Water Policy Briefing

Issue 15

Putting research knowledge into action

Kelani River, Sri Lanka. Photo credit: Frank Rijsberman

ENVIRONMENTAL FLOWS
Planning for Environmental Water Allocation

IWMI
International Water Management Institute

COMPREHENSIVE Assessment of water management in agriculture

New research shows that, in many parts of the world, not enough water is being left in rivers to sustain the valuable environmental services that they provide to society. This is jeopardizing species that depend on fresh water—as well as the livelihoods of farmers, fishers, and downstream communities and water users.

Tools have now been developed to help planners establish the water needs of specific environments, even when little data is available. But policymakers need to recognize the urgent need to allocate water to satisfy environmental demands.

Planning for Environmental Water Allocation

Overuse of freshwater resources is reducing the ability of aquatic ecosystems to clean up wastewater flows and, in the case of wetlands, reduce flooding—both of which are 'services' that benefit society as a whole. As well as damaging the health of rivers, lakes, wetlands and coastal lagoons, overexploitation is also harming the people—often the poor—who depend on them for clean drinking water, irrigation, and fish resources.

Safeguarding the benefits of freshwater resources means safeguarding their environmental flows—the flow regimes needed to keep freshwater ecosystems healthy and productive and to maintain the services they provide. This kind of active maintenance is often necessary when the flows that feed rivers and wetlands are regulated and when multiple users are competing for the water.

New research has shown that environmental flows are, unfortunately, not being met in many parts of the world. Basins where current water use is already in conflict with water resources needed to maintain ecosystems cover over 15 percent of the world's land surface and are populated by over 1.4 billion people.

Policymakers and planners therefore need to ensure that environmental flows are assessed, defined, and delivered and that stakeholders participate fully in the process. Fortunately, simple and quick methods of assessing environmental flows are now available to help planners take the first steps needed.

River basins at risk worldwide

Water resources, current and future food security, and water use and scarcity have all been the subject of many global assessments. Until recently, however, studies have only considered agricultural, domestic and industrial water needs in relation to the total amount of water available. The water requirements of ecosystems, and the needs of the people who depend on them, have not been taken into account. IWMI therefore conducted the first ever global assessment of environmental water needs. This pinpointed several 'danger areas' in which environmental needs are not being met (the red areas in Fig. 1) because too much water is being withdrawn.

The study clearly illustrates that the problem of water scarcity is actually far more serious—and widespread—than previous assessments suggested. This raises some obvious problems, as allocating more water to make up for the shortfall being suffered by the environment will clearly leave less water for other sectors. However, this must not be seen as a reason to ignore the issue. Failing to allocate enough water for environmental needs is likely to cause the ecosystems of the basins marked in yellow and red (Fig. 1) to deteriorate further, seriously affecting local livelihoods. A compromise will therefore have to be struck between providing water for 'development' and providing water for nature, because ignoring environmental demands may ultimately result in heavy medium- and long-term costs (see Box 1).

Box 1. What is at stake? The costs of not maintaining environmental flows.

Public health risks—reduced river flows mean less available drinking water and more concentrated pollution.

