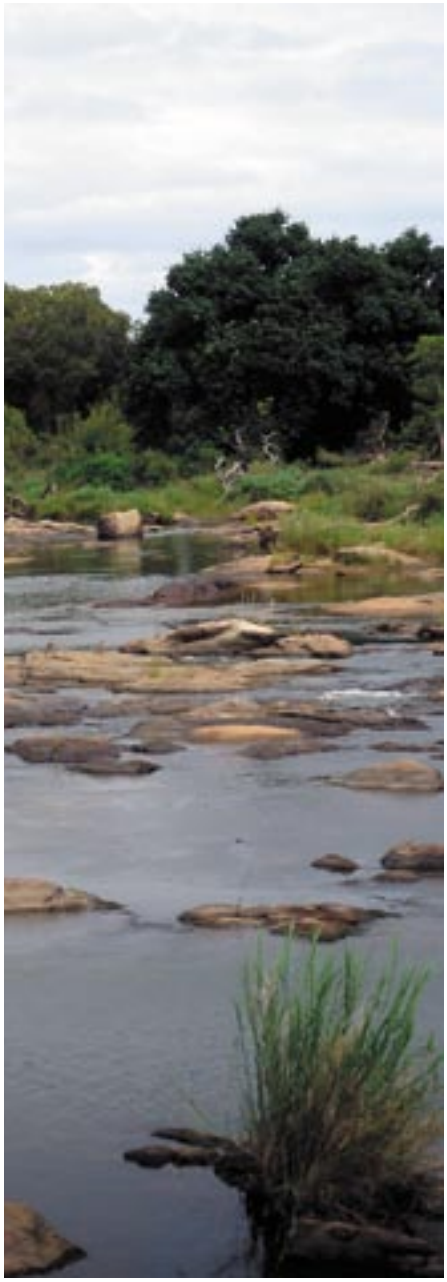
Taking from the Top: Looking Upstream in India

River basin closure has developed into a sizeable challenge of extreme importance. Over the past 50 years, many of the river basins that support the world's breadbaskets have already or will soon become closed basins. Like the basins themselves, the world's eye on this critical issue seems to be closing at a time when it can least afford to look away. Applying the findings of a groundwater use case from India, this article sheds some light on this blind spot in water resource management to see what is going on downstream in the great sub-continent.



When water is used for irrigation, the consumed water returns to the atmosphere as part of the biomass production process and the rest forms a return flow to the river system. Photo: Cecilia Martinsen, SIWI.

Within water resources management there is a tendency for nearly exclusive focus on how water is withdrawn and used, while little attention is paid to what happens to the water after it is used. When water is used for irrigation, for instance, the consumed water returns to the atmosphere as part of the biomass production process and the rest forms a return flow to the river system. The smaller this return flow, the larger is the depletive effect the irrigation has on the streamflow. But the water consumed may produce more or less crops depending on the amount of pure evaporation losses.

It is now evident that the improvements and increased utilisation of irrigation water that was the backbone of the increased global food production of the "Green Revolution" have come at a cost – large-scale river depletion has changed the face of the planet. Today, 15 percent of continental land area and as many as 1.4 billion people are now living in closed river basins.

A river basin is said to be closing when committed outflows required to meet environmental flow needs, including sustenance of estuarine and coastal ecosystems, flushing sediments and controlling saline intrusion, can no longer be met. Generally, river basin closure is defined by a withdrawal-to-availability of water ratio of greater than 0.7. Today, 15 percent of continental land area and as many as 1.4 billion people are now living in closed river basins.

Groundwater Irrigation and Decreasing Water Tables – An Indian Case

It is not only surface water use that is involved in these processes. Surface water and groundwater are interconnected, which means that the consumptive groundwater use can strongly impact streamflow. The Upper Musi Basin provides a clear example of this link between large-scale groundwater use and its consequences on decreased inflow to downstream reservoirs.

The sub-basin of the Krishna River, in Andhra Pradesh, India, is both an important source of drinking water for the city of Hyderabad and also an important source of irrigation water for many villages downstream. One major driver of increased water use is the growing demand for fruits and vegetables in the city downstream, which requires a source of blue water. Farmers respond by tapping into groundwater, or harvesting rain, to provide irrigation for their crops – practices that are central to their livelihoods. Groundwater withdrawals thus support market-oriented agricultural production and help meet rising demand for vegetables and fruits from urban populations.

In the basin, there is serious concern over decreasing water table and streamflow levels in large parts of the Upper Musi catchment. No longer are the flows large enough to refill two reservoirs. As groundwater use has been increasing, inflows into the two reservoirs that are supposed to secure downstream water use in the basin are decreasing. In addition to consumptive/depletive water use, increased water conservation works to harvest more rain. This may also have contributed to decreases in the flows supplying the reservoirs.

Twenty years of intensive groundwater monitoring showed that actual groundwater recharge between pre-monsoon and post-monsoon situations in the upstream basin occured, indicated by rising water tables. Interestingly, in most years the recharge was greater when the pre-monsoon groundwater withdrawal was greater.

Thus, while the results for the 20-year period seemingly indicated that conditions were good for rapid groundwater recharge, and despite isolated locations where wells recovered and groundwater use was locally sustainable, over the longer term groundwater tended to be overused in large parts of the basin.

Photo: Mats Lannerstad

One major driver of increased water use is the growing demand for fruits and vegetables in the city downstream, which requires a source of blue water. Farmers respond by tapping into groundwater, or harvesting rain, to provide irrigation for their crops.

Consumptive Upstream Water Use "Robs" Water on its Way Downstream

Increased consumptive use of groundwater upstream has effectively robbed water that would otherwise have contributed to reservoir inflow. In the Upper Musi river, this has contributed to basin closure.

In spite of the basin being closed, groundwater sources are relatively easy for farmers to use. It has been extremely difficult to control the use of these additional sources of water, and the connection between additional groundwater use and declining reservoir supplies is not well recognised and difficult to manage. This case shows that for proper planning, all sources of water within a basin including groundwater and rainwater, and not just the river flows, must be considered and brought into the overall context of water resource management.

Major Downstream Effects for Delta Livelihoods

Since upstream tributaries like the Musi river contribute to the flow in the Krishna river, depletion of tributary inflow will be propagated downstream. If expanded further, the phenomenon will have major implications for life in the delta regions of several large rivers in Southeast India. This particular case highlighted the Krishna River, but more examples in India include the Godavari and Cauvery rivers, which also suffer from similar upstream developments. This means that the well-established downstream deltaic irrigation systems in these three large Indian rivers may be receiving less and less surface water. Ultimately, the former command areas that once enjoyed copious quantities of water will have to adapt to this new reality and turn to conjunctive uses of local groundwater, surface water and rainfall.

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The article is based on a paper by Venkateswara Rao et al., which was presented at the 2006 World Water Week in Stockholm.

Surface water and groundwater are interconnected, which means that consumptive use of groundwater resources can strongly impact streamflow. Photo: Jan Lundqvist, SIWI.