided by the Expert Appraisal Committee (EAC) based on the hydrology and the available discharge, though the minimum e-flow still would have to be 20 per cent of the post-monsoon flow in the 90per cent dependable year. This recommendation of the MoEFCC itself shows the lack of understanding of e-flows and the importance of objective setting. E-flows cannot be generalised for rivers across the country as each river is unique and has its own needs.
- Though there is no one correct approach to estimate e-flows, most of the e-flow assessments in India seem to lack a holistic approach. They do not take into consideration the interconnections between river hydrology, morphology, ecology, livelihoods, and socio-cultural and religious practices. Moreover, e-flow requirements are derived as a percentage of 90 per cent dependable flow, which leaves practically very little flows for the river.
- Dams are direct modifiers of flows. Cascading dams interrupt the flow, breaking and disrupting the lateral and longitudinal connectivity. E-flow assessments and recommendation of minimum e-flows by the MoEFCC do not address this issue. There are no norms defined on what should be the minimum allowable distance between two projects.
- Peaking power operations from the dams cause drastic diurnal changes to the flows on the downstream of the dam especially during the lean season, completely changing the natural hydrograph of the river, which is not taken into consideration in current e-flow assessment methods.
- None of the cumulative impact assessment and carrying capacity studies of river valley projects have reviewed how floods and sediment transport can be maintained in a river with a series of cascading dams and what would be their cumulative impact on the entire fluvial geomorphology, riparian ecology and livelihoods till the sea.
- Contributions from tributaries joining the river on the downstream of a dam, cannot be considered as contributors to the e-flow unless there is a legally binding direction that their flows shall be maintained in the natural state. This is never done, and thus the notion that allocations of e-flows from the dams can be compensated with these downstream contributions from the tributaries, is incorrect. But a number of assessments in India have followed this principle.
- The Expert Appraisal Committee (EAC) of the River Valley Projects in India permits releases of e-flows from dam toe power houses. Sediments are filtered out before entering the dam toe turbine, affecting the downstream sediment transport.
- Currently, e-flows are assessed for obtaining environmental clearance for new projects. E-flow assessment in river basins with existing dams also need assessment as most of the main rivers like the Krishna and Cauvery are now turning into 'closed' basins and are no longer flowing into the sea.



- Monitoring of compliance is another grey area which mostly remains on paper. As per the Model ToR for river valley and hydroelectric projects of the MoEFCC, the project proponent is supposed to submit a post-project monitoring plan for implementation, based on the environmental management plan (EMP). However, there is no mention of monitoring e-flows in the ToR parameters, whose cost has to be borne by the proponent of the project. In India, there is no legal or institutional mechanism to ensure that they are implemented and are monitored from time to time.
- There is a lack of relevant data especially of hydrological, ecological and morphological parameters. Though the local riparian communities have a good knowledge of the flows and the flora and fauna in the basin, the knowledge has not yet been well integrated and documented.
- As e-flow is a scientific process, the expertise of hydrologists, ecologists, wildlife conservationists, geomorphologists could be beneficial in the e-flow assessment. However, in India, the experts having basin-specific knowledge are very few and their inputs could also imply significant financial costs.

Development of a Framework for River Basins Using Indicators and Conditions for Allocations of E-flows – Learnings from the Hasdeo River Basin

With the Forum's on-going work in the Mahanadi basin, the Hasdeo sub-basin was selected to understand how this framework can be implemented across the other basins in India. The Hasdeo basin was selected due to the Forum's long interaction with the stakeholders through its action research in the previous phases. Moreover, there are many interventions present on the river in the form of dams, barrages and anicuts, the basin is heavily industrialised with major thermal power plants, and there are livelihoods that have been affected, making it ideal for the development of a framework for e-flows allocation. To give a brief description of the river basin, the Hasdeo river originates in the Koriya district of Chhattisgarh and then flows through the districts of Korba and Janjgir-Champa of Chhattisgarh to meet the Mahanadi at Mauhadih in the Janjgir-Champa district. The total length of the river is 333 km and the area of the basin is approximately 10,780 sq.km. It contributes approximately 4.5 BCM of flow to the Mahanadi.