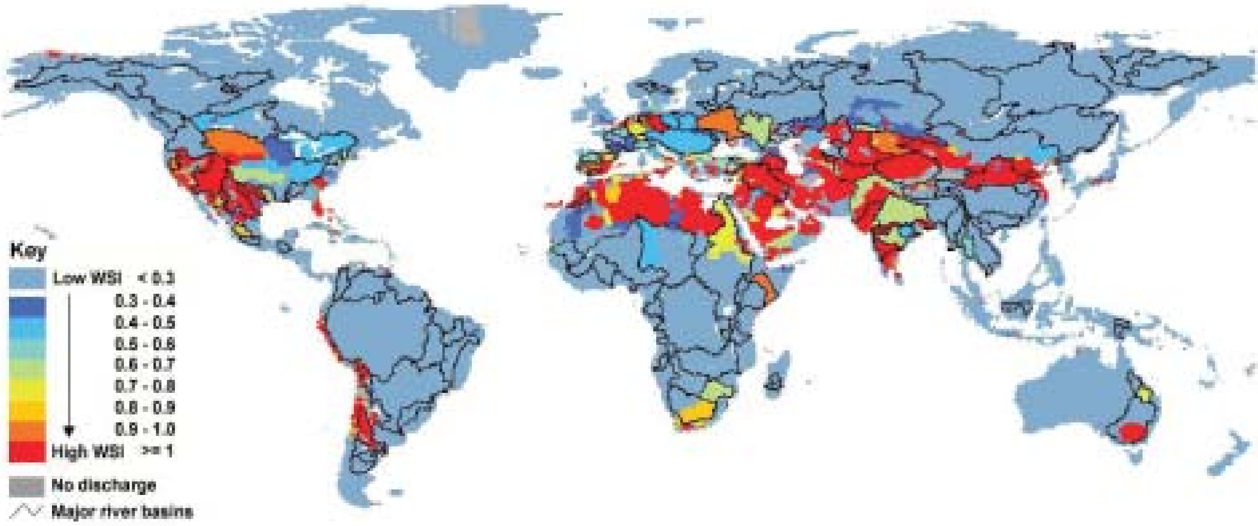
Loss of food security and damage to livelihoods—a decrease in the amount of water available means less water for agriculture. It also reduces fish stocks, and damages both commercial and subsistence fishing. This has a direct impact on the poor who have few assets and rely on common property resources such as rivers and wetlands. Wild fish, for example, are often their only source of protein.

Loss of biodiversity and associated potential revenue—loss of biodiversity and resource degradation prevents countries from taking advantage of the revenue earning options offered by recreation and tourism.

Increased water-related conflict—Resource degradation and loss result in conflict, as users compete to satisfy their needs.

This Water Policy Briefing is based on research presented in the Comprehensive Assessment Research Report No: 2 (2004): Taking into Account Environmental Water Requirements in Global-scale Water Resources Assessments, by Vladimir Smakhtin, Carmen Revenga and Petra Döll; IWMI's Research Report No. 89 (2005): Planning for Environmental Water Allocations: An Example of Hydrology-based Assessment in the East Rapti River, Nepal, by Vladimir Smakhtin and R.C. Shilpakar; and *Environmental Flows* newsletter, *http://www.iwmi.cgiar.org/pubs/Newsletters/Index.htm*

Figure 1. A new view of water scarcity: a map of a water stress indicator (WSI) which takes into account environmental water needs. These environmental needs—the amount of water required to keep freshwater ecosystems in a 'fair' condition—were calculated using global models of hydrology and water use. Red areas show where these needs aren't being satisfied, because too much water is already being withdrawn for other uses.



New approaches are needed

Currently, however, decision makers in many developing countries are failing to see that a balance needs to be struck between allocating water for direct human use (agriculture, industry, power generation and domestic supply) and allocating it for indirect human use (through the benefits that well-maintained ecosystems provide). As a result, water is being managed in a fragmented and sectoral way, and short-term needs and gains are being prioritized. This is causing many freshwater ecosystems to degrade to the point that they can no longer support biodiversity or food production. To prevent or reverse this, policymakers must consider the needs of freshwater environments and the priorities for action (see Box 2).

Box 2. Priorities for action

- Recognize the importance of allocating water to maintain environmental flows.
- Ensure that water management is holistic, and takes account of the needs of all sectors, including industry, agriculture, and the environment.
- Identify the desired environmental status of a river—stakeholders should negotiate to identify a compromise that they are all willing to accept.
- Establish, using models, the amounts of water and the timing, frequency and duration of flow needed to achieve the desired environmental status.
- Implement the required flow regimes by controlling discharges and withdrawals and monitoring the resulting flows and their environmental effects.

