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Environmental Flow Management Strategies through Flow Augmentation—Concepts on Alternatives

Chachadi A G[1] and Rhythm Warik
Department of Earth Science, Goa University, Taleigao Plateau, Goa–403206, India
E-mail: [1]chachadi1@gmail.com

ABSTRACT: *There is a need to ensure environmental quality and ecological requirements by allocating adequate environmental-flows in regulated rivers. Thus, the concept of minimum flow came into existence in 1970's. In 2007 the Brisbane Declaration on Environmental Flows (EF) was endorsed by more than 750 practitioners from more than 50 countries. The declaration announced an official pledge to work together to protect and restore the world's rivers and lakes. By 2010, many countries throughout the world had formulated environmental flow policies and laws to ensure priority allocations of water to river ecosystem after the basic human needs have been satisfied, however, their implementation remains a challenge. The status of EF research in India at present may be categorized as being in its infancy. India faces a number of water related challenges, including increasing water scarcity and competition for water between different sectors and states. The first National Workshop on Environmental Flows, held in New Delhi in March 2005, highlighted a great interest in the concept of environmental flows in India. Due to several constraints there are very few examples in the world where environmental water requirement are actually satisfied by actual EF releases. This is one of the major stumbling blocks on the way to environmentally sustainable water resources development in India. Therefore, due consideration has to be given to experiment alternative strategies for augmenting the e-flows besides considering relevant policy support and their enforcement. In the present paper we have put together and discussed some concepts on alternatives which can enhance the availability of required flows in the downstream of the regulated rivers so that the required environmental flows are fully met when such releases from the upstream structures are not adequate.*

Keywords: Environmental Flow, Flow Augmentation, Strategies, Bandhara.

INTRODUCTION

Increasing demands for the allocation of water for off-stream uses has resulted in substantial changes in the stream flow regimes in many streams and these changes in stream flow have contributed to major impacts on aquatic habitats and ecology. For the better understanding of the system, thus the concept of Environmental Flows came to existence in 1970's. Acreman and Ferguson (2010) explained the term to denote the quantity, timing, duration, frequency, and quality of water flows required to sustain freshwater, estuarine and near shore ecosystems and the human livelihood that depends on them. By the 1990s, scientists came to realize that the biological and social systems supported by rivers are too complicated to be summarized by a single minimum flow requirement (Bunn and Arthington 2002; Richterand Thomas, 2007) and thus assessment and management of the Environmental Flow has gained more importance. The status of the environmental flow research is in the initial stage in India.

In a regulated river system the scheduled releases from the reservoir are always constrained due to various compulsions. Therefore the downstream flows are substantially reduced. As the compulsions are invariably remain unchanged it is necessary to think and adopt alternative ways of compensating for the reduced environmental flows. In the present paper some concepts have been discussed which include intra basin and in-stream hydrological modifications for enhancing the availability in the stream flows.

REDUCING EVAPORATION LOSSES FROM DAM RESERVOIRS AND CANALS

For the sub-tropical country like India, the evaporation loss of about 450 MCM of water every month from an area of 2,000 $km^{2,}$ which amounts to an annual loss of 5,400 MCM. The evaporation losses for West coast of India, South of 20°N latitude are about 150cm (CWC, 1988, 2006). Thus reducing the water losses due to evaporation could be considered as source of water. Evaporation can occur from reservoir, tanks, ponds, transmission canals, field channels or any open water body. The conventional methods of reducing evaporation losses from large water bodies using chemical and other mechanical covers is found to be inefficient and not economical. However, the area covered by these water bodies can be effectively put to an alternative use while simultaneously reducing the evaporation losses and earning the carbon credits for greener energy. This can be achieved by using reservoir areas for setting up the solar power farms (Figure 1). Now, several start-up companies see potential for solar panels that float on water. Sunengy from Australia with Tata Power, has proposed to build a small pilot project on a hydroelectric reservoir near Mumbai. Solaris Synergy of Sydney has planned to float solar array units on a reservoir in the south of France in a trial with the French utility EDF. Gujarat Government has already started installation of solar units on major canals (Figure 2).