E-flows Allocation Framework Based on Indicators and Conditions

E-flow assessment is based on a scientific process and therefore to analyse river systems based on it, requires data. The issue of the lack of data and documentation related to e-flow assessment, which was mentioned in the earlier section, was also encountered in the Hasdeo basin. To tackle this issue, the approach used by Smakhtin et al., (2007) was used in the study. This approach uses a set of indicators they have termed as 'aggregate environmental indicators' which can be used as proxies to assess the health of the river basin. The indicators can be used to understand how much the river basin has deviated from its natural condition and then develop conditions/criteria and objectives to improve and enhance its health. This approach was used to develop a set of critical indicators in the Hasdeo basin that determine the overall health of the river. This provided the first basic framework for assessment of e-flows in the basins where basic ecological knowledge/information and data is very limited.

Indicators

- **Percentage of natural vegetation remaining in the basin and in floodplains:** The higher the percentage of natural vegetation, better the biodiversity and thus more the sustainability of the basin. Almost 59 per cent of the natural vegetation in the form of rich and diverse forests has been lost in the Hasdeo basin because of different land uses; and the remaining is under threat from coal mining. Flood plains, which are predominantly used for agriculture, have very little natural vegetation left, to the tune of only 10 per cent approximately.
- **Presence of rare and endemic species and species sensitive to flow changes in the basin:** Presence of such biota is an indication that more effort is needed to maintain the flow in the river, at least at the existing conditions. There is very little information available on the aquatic species in the Hasdeo from secondary and even primary data sources. However according to the IUCN (International Union for Conservation of Nature) Red list, two threatened species are found in the Hasdeo namely 'Padhana' (*Wallago attu*) and 'Mirgal' (*Cirrhinus cirrhosus*). According to the first-hand information received from the field interviews with the



fishing community, 'Sirangi' (*Salmophasia bacaila* or *Oxygaster bacaila*), a fish that prefers flowing water, has slowly disappeared completely from the Hasdeo river, after the construction of the Minimata Bango dam.

- **Presence of introduced or exotic species:** The higher the invasion by exotic or introduced species, the more susceptible is the basin to the loss of ecosystem structures and functions. They also tend to create unnecessary competition with the endemic species and in turn reduce the biodiversity in the basin. From the primary field observations and interviews, two varieties of the exotic fish species are being introduced in the Hasdeo, namely, Tilapia and Pangus (*Pangasius pangasius*).
- **Overall aquatic species richness:** The greater the overall species richness, the better is the resilience of the ecosystem to cope with extreme events and other stressors. The confidence level of determining the overall species richness is very low. From the first-hand information received from the fishermen, only nine varieties of fish could be identified. However, according to some of the scientific studies, there are at least 40 varieties of fish species in the Mahanadi river basin, and therefore the number of species could be higher than that mentioned by the fishermen.
- **Degree of flow regulation:** The degree of flow regulation is measured as the total dam storage in a basin as a percentage of the mean flow. The degree of flow regulation from the Minimata Bango dam is 109 per cent.
- **Degree of flow modification:** The degree of flow modification is an indication of how much the river has deviated from its natural hydrograph due to the regulations from the dam and, to a certain extent, from the barrages and the anicuts. It is also an indicator of how much longitudinal and lateral connectivity of the river has been disrupted and what impact it could have on the fish species that are sensitive to flow changes. The hydrological analysis of the historical gauge–discharge data for a period of 40 years measured at the gauging station at Bamnidih, just before the Hasdeo Mahanadi confluence, and downstream of the Minimata Bango dam, the Hasdeo barrage and the four anicuts on the river, showed that:
 - The mean annual flow for every 10-year period over 40 years has shown a decreasing trend. There has been a 38 per cent reduction in the runoff and corresponding discharge rate.
 - The mean seasonal runoff shows reduction in the monsoon flows and increase in the non-monsoon runoff.
 - The monthly hydrograph of runoff before and after the construction of the Minimata Bango dam also show significant reduction in the monsoon runoff and increase in the non-monsoon runoff.
 - At the end of the hydrological year (May), the average live storage in the dam is about 50 per cent which is not being utilised even during the years when there is water scarcity or water stress.
- **Human population pressure:** Human population, especially in the floodplain, is considered as a stressor for the overall health of the river. Human population pressure is expressed as the percentage of the total population residing in the floodplains to the total population in the entire basin. The total population in the Hasdeo basin is 2,375,205. The total population in the command area is 1,360,474. Therefore, the total population as a percentage of those residing in the flood plains is about 57 per cent—higher the percentage, more the flows needed downstream.
- **Water quality in the basin:** Water quality is a major concern in the Hasdeo river. Flyash can be seen flowing into the Hasdeo via the Dhengur naala and Ahiran river. Heavy metals like lead and cadmium, manganese and iron were detected in concentrations significantly higher than the acceptable limits¹ from samples collected from the Dhengur naala and Ahiran river. Hot water from the cooling towers of the thermal power plants is also released into the reservoir of the barrage leading to thermal pollution. Arsenic was detected above permissible limits in most of the groundwater samples. The hydrogeological strata in the Hasdeo basin is such that arsenic does not naturally occur in the aquifer, therefore its detection above permissible limits may be correlated with leaching from flyash ponds in the vicinity. Overall, the water quality in the Hasdeo basin is very poor and is not fit for human consumption or irrigation.

