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Environmental flows in water-scarce river basins in Peninsular India

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Abstract- Indian Peninsular rivers fed by 3-4 month long seasonal monsoon are essentially non perennial. High evaporation rates in the semi-arid, sub-tropical climate take heavy toll on the scarce water resource. Construction of costly storages to meet year round demand for water has been the only solution to achieve sustainable water resource related development. Destruction of forests and heavy groundwater abstractions during later half of the 20th century have reduced fair weather flows of the pristine rivers now to a trickle. With or without dams, the situation would have remained unchanged. Water released from reservoirs for canal irrigation on the contrary recharges groundwater and maintains some fairweather flow in rivers to support aquatic ecosystems. Hence there is no logic in the demand by some environmentalists that water stored in the reservoirs should be released in fairweather to rejuvenate the riverine ecosystems. For rivers having high urban & industrial use from storage reservoirs, better way to restore riverine ecosystems would be to treat entire industrial & domestic effluent generated and release it back into rivers for its reuse in irrigated agriculture. Policies suitable for snow-fed rivers in temperate climate cannot be applied to seasonal water-scarce rivers in semi-arid sub-tropical climate in the developing countries.

Rivers in India-Rivers in the Indian subcontinent could be distinctly divided into two types. First being the snow-fed rivers rising in the Himalaya mountain ranges in the North and draining to cover major part of the Indo-Gangetic alluvial plains in the North India. Second type is the East-flowing & West-flowing non snow-fed rivers in the water-scarce, semi arid Central and Peninsular India. Even though Indus & Ganges river