WATER POLICY BRIEF

Issue 29

Putting Research Knowledge into Action

Creating healthy working rivers: the wisdom of environmental flows

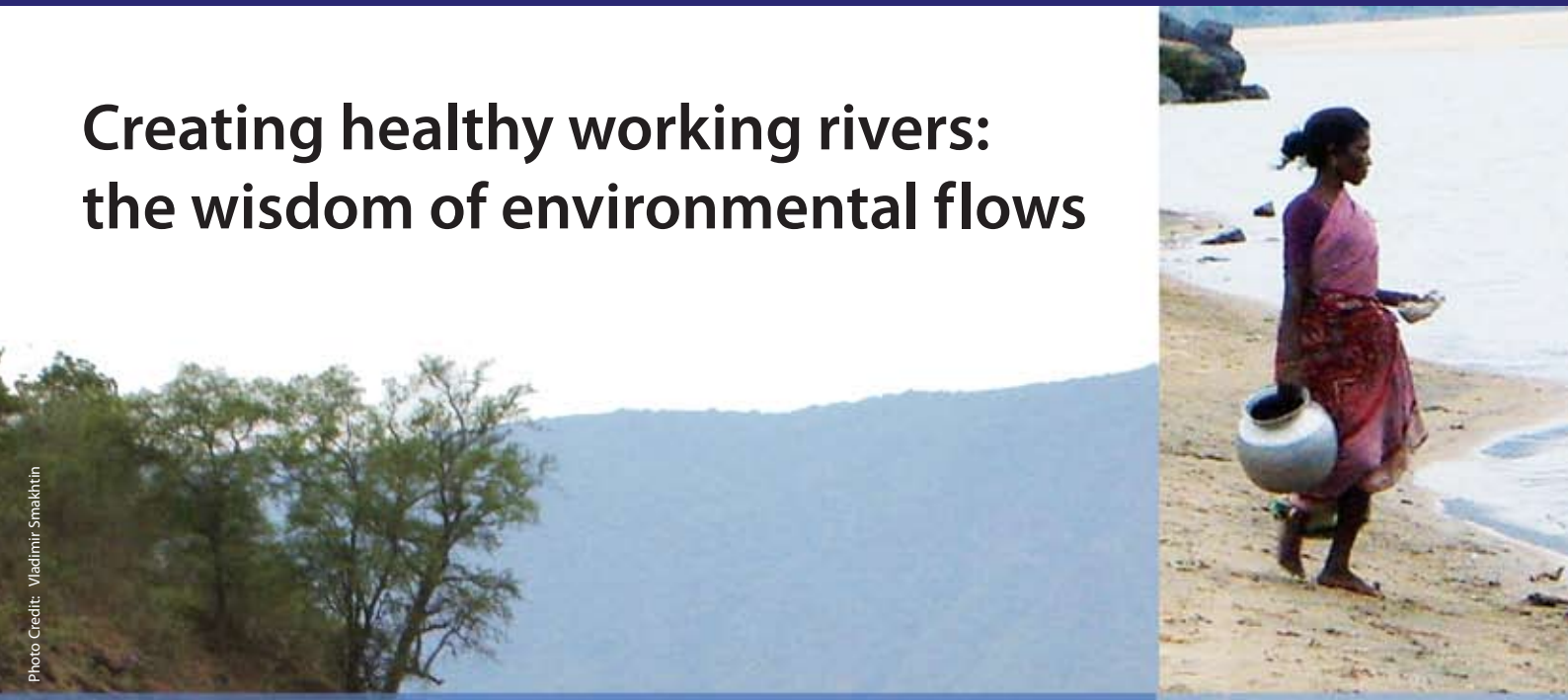

Photo Credit: Vladimir Smakhtin

As demand for water grows, pressure to develop river water resources also grows. At the same time, enough water needs to remain in rivers to keep them in good ecological health. This is the aim of maintaining environmental flows.

But how do we work out how much water a river requires to meet environmental needs, and when does it need that water? So far, most environmental flow assessments have been done in developed countries where river flow data is good and there's plenty of expertise. A new approach, aimed at meeting the need for environmental river flows in India, promises to help developing countries assess the environmental water requirements of their rivers using existing data and current knowledge.

Key findings

- The ecological status of rivers needs to be assessed BEFORE making any decisions to develop water resources.
- Simple tools are already available for rough-and-ready—though quite reliable—assessments of rivers' ecological status and the environmental flows needed to maintain or improve this status.
- These tools can encourage greater investment in building national capacities—to develop detailed methods tailored to specific contexts and to engage ecologists and hydrologists who know their local rivers.
- River flow data is essential, so should be made more accessible. Other priorities are to inventory the ecologically relevant information that already exists in-country and to quantify how hydrology affects river ecology.
- Policy support and enforcement should ensure that water is released and abstraction is limited to maintain the recommended environmental flows.