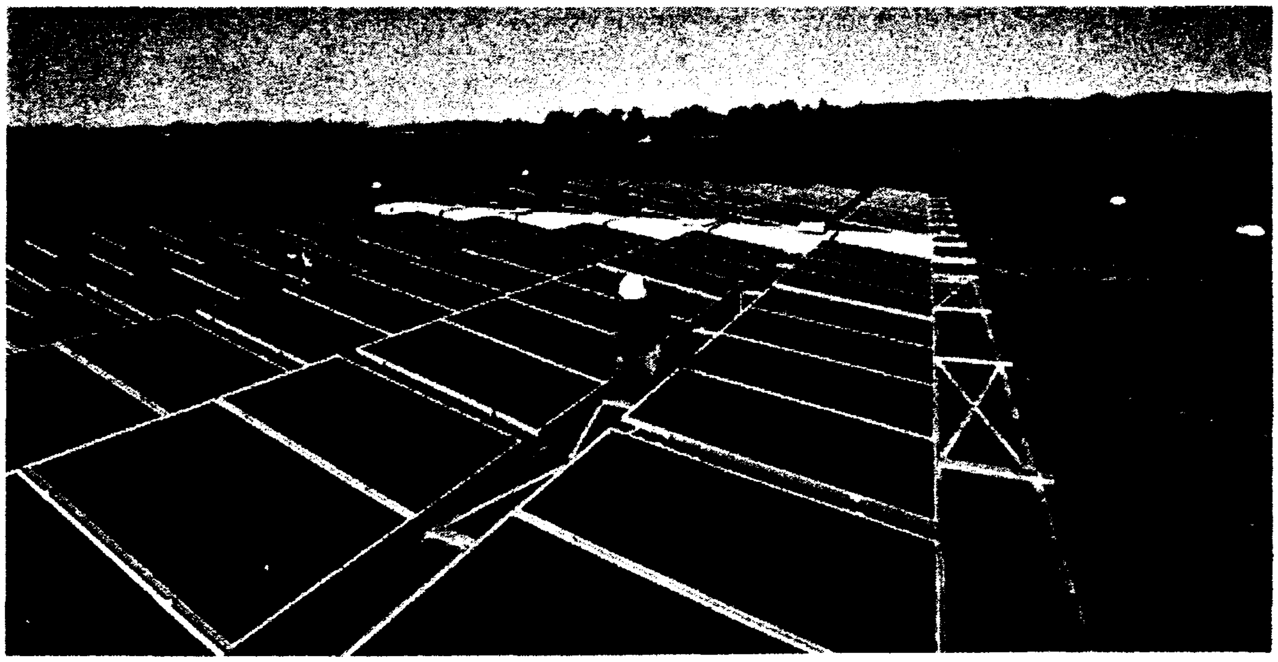

Fig. 1: Solar Aqua Farm on Irrigation Pond in California

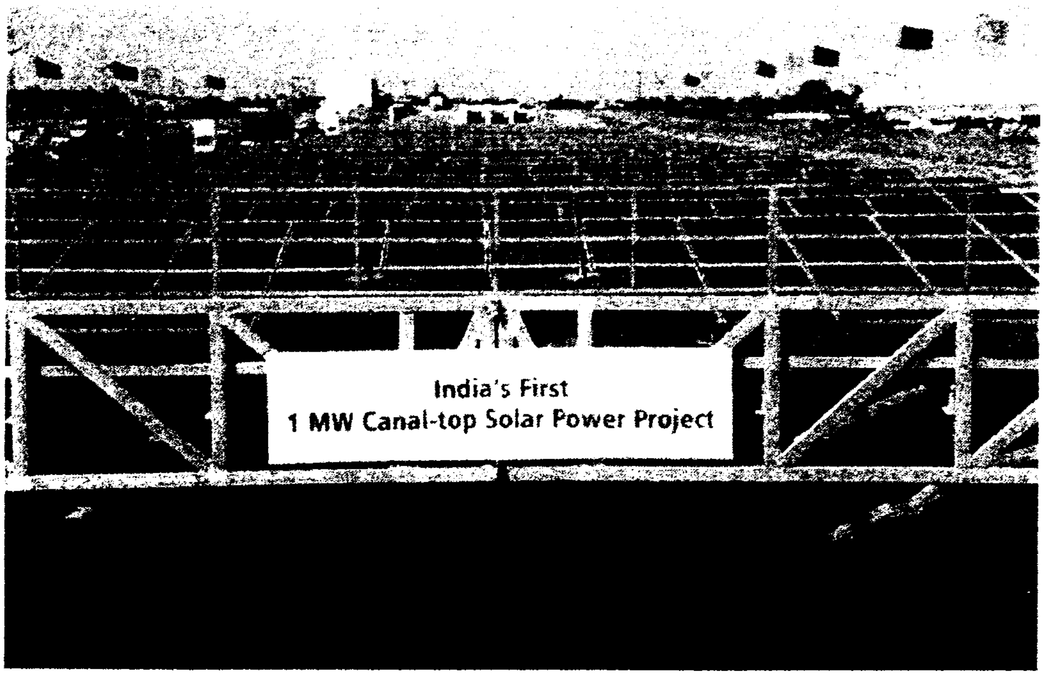

Fig. 2: Solar Power Unit on Canal in Gandhinagar, Gujarat

Construction of Check-Dams in Downstream Catchment Area

A **check dam** is a small dam, which can be either temporary or permanent, built across a minor channel or drainage ditch (Figure 3). These reduce erosion and gullying in the channel and allow sediments and pollutants to settle and enhance recharge to groundwater. They also lower the speed of water flow during storm events. Check dams can be built with logs, stones, or sandbags. Many check dams tend to form stream pools. Under low-flow circumstances, water infiltrates into the ground, evaporates, or seeps through under the dam. Under high flow conditions, water flows over or through the structure. Coarse and medium-grained sediment from runoff tends to be deposited behind check dams, while finer grains are usually allowed through. Extra nutrients, phosphorus, nitrogen, heavy metals, and floating garbage are also trapped increasing their effectiveness as water quality control measures. Serial construction of check dams on the lower order streams at regular interval could provide a storage structure which could hold water and increase the groundwater recharge. This water could reappear over a period of time as seepage or base flow in the river system which could be available for the later period.

Fig. 3: Check Dams on First Order Drain on a Hilly Slope

In-Stream Water Storage Structures

Bandharas are the engineering structures meant for holding and creating temporary storage of the lean period base flow within River banks (Figure 4). Series of bandhara scan augment supplies to water treatment plants, create non monsoon ground water recharge, and retard the base flow from the river banks in the riverine system. A notable feature of these development projects is that the benefits will come without any environmental destruction/degradation and their design features ensure that the rivers do not silt up due to the storages. Beneficial effects of these schemes can be felt in a tangible and substantial way and river flood plain agriculture will benefit due to the uninterrupted supply of irrigation water thereby opening up innumerable avenues for growth and prosperity of the marginal farmers.