Areas where water resources are just beginning to be developed offer a real opportunity to avoid past mistakes. Planning for environmental flows should therefore be a priority in such regions. However, policymakers also urgently need to establish environmental flows in those basins in which water resources have already been developed—although this will be more difficult in practice.

In either case, the process will be made easier by the fact that the environmental flows concept is already being applied in some form in 72 countries around the world. As a result, some of these countries (e.g. South Africa and Australia) have a wealth of practical experience which decision makers can tap into.

Environmental water assessment at the global scale

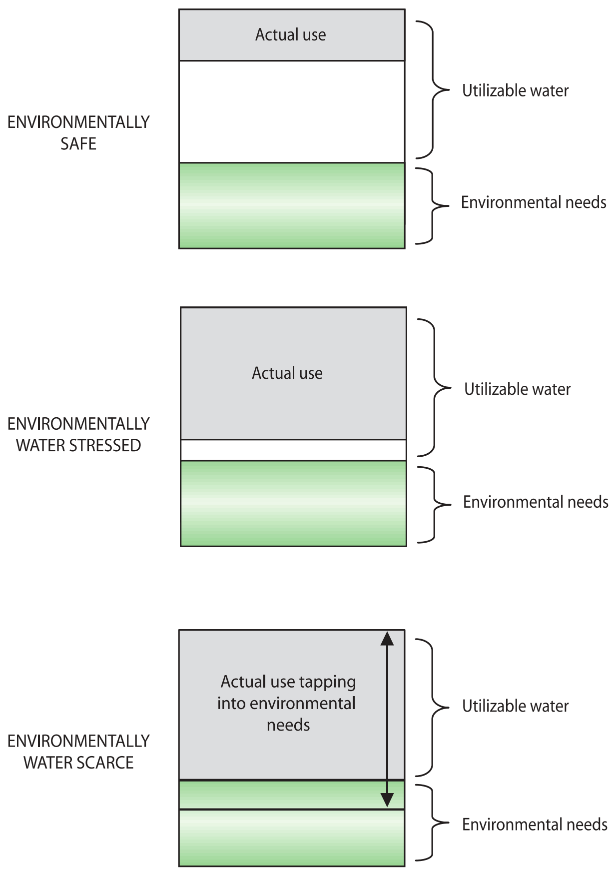
Estimating environmental water needs

Because ecological information is almost completely lacking for most of the world's river basins, IWMI's global assessment only used hydrological data. Based on this, researchers estimated the low-flow and high-flow environmental water requirements of river basins around the world. In each case, these were added together to give the total volume of water that should be allocated to each river over the long term, on average, in order to maintain its environmental functions.

The study estimated that, generally, the amount of water required by each river to keep it relatively healthy—its 'environmental water requirement'—ranged from between 20 percent to 50 percent of its total mean annual flow. It should be stressed, however, that these volumes of water are only enough to maintain those ecosystems in a 'fair' or 'moderately modified' condition.

Though the global estimates obtained aren't precise, they do provide useful measures for developing countries which have never assessed their environmental flow requirements. Such rough figures could be used to set priorities for action (see Box 2). Or, they could be 'downscaled' and used as a starting point for more site-specific estimates, based on more detailed information for a particular region or basin.

Figure 2. A schematic representation of total water resources, current water withdrawals (actual use) and environmental water needs, in river basins that are 'environmentally safe' (top), 'environmentally water stressed' (middle) and 'environmentally water scarce' (bottom). 'Utilizable water' refers to the amount of water available for use by people after the environmental water requirements have been met.



Estimating environmental water scarcity

The study also identified specific regions in which overexploitation of freshwater resources is threatening the water requirements of ecosystems (Fig. 1). A global water-use model was used to calculate basin-level water withdrawal. This took into account the amount of water withdrawn for irrigation and use by, livestock, households, thermal power plants, and the manufacturing industry.