IWMI
International Water Management Institute

What are environmental flows?

Environmental flows are natural flowsor water left untouched or specifically released to supply the needs of the environment. Not only the amount, but also the timing, quantity and duration are important. As demands for water increase, it's becoming critical to share finite water resources between human and ecological needs. But little is known about what happens when river basin developments modify flow patterns significantly (Figure 1).

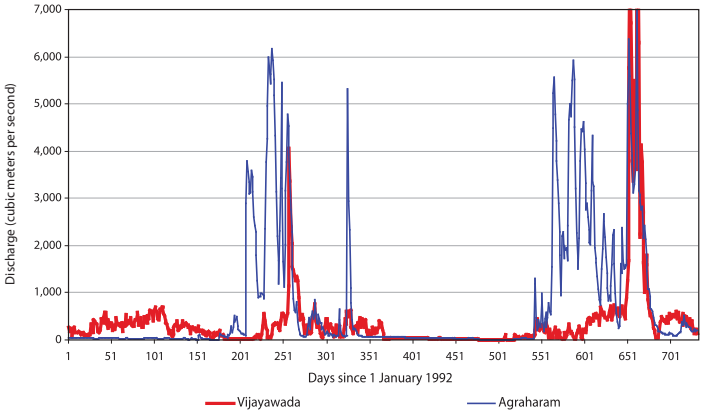

Figure 1. Graphs of daily flow in two towns on the Krishna River, India show the effect of dams. Agraharam is upstream of all major dams. But downstream, at Vijayawada, the flow is highly regulated by releases from the dams. This negatively impacts the pattern of seasonal inundation of the ecologically sensitive Krishna delta.

Why should policymakers be concerned about environmental flows?

Ignoring the need for environmental flows to keep river ecosystems healthy may do serious and even irreversible damage (Box 1). In many developing countries, the realization that environmental water requirements need to be taken into consideration in plans for developing water resources is emerging rapidly.

Box 1. The costs of ignoring environmental flows

Loss of ecosystem services—reducing river flows means less fish, lower quality water and less wildlife. To maintain these and other ecosystem services, water needs to be allocated to sustaining the ecology of rivers.

Loss of biodiversity—making changes to the flow in rivers leads to changes in the diversity of aquatic communities. Species adapted to natural flow regimes will disappear.

Invasion by exotic species—making changes to flow regimes may help spread exotic species, especially when water is transferred from one basin to another.

Environmentally unsustainable development of water resources—there are very few rivers in the world where environmental water requirements have been estimated let alone actually satisfied. This is a major stumbling block to environmentally sustainable water resources development.

For example, frequent flooding in some rivers, often interpreted as too much water, sometimes leads to proposals to create diversions taking water from rivers where there is lots of water to those where there is too little. One such case is India, where there is an ambitious proposal to divert water from the Ganga, Bramaputra and Meghna Rivers to river basins in the south and west of the country where water is scarce. Planners need to be able to consider what ecological differences this may make in both rivers where water is taken out and in rivers into which the water is diverted.

Estimating environmental flows offers a real opportunity to avoid and even work towards reversing past mistakes. Planning for environmental flows should be a priority not only in new developments of water resources and river basins but also in basins where water resources have already been developed (Box 2).

Box 2. Priorities for action

- Assess the environmental requirements for water and check the health of rivers before deciding on any development.
- Make simple preliminary assessments of environmental flows as a first step towards more comprehensive assessments.
- Make use of the information that already exists on the ecology of rivers and the relationships between ecology and hydrology.
- Make aquatic ecology, where possible and feasible, a priority in water allocation—at least in basins or parts of basins which are under-developed at present.
- Take action to keep environmental flows at the level required to maintain rivers in their desired condition.

Why is assessing environmental water requirements a problem?

Daily flow data are the ideal starting point for assessing environmental flows. But, in developing countries these rarely exist and, if they do, they are often not reliable or even accessible because they are classified as confidential government information.

Monthly flow data, if available, are a good alternative. But because natural flow patterns vary so much from year to year, the data sets need to cover at least 20 years. Few, if any, developing countries have unbroken 20-year records of river flow data.

Assessing environmental water requirements is also a relatively new research field. Currently, few developing countries have built up expertise in making these assessments.

Photo Credit: Frank Rijsberman

A way forward—preliminary environmental flow assessment

Using a sample of Indian rivers in geographically different areas and stages of development, researchers have developed a practical method for making preliminary assessments of environmental flow.