Key Impacts of Flow Modifications in the Hasdeo River

- Interventions in the form of the Minimata Bango dam, the Hasdeo barrage and the anicuts have modified the flows such that the longitudinal and lateral connectivity of the river has been severely disrupted. There are practically no flows immediately below the Hasdeo barrage and the water forms a stagnant pool. From the

1. All samples were compared to the BIS (Bureau of Indian Standards) drinking water standards (BIS, 2012).



downstream of the barrage till the confluence of the Hasdeo with the Mahanadi, the river channels are braided.

- Monsoon flows in the river have reduced and non-monsoon flows have increased. The sediment flows in the river have also reduced as a result of the reduction in the monsoon flows. The impact of reduced sediment flows has been observed on riverbed and floodplain cultivation as most of them are now using fertilisers and applying soil from elsewhere to improve yield.
- Water quality, both surface and groundwater, is of serious concern as heavy metals like lead, cadmium, chromium, manganese, arsenic and iron are above the permissible limits such that the water is not fit for consumption or even irrigation.
- Reduced flows below the barrage and pollution have impacted the aquatic habitats such that the fish populations have declined drastically. This has impacted the livelihoods of the fishing community on the downstream of the barrage.
- From the first-hand interviews with farmers, it was revealed that water is not being provided for rabi irrigation and summer crops. More surface storage and diversion structures in the form of barrages and anicuts have been planned in the Janjgir-Champa district. It seems that that more surface water is being stored for industries and therefore the cultivators have to use groundwater for rabi and summer crops, when there is water available in the dam to provide for both the ecological needs of the river and for the rabi and summer crop irrigation.

Scenarios for Providing E-flows in the Hasdeo

Based on the keys impacts seen in the Hasdeo, three scenarios were evaluated for the dammed rivers to understand if the flows in the river can be restored to some extent, ensuring that irrigation and other needs were also protected. Three scenarios, namely i) average inflow year ii) water scarce year iii) more than average inflow year, were evaluated based on the inflow, discharge and live storage data of the Minimata Bango dam for a period of ten years from 2005 to 2014. The analysis revealed that average or more than average inflows into the dam occur for more than 60 per cent of the time and therefore it is possible to allocate e-flows. Even during the years of water stress or scarcity, which occur for about 30 per cent of the time, water can be provided for the e-flows without tapping into the dead storage of the dam. However, this would require better management of the water that is available in the river in different seasons. It does not mean merely allowing some water to flow based on 90 per cent dependability in the river throughout the year as per the MoEFCC norms. There are certain other aspects that need to be implemented in concurrence with providing e-flows that are also important to maintain the overall health of the basin. A number of 'conditions' which we have arrived at based on our field trips to the Hasdeo, will have to be met. In fact, these conditions would have to be met for any such dammed rivers in India and also apply to the newly dammed rivers. Some of them are presented below.