Comparing total water use with the total amount of water available and the environmental water needs already calculated by the study, allowed researchers to classify the basins into three groups: (1) 'environmentally safe', (2) 'environmentally water stressed' and (3) 'environmentally water scarce' (Fig. 2).

What was startlingly obvious was that most water resource models and scenarios underestimate water scarcity, because they don't take environmental water needs into account. As a result, they give the 'all clear' (Fig. 3) to areas that are actually suffering severe environmental water shortages (Fig. 1).

As water withdrawals increase, more river basins will move from the 'environmentally safe' category into the 'environmentally water stressed' and 'environmentally water scarce' categories. The process is unlikely to be reversed until agriculture uses water more efficiently (to get 'more crop per drop') and environmental flow allocation is integrated into river basin management plans.

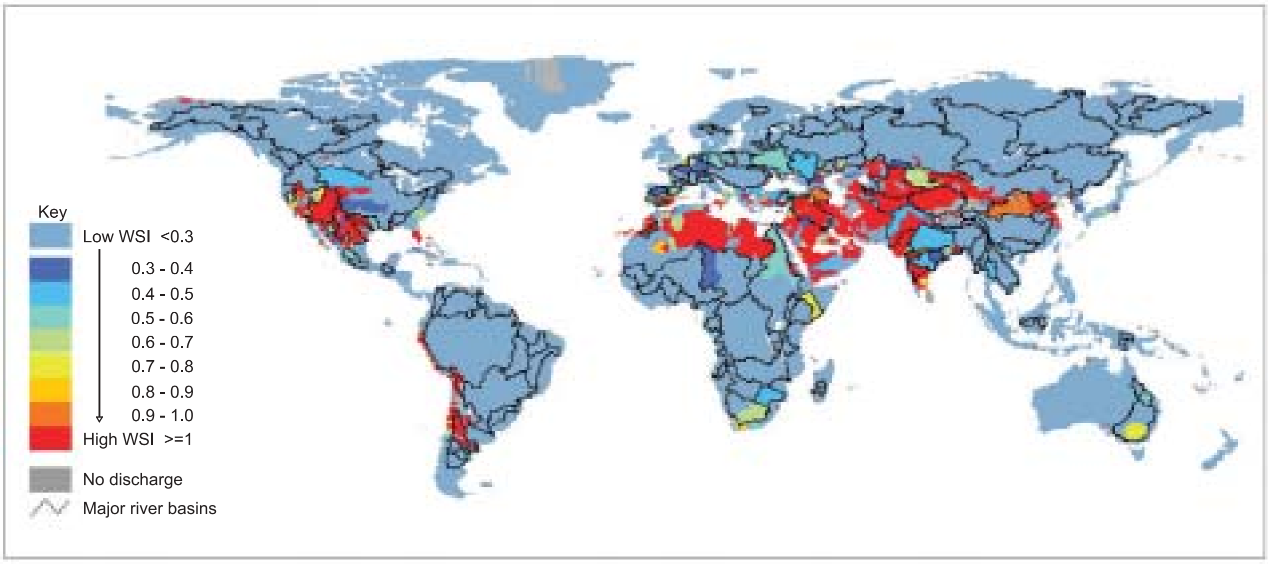
What exactly are environmental flows and how can we assess and deliver them?

Definitions vary

There is no universally agreed definition of environmental flows. As a result, researchers refer to them using a variety of terms, including 'minimum flows', 'environmental demand', and 'in-stream flow requirements', each of which sometimes describes a slightly different concept. However, a good general blanket definition describes environmental flow regimes as discharges of a particular magnitude, frequency and timing, which are necessary to ensure that a river system remains environmentally, economically and socially healthy.