Preliminary environmental flow assessment takes into account existing data and current knowledge of the relationships between ecology and hydrology. The method is generic and can be applied to catchments of all sizes in all environments. It's also flexible and can be used to weigh up different scenarios of flow regimes.

By combining estimations of environmental flow and the ecological status of a river the method makes it possible to work out the entire range of possible flows—from lowest to highest—and how often they are likely to occur. The end result is an indication of the amount of environmental flow needed to maintain the ecological functions of a river (Figure 2).

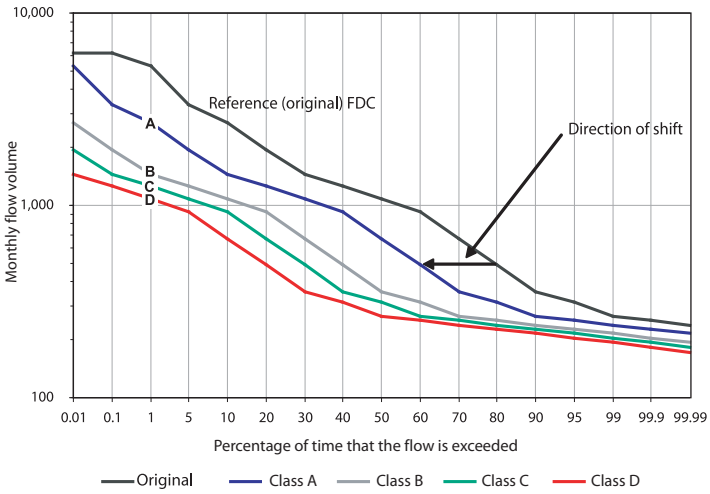

Figure 2. Preliminary environmental flow assessment indicates the monthly flow (millions of cubic meters) needed to maintain the river in a certain ecological condition. The Reference Flow Duration Curve (FDC) represents the flow in a river in its natural state (the curve shows the percentage of time that the flow in a river is likely to equal or exceed a certain amount). The curves to the left show the environmental flows in the same river where it is largely unmodified (classes A and B), moderately modified (class C) and largely modified (class D). The curves to the left preserve the monthly pattern of flow, although the total flow is smaller and flow variability is less because the same flows occur less often.

Estimating the environmental water requirement for Indian rivers showed that the more variable the flow, such as in the Mahi and Sabarmati Rivers, the less the requirement. On the other hand, the Bramaputra and Ganga Rivers, which have very steady flow regimes, require more water.

Another striking feature was that, with a few exceptions, the environmental water requirement to keep the ecology of a river largely unmodified needs to be only one-quarter to one-third of the annual flow. Even in extensively modified rivers, an environmental water requirement of only around one-tenth of annual flow may be sufficient to maintain at least some ecological functions (Figure 3).

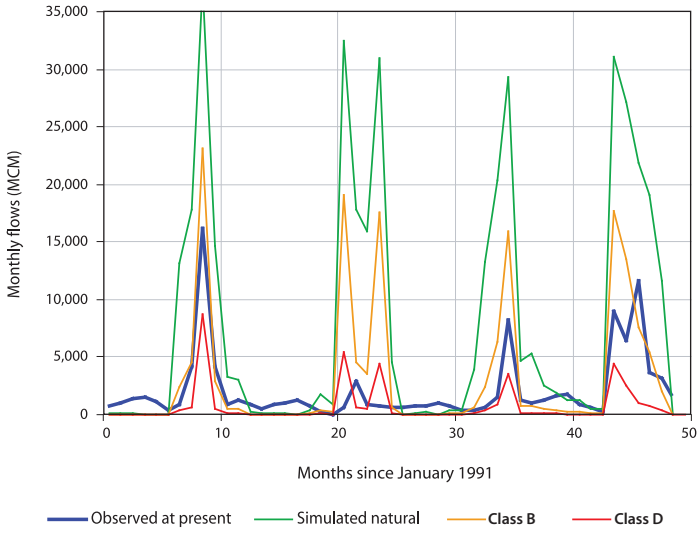

Figure 3. Observed and simulated monthly flow for the River Krishna at Vijayawada, and the environmental monthly flow requirement for the same river if it was slightly modified (class B) or largely modified (class D). (See Figure 2 for environmental flow requirements for different classes of river and Table 1 for classification of the ecological condition of rivers.)

Estimating the ecological condition of rivers

Rivers not only supply water for homes, cities, agriculture and industries but their floodplains and wetlands also have an ecological value that is often overlooked. Modifying flow patterns can damage or destroy the ecology of rivers. Classifying rivers according to their ecological condition gives us a yardstick against which the costs and benefits of changing the ecology can be measured and also gives us a guide for setting and managing environmental flows.