Conditions for E-flow Assessment with Policy Implications for Indian Rivers

- **Comprehensive Carrying Capacity Study (CCS) with post-facto assessment of the dams, barrages and anicuts on the flows:** A comprehensive carrying capacity study and post-facto analysis of the dams, barrages and anicuts is a very important condition and must be carried out before giving environmental clearances to pending and new projects.
- **Maintenance of natural vegetation:** Since mostly forests and glaciers give birth to rivers and maintain flows, the natural vegetation in a basin/sub-basin cannot degrade or be lost beyond a limit, which has to be determined for each river. In the Hasdeo basin, only 41 per cent of natural land use remains, which must be protected.
- **Conservation of rare and endemic species:** Fishes are one of the most significant indicators of flow modification. Migratory fish like the 'Sirangi' in the Hasdeo basin have been observed as direct indicators of flow modifications. It is important to conserve rare and endemic species because they help restore the livelihoods of the fishing communities.
- **Water quality:** Though dilution is not the complete solution to pollution, enhancing flows especially in the lean season, can help dilute/disperse some of the pollutants which can otherwise degrade the quality of the water which would make it difficult for the survival of the aquatic species and human consumption/use.



However, the overall condition would be to enforce very strict effluent control rules and to levy penalties on those violating them. Regular effluent monitoring must be carried out by the Central Pollution Control Board (CPCB) and the local residents living by the river side.

- Preserving existing livelihoods and cultural sites:** Ensuring certain flows in the river can help preserve the livelihoods of the fishermen and riverbed/floodplain farmers living in the basin. Restoring flows in the monsoon can help restore sediment flows to a certain extent which can help the deposition of fine sediments on the flood plains, thus reducing the dependability of the riverbed and floodplain farmers on artificial fertilisers. Similarly, the livelihood of the fishermen can be restored by ensuring flows in the river which allow fish migration, spawning and proliferation. A number of cultural sites have been submerged after the construction of the dams. For e.g., cultural monuments going back to 7000 BC in the Narmada were submerged. There are many more such examples. Ensuring e-flows can help the conservation of cultural sites.

Recommendations

E-flows assessment is not for environmental clearance alone

The Government of India has been trying to standardise e-flows methodology and allocation through its recommendation in the ToR. The ToR needs to take into account the heterogeneity in riverine ecology, the issues concerning livelihood dependence on the river, river biodiversity, river hydraulics, riverbank ecosystem properties, river morphology and sensitive issues relating to socio-cultural rights and practices that vary extensively among ecosystems and human societies. Standardisation is bound to create more problems rather than meet the needs of the people and ecology.

River basin planning should be comprehensive

The MoEFCC needs to broaden the approach to e-flows assessment and acknowledge that a single norm cannot serve the purpose. Presently, river basin studies have been commissioned for many river basins by the MoEFCC. However, they lack a river basin approach and are not comprehensive. A proper River Basin Planning approach, with e-flows at the centre, should include many other aspects like those mentioned in the earlier paragraphs. Basin planning is not meant only for dam building. River basin planning also means assessing the indicators which would vary from river to river, evolving ways to fulfil or meet them, setting long term objectives and conditions for better river basin management, finding ways to include people/diverse users. The number of dams that can be constructed should be the last priority. E-flows should be seen as an integral part of a robust river basin planning strategy.

Participation—the core of e-flows assessment, implementation and monitoring

Implementing e-flows is a societal choice and a big challenge. Ensuring proper implementation requires the supervision and monitoring by the local communities and departments. Currently, research on e-flow assessments and river basin planning in India is largely done at the academic level and often does not include civil society organisations, other grassroot level research organisations and riparian communities. Therefore, participation of stakeholders should be a basic principle to be followed in any e-flows assessment and implementation process. In fact, a participatory e-flows assessment should be at the core of river basin planning since it would decide the future allocations possible.

Ensuring proper objective setting

Without doubt, the toughest challenge before the government in the coming years will be to revive the lost flows and functions in our rivers. However, when it comes to actually assessing and implementing e-flows, the foremost question that would arise is: Why do we need a certain quantity of flows for a particular river or a stretch of the river? What all social, livelihood and ecological needs are to be met through the flows? Hence, setting objectives is at the core of assessing e-flows. In India, no e-flows assessment or allocation has been based on clearly defined objectives. The role of riverine communities in setting objectives is always brushed aside. If communities are not involved in the objective setting exercise, then the resultant e-flows regime and river health cannot be a reflection of 'social choice', and the communities can reject it. Objectives cannot be standardised either. They will vary, based on the river and its various services and values, and objectives have to be set at the planning stage itself. In the context of river basin planning, objective setting can be done at the planning stage itself which is relevant for e-flows as well. This is applicable to both developed and over-allocated rivers, as well as those rivers where new projects are in the pipeline. Meanwhile,



objectives can be set only within the ecological and hydrological limits of the river. Hence, objective setting would also mean making the people aware of the limits to development of a river basin beyond which it will dry up and degrade irreparably. We need to put in place legal, institutional, regulatory and social structures and processes for objectives setting for rivers and e-flows.