Simply put, environmental flows represent a compromise between water resource use and watershed

Figure. 3. A map of the traditionally used water stress indicator, i.e. water withdrawals divided by the average total amount of water available per year (mean annual river runoff). This does not take into account environmental water needs.



developments on one hand and keeping rivers in a healthy, or at least reasonable state on the other. But they don't just consist of set volumes of water flowing through a river. They have to be varied at different times of the year. This helps to keep the ecosystem in good working order by mimicking the natural variability seen in river flows (i.e. rivers flood at some periods of the year and drop to low levels at others).

This variability is very important to the health of ecosystems. Low flows, for example, trigger migration and reproduction within different animal species. High flows, by the same token, help some riverside plants to reproduce and also ensure that river channels keep their shape and don't silt up.

Assessing the environmental flows needed

The environmental flow appropriate for an area is decided using a process known as Environmental Flow Assessment (EFA). This involves identifying a number of different flow regimes and evaluating the different environmental and social benefits and costs associated with each. The various scenarios identified must then be discussed with all the stakeholders involved, so that they can choose the one which best represents all their needs.

The methods used to conduct EFAs vary from 'quick-and-dirty' low-confidence 'desktop' techniques to detailed, more time-consuming, comprehensive approaches which involve field work and the use of experts from many disciplines. The first are suitable for initial planning, and the second for detailed studies, particularly in water systems under stress. Ideally, both types of EFA should be used when drawing up national environmental water policies.

The challenges

Even using these tools, however, it isn't easy to identify the 'correct' environmental flow for a particular system, because this depends on its hydrology and ecology and also on the condition in which the stakeholders agree it should be maintained.

Additionally, because freshwater ecosystems have a complex ecology, there are no hard and fast water-volume thresholds below which the system will simply collapse. Degradation happens gradually— there are no immediately obvious lines it is dangerous to cross. However, there are some general rules of thumb which can be applied.

If the river is to be maintained close to its pristine state, as much as 60-80 percent of its total annual natural flow may be required. However, in highly developed river basins, where water-reallocation is difficult, an environmental flow component of as little as 15-20 percent may be acceptable. But allocating 1-10 percent of the total natural flow to environmental flow is unlikely to ensure a healthy river ecosystem.

Environmental flows can be delivered in many ways

One way of delivering environmental flows is through the use of dams, channels, and pumps, to add or remove water. For example, water can be released into rivers to increase dangerously low flows or to cause flooding—either by allowing the first flood waters of the season into the system or by adding stored water to augment a flood already underway naturally.

Box 3. Environmental flows: perceptions and implications for water management

A recent survey of 272 water professionals in 64 countries showed that a large majority (88 percent) agreed that environmental flows are an essential element of efforts to achieve sustainable water resource management.

However, some respondents were concerned that allocating water for environmental purposes might increase water-related conflicts. Reasons for the failure to implement environmental flows in some areas were cited as (1) a general lack of awareness among stakeholders, (2) insufficient policy guidance, and (3) insufficient management capacity.

Identifying the direct and indirect benefits of environmental flows and then communicating them effectively to communities and water users were seen as essential tasks.

Infrastructure such as dams and pumps can also be used to regulate water flows to other environments. Examples of such uses include simulating the natural floods that flush out salty coastal lagoons and restricting the water supplied to wetlands, to mimic the dry periods that affect them naturally.

In those basins where flows aren't regulated, land-use management options can be used to manage water flows indirectly. For example, appropriate management can increase groundwater recharge. This in turn increases outflow from aquifers into rivers.

Planning for local environmental water allocation

New methods are available

In recent decades, various environmental flow assessment (EFA) methods have been developed that are suitable for planning purposes. A database of these methods, and summaries of the various studies that have used them, have been developed by IWMI and are available at *http://www.lk.iwmi.org/ehdb/EFM/efm.asp*.

Problems arise, however, because the detailed hydrological data needed to apply these methods is often lacking in developing countries. Planners also face difficulties because the methods available are often not tailor-made for the specific conditions found in their country or region.