Because ecological information for classifying rivers is practically non-existent in developing countries, IWMI has come up with an alternative that can be used as a temporary measure. This alternative approach uses a set of indicators to score the ecological health of rivers. The final score classifies a river according to its ecological state.

Indicators of environmental health in Indian rivers

Environmental indicators have been widely used in global water assessment programs and can be adapted to assess the ecological state of rivers for the purpose of estimating environmental water requirements. Table 1 shows how a set of such indicators has been used to score the ecological condition of three rivers in India. The scores indicate how sensitive the rivers are to change and answer three important questions: How significant is the river from an ecological point of view? How sensitive is it to change? And what is its current condition?

The indicators used in this case are examples chosen to demonstrate how national expertise and data can be used. More detailed indicators can be developed for specific rivers. It's not a one-size-fits-all approach but one that is put forward to invite and stimulate more sophisticated methods.

A high total score means that the river is pretty much in a natural state, whereas a low score means that the ecology of the river has changed drastically. Once this is known, then various ways of using the score to decide the environmental flow can be applied. The system is most useful for rivers where most changes are likely to happen, i.e. those in the middle of the range where water resources are already comparatively developed.

Developing countries which have never assessed the ecology of their rivers can use this classification as a guide in deciding how to manage their rivers. Knowing the ecological state of a river and the effect that different levels of environmental flows might have—on improving the situation or making it worse—can help inform decisions when compromises have to be made. Such knowledge can also help in setting feasible limits for future water resource development.

The approaches outlined here are meant to stimulate the development of national environmental flow assessment methods further, and illustrate the principle rather than giving set-in-stone prescriptions.

Table 1. Gauging the ecological condition of rivers in India for assessing environmental flows

Adding up the scores for ecological indicators put three rivers in India in different categories. In general, high scores for sensitivity together with high scores for the current ecological condition, such as for the River Periyar, mean that ecological aspects of the river are valuable and need to be maintained with high environmental flows. Lower scores, such as in the Lower Cauvery where the river is highly modified, mean that environmental flows are low.

Ecological indicator	River Periyar	River Ganga (Rishikesh Naraura reach)	Lower Cauvery
What is the ecological sensitivity and importance of the basin?			
Rare and endangered aquatic biota	✓✓✓✓✓	✓✓✓✓	✓✓
Unique aquatic biota	✓✓✓✓✓	✓✓✓✓	✓
Diversity of aquatic habitats	✓✓✓✓✓	✓✓✓	✓✓✓
What is the current condition of aquatic systems in the basin?			
Presence of protected or pristine areas	✓✓✓✓✓	✓✓✓✓✓	✓
Sensitivity of aquatic ecosystem to flow reduction	✓✓✓✓	✓✓✓	
Percentage of watershed remaining under natural vegetation		✓✓	✓
Percentage of floodplains remaining or remaining under natural vegetation		✓	✓
Degree of flow regulation	✓✓✓	✓✓✓✓	✓✓✓✓
Percentage of watershed closed to movement of aquatic biota that are exotic	✓	✓✓✓	
Percentage of aquatic biota that are exotic	✓✓✓	✓	✓✓✓✓
Aquatic species relative richness	✓✓✓✓✓	✓✓✓✓✓	✓✓
Human population density as a percentage of that in the main floodplains		✓✓✓✓✓	✓✓✓✓
Overall water quality	✓✓✓✓	✓✓	✓✓
Total score	43	42	25
Maximum possible	55	65	55
Percentage of the maximum	78	65	45
Environmental class	**B** Slightly developed and/or ecologically important. Biodiversity and habitats are mostly intact.	**C** Although habitats have been disturbed, basic ecosystem functions are still intact. Some species have been lost and some alien species are present.	**D** Large changes in habitats and ecosystem functions. Most species are alien, not indigenous.

This Water Policy Brief is based on research presented in IWMI Research Report 107 (2006): An Assessment of Environmental Flow Requirements of Indian River Basins, by Vladimir Smakhtin and Markandu Anputhas, and IWMI Research Report 114 (2007): Developing Procedures for Assessment of Ecological Status of Indian River Basins in the Context of Environmental Water Requirements, by Vladimir Smakhtin, Muthukumarasamy Arunachalam, Sandeep Behera, Archana Chatterjee, Srabani Das, Parikshit Gautam, Gaurav D. Joshi, Kumbakonam G. Sivaramakrishnan and K. Sankaran Unni.

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