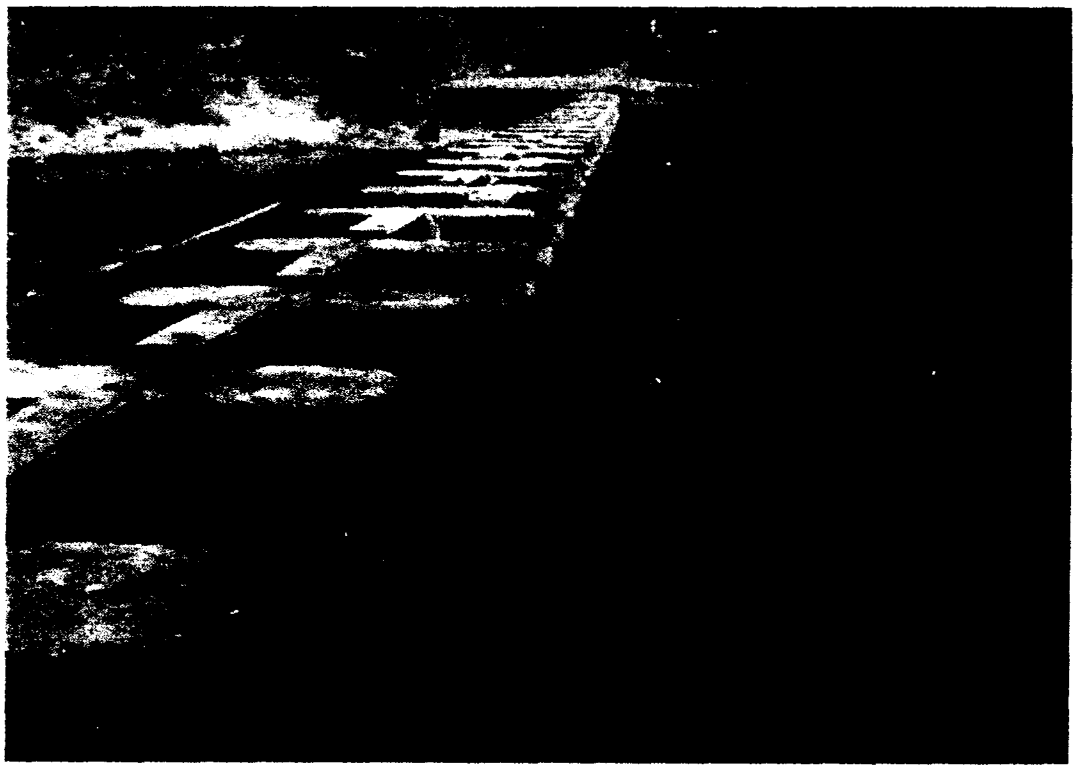

Fig. 4: View of a Bandhara on River Mhadei in Goa

Depression Storage Augmentations

In hydrology, depression storage is the water retained in puddles, ditches, and other depressions in the surface of the ground (Figures 5 and 6). The dimensions of the depressions may vary from micro level to large depressions. The depression storage capacity of the watershed is the ability of a particular area of land to retain water in its pits and depressions, thus preventing it from flowing and generally is governed by land use, landscape, and land cover characteristics. In general the depression storage studies are required to be carried out systematically to ascertain the basin capacity to retain water. Augmenting and enhancing the depression storages in a basin can increase the water availability over a period of time. Land ploughing before the rains, creation of new depressions, de-silting of existing depressions and diversion of surface runoff to depressions which are not receiving the overland flow are some of the basin modifications that can ensure larger depression storages and their availability. In this context the exhausted open cast mine pits play a very important role in retaining large volumes of flood water in them (Figure 7). Under favorable conditions flood waters can be diverted and stored in them. These structures can also recharge groundwater in the adjacent areas.