To find ways of overcoming these difficulties, IWMI applied several hydrology-based, 'desktop' assessment methods in Nepal. The East Rapti River was chosen for the case study, because it runs through the World Heritage Site of the Royal Chitwan National Park. This is one of Nepal's main tourist attractions, and supports many endangered plants, mammals and water birds. In addition, local people, including asset-poor tribes, rely on the river for small-scale irrigation, fishing and timber collection after floods.

However, areas upstream of the park are undergoing rapid urbanization and industrial development. Therefore, in order to safeguard the quantity and quality of water in the river, there is an urgent need to assess and implement environmental flows. This will help to secure the area's natural beauty and safeguard the livelihoods of the rural people who live there.

Hydrological information can be generated where little data exists

The first obstacle the study needed to overcome was the fact that no specific data was available for the park. Every EFA method requires time series data on natural river flow. The researchers therefore found a way to extrapolate such information from data collected in other areas.

This involved using measurements taken at gauging stations at three upstream sites to construct a general flow duration curve—a curve which describes the natural frequency of flows of different sizes. This was then adapted to three sites within the park, by calculating the annual flow at each site using a country-level equation and altitude and rainfall data. The newly-constructed flow-duration curves were then used to predict daily river flow at each site, so generating the flow time series needed by the EFA (Fig. 4).

Methods can be modified for use in different regions

The study's researchers faced another common problem, in that some of the desktop techniques available were too complicated for use in the study, while others were too simplistic and did not take into account recent hydroecological theories. None were suitable for immediate application.

Researchers therefore adapted the initially overcomplicated 'range of variability' (RVA) approach, so that it used only 16 variables to describe river flow rather than 32. This allowed them to calculate environmental flows which fluctuated within the range of variability found to occur in nature (Fig. 5).

The potential exists to adapt other useful methods (such as the South African 'Desktop Model') to the needs of different regions or countries. However, in every case the modified method would need to be tested before it could be applied reliably. IWMI is therefore working to adapt the South African model for use in other countries.

Once these methods have been adapted, planners in developing countries will be able to use them to effectively estimate water allocations for the environment, even when little hard data is available. This will allow them to take the first steps necessary to safeguard at least some of the environmentally and socially important functions of their countries' rivers.

Figure 4. Simulated daily river flows at a site within the East Chitwan National Park, based on real flow data from upstream gauging stations outside the park. The figure shows that the simulated flows are quite realistic, as their peaks occur at the same time as those of the real flows (although the actual size of the flows at the two locations is of course different). In developing countries where few gauging stations exist, simulations such as these provide valuable hydrological information that can then be used to assess environmental water needs.