Lack of relevant data

Lack of good, reliable data often becomes an excuse for most EIA and CIA agencies to take up quick desktop assessments for e-flow assessment which cannot assess the impacts of change in flow regime on a river's ecology, livelihoods and other social and cultural parameters. This limitation can be tackled through participation in the e-flow assessment process. Thus, we suggest that base line studies be initiated in all the river basins, to try to bring together the knowledge of local communities and experts, to generate and compile data on different ecological, morphological, social and economic aspects pertaining to rivers basins. Scientific organisations and academic institutions with the help of civil society organisations should work together with local communities to bring this data into a structured knowledge stream and it should be made publicly available.

Community-led field research

Community-led field research and surveys should be put in place which can generate data on fishes, fisheries, flood plain and river bed farming, habitats of indigenous communities and other river dependent livelihoods (for example, sedge grass and reeds are raw material for many household items like mats, containers and artefacts). Academic and civil society organisations should work towards building an institutional platform where the capacities of the CSOs can be enhanced to lead community-based or participatory field research.

Enabling policy and legal provisions

The concept and implementation of e-flows in India is at a very nascent state with respect to policy, law and the enabling institutional and regulatory mechanisms. The proposed National Water Framework Law, in its Draft Bill, and the Water Policy (2012), alone have articulated e-flows appropriately. However, water being a state subject implies that such central legislation can be challenged by the states. We believe that the law should be framed in such a manner that politicians have no other option but to make it compulsory for the states to implement it. The water policy decisions at the state and central levels have not yet been translated into legal instruments either. The MoEFCC norms are not legally binding.

Another option is to have a separate policy for e-flows and integrate it into the river basin plan. Such a policy can include non-prescriptive 'technical guidelines' that provide the range and suitability of various e-flows methods and approaches for different river systems in different eco-regions, and 'operational guidelines' for undertaking a participatory e-flows assessment, integrating it into the river basin planning process. The policy needs to be backed by enabling legal norms. Some of the non-negotiable legal norms should be:

- E-flows assessment and allocation will be at the core of a river basin management plan and should be carried out with participation of the direct river dependent local communities.
- E-flows should mimic the natural flow regime.
- E-flows should be set apart as 'beneficial use' on par with other water uses as recommended in Joy et al. (2011) and should respect the fundamental principles of equity, sustainability and gender equality.
- Objective setting should be a mandatory part of e-flow assessment and should be participatory.
- Basic and livelihood rights and ecosystem needs shall be given top priority.
- Constant supply of water from groundwater source or from the river should be strictly banned.
- Transparency should be maintained regarding consumption of water by the industries and should be made available to the public.
- Review and revision of the e-flows allocation shall be mandatory and should be carried out ideally after every five years.
- Compliance of e-flows flow regime arrived at, shall be legally mandatory. Violation of compliance shall be a punishable offence.



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The Forum and its Work:

The Forum for Policy Dialogue on Water Conflicts in India—a dynamic initiative of individuals and institutions—has been in existence since 2004. Founded by a handful of organisations that came together to document conflicts, it has now become a network of more than three hundred individuals and institutions attached to it.

This Policy Brief is based on the report 'E-flows in Indian Rivers: Methodologies, Issues, Indicators and Conditions—Learnings from the Hasdeo Basin' prepared by Latha Anantha, Shripad Dharmadhikary and Neha Bhadbhade, for the action research which was carried out in the third phase of the Forum and was supported by the Arghyam Trust, Bengaluru. The complete report is available at <http://waterconflictforum.org/>. For printed copies, please write to:

Contact

Forum for Policy Dialogue on Water Conflicts in India
c/o SOPPECOM, 16 Kale Park, Someshwarwadi Road, Pashan, Pune 411008, Maharashtra, India.
Phone: 0091-20-25886542, 20-20251168, Email: waterconflictforum@gmail.com
Website: www.waterconflictforum.org