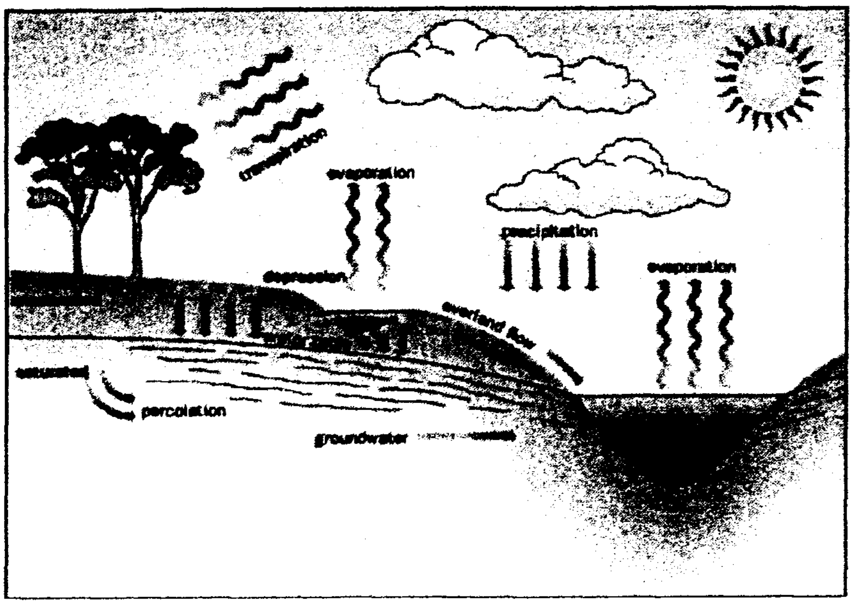

Fig. 5: Schematic Diagram of Depression Storage

Fig. 6: Depression Storage in the Field

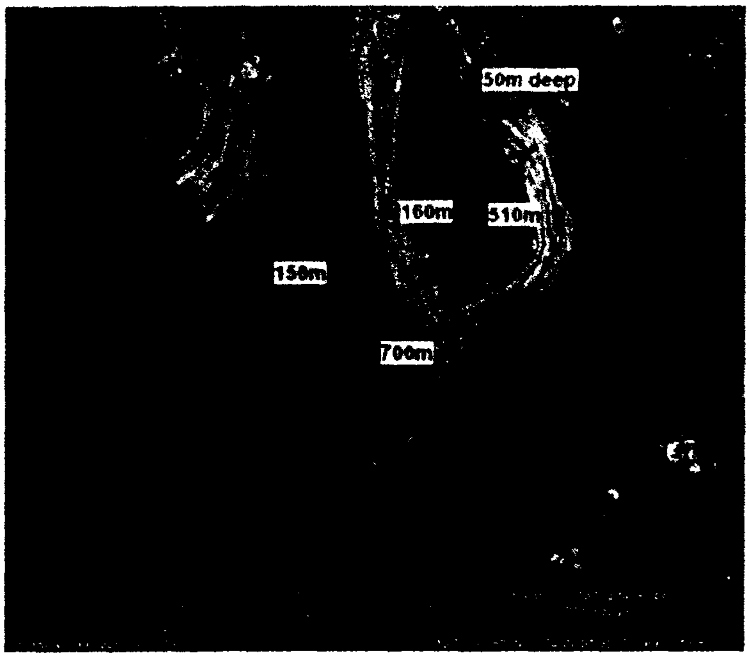

Fig. 7: Huge Mine Pit Located at the Edge of the Perennial River in Goa

Stream Channel Modification and Other Interventions

Along the river channel the geology as well as the topography changes. The water retention capacity of the stream bed can be enhanced by stream channel modifications. Trenching and refilling at regular interval could provide more storage area in the stream bed, increasing the water retention capacity (Figure 8). Similarly, Construction of dikes on the stream channel perpendicular to the flow direction with slight protrusion (Figure 9) could retain a thin layer of water, reduce the flow velocity of the stream and allow more time for groundwater recharge.

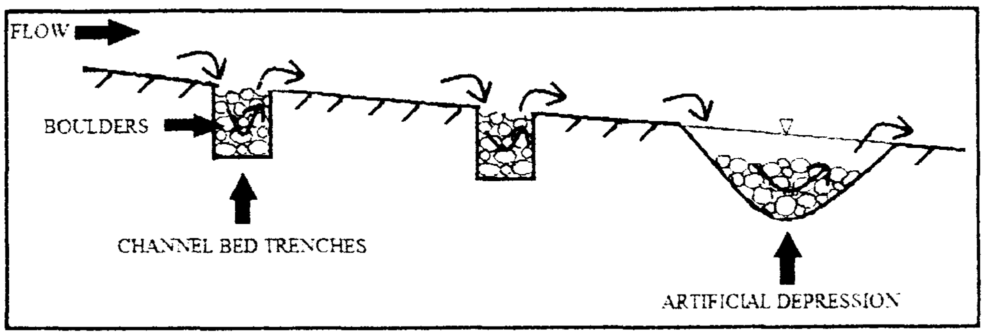

Fig. 8: Permeable Trenches in the Stream Bed for Enhancing Water Retention

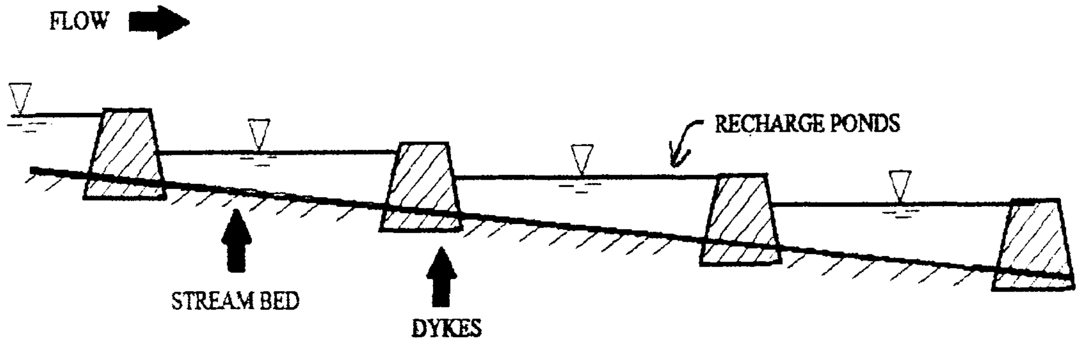

Fig. 9: Dykes in the Stream Bed to Retain a Thin Layer of Water

The flood water during the rainy season may be diverted into the retention basins in topographically favorable river banks (Figure 10). This would create temporary water storages in proximity of the river and also act as source for subsurface recharge, which may enhance base flow. These structures can also be used as artificial recharge sites for treated municipal and industrial waste waters.

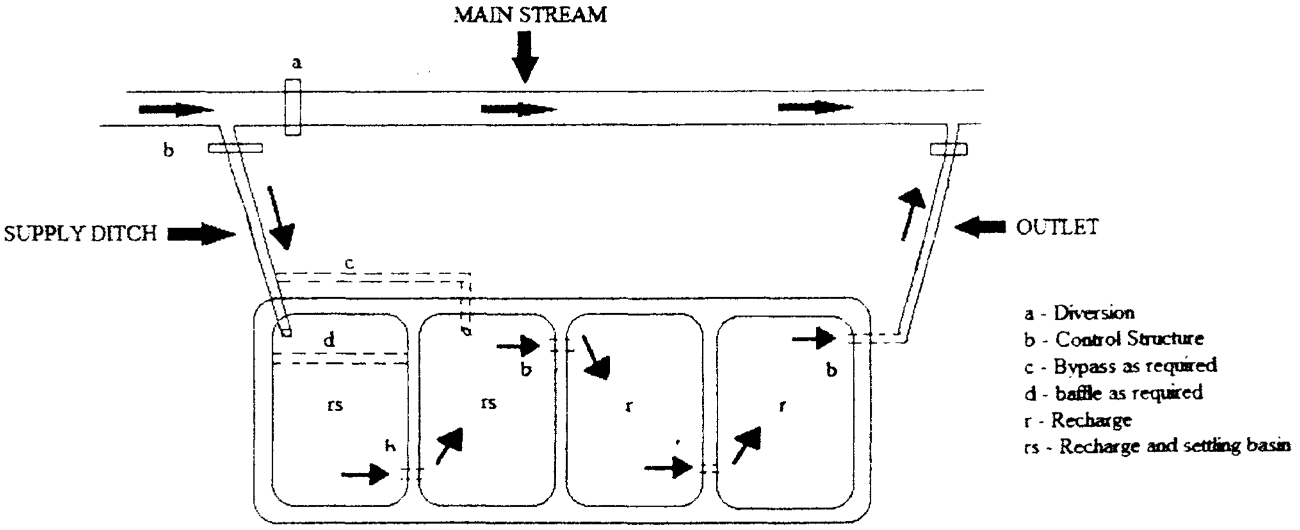

Fig. 10: Basin Type Recharge and Storm Water Retention Structure

Groundwater Recharge Area Protection Zoning

Groundwater recharge areas are sites of natural rainfall recharge to subsurface. In the recent past, groundwater recharge areas are extensively subjected to various anthropogenic activities like urban development, mining, agriculture, industrial estates, etc. without considering their potential for groundwater recharge. Therefore, in order to maintain and/or increase the recharge to groundwater storage, one need to identify and demarcate these recharge areas using sound scientific methods and establish protection zones around such sites, which prohibit certain specific activities on the lines of flood plain protection zones. These recharge areas once identified, can also be used for artificial recharge to groundwater using treated industrial and urban waste waters.

Augmentation of Water from Topographic Structure

Terraced cultivation and contour bunds and trenches (Figure 11) not only increase the water holding capacity of the steeply sloping topographic land, but also arrest the soil erosion and nutrient loss. This practice can help store more water into the soil zone for longer period and enhance recharge to ground water and its subsequent transmission to the river bed.

Fig. 11: Terraced Cultivation on Hill Slopes

Optimizing Various Uses of Water

Irrigation utilizes maximum quantity of water. Consumption of water in agriculture for India is around 70%. By managing the water usage to its optimal level, water loss could be reduced. Water conservation techniques in the irrigation sector like micro irrigation, drop irrigation, etc. could be used to optimize the quantity of irrigation in the downstream region. According to the availability of water, suitable crops could be selected. Irrigation scheduling at appropriate timings, can minimize the water losses and wastages. Pumping of groundwater from the waterlogged command areas to River system during non-monsoon season can greatly contribute to environmental flows. This could also bring back the water logged area for use of cultivation.

Policy Decisions Towards e-Flow Releases

In an unregulated river system, the eco system is in a dynamic balance. That means the long term non monsoon base flow rate is the minimum flow that should be ensured in a river system downstream of the structure. Now the question is, how much shall be the minimum flow rate during rainy season needs to be worked out. This largely depends on the estimates of the biomass nutrient requirements downstream, flushing requirements of the river channel and other mandatory releases. These requirements may vary from river to river system and geographical locations. Therefore evolving any policy on mandatory releases has to consider these aspects.

CONCLUSION

In the present paper we emphasize that human interventions in the reservoir area and the downstream watershed to promote activities leading to reduction of evaporation losses, runoff and enhanced aquifer recharges can truly offset the reduced environmental flows.

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