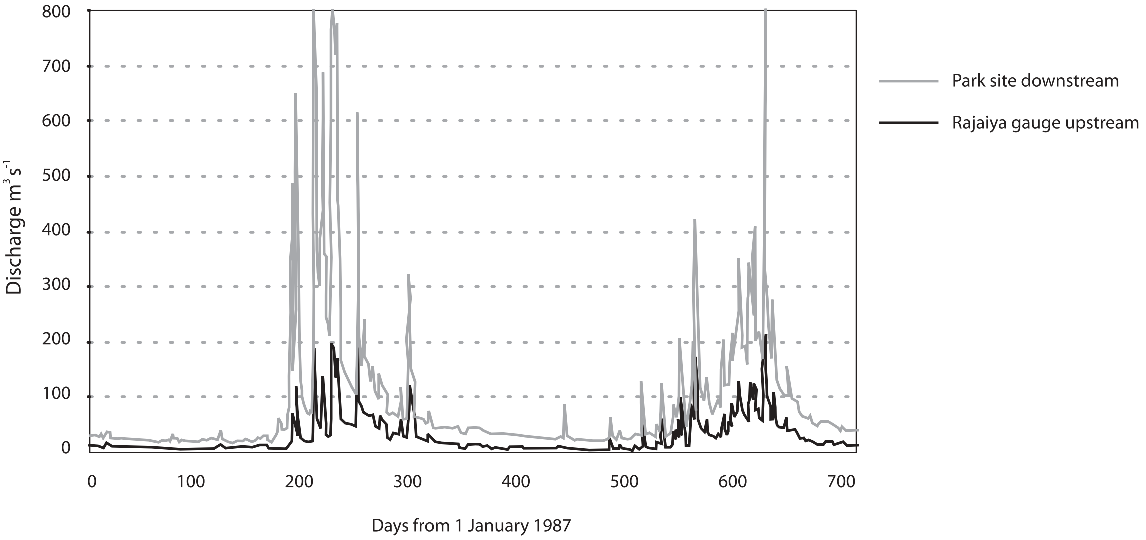
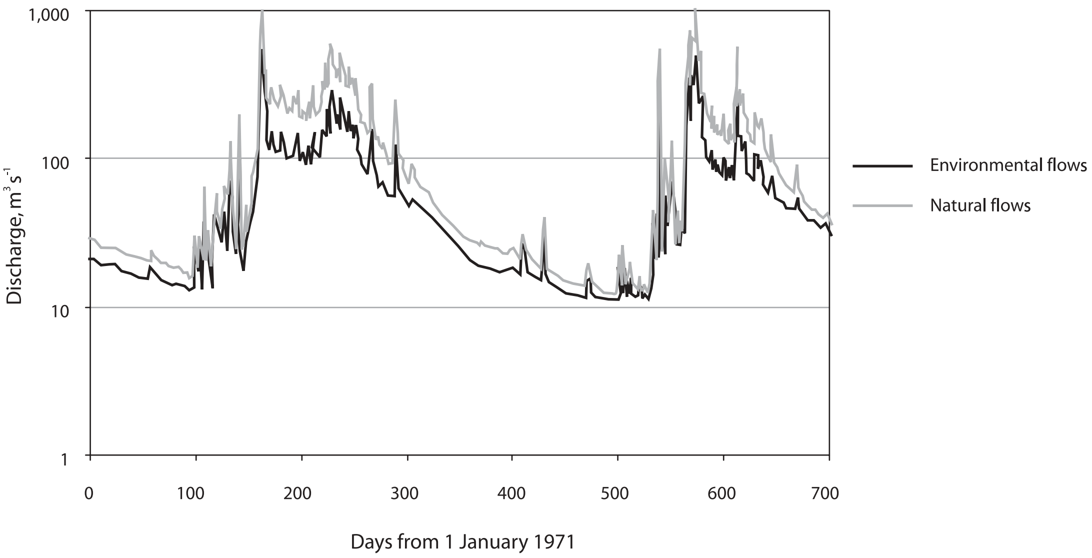


Figure 5. Target estimated daily environmental flows (dark line) River flows should ideally not fall below the dark line. The gap between the two lines represents the amount of water that could be withdrawn safely from the river at a particular site in the National Park. The natural flows (light line) were simulated as described in the text.



Akosombo, Ghana. Photo credit: Sanjini de Silva

Water Policy Briefing Series

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About IWMI

IWMI is a non-profit scientific organization funded by the Consultative Group on International Agricultural Research (CGIAR). IWMI's research agenda is organized around four priority themes covering key issues relating to land, water, livelihoods, health and environment:

Theme 1: Basin Water Management: *understanding water productivity*
Theme 2: Land , Water and Livelihoods: *improving livelihoods for the rural poor*
Theme 3: Agriculture, Water and Cities: *making an asset out of wastewater*
Theme 4: Water Management and Environment: *balancing water for food and nature*

The Institute concentrates on water and related land management challenges faced by poor rural communities in Africa and Asia. The challenges are those that affect their nutrition, income and health, as well as the integrity of environmental services on which food and livelihood security depends. IWMI works through collaborative research with partners in the North and South, to develop tools and practices to help developing countries eradicate poverty and better manage their water and land resources. The immediate target groups of IWMI's research include the scientific community, policy makers, project implementers and individual farmers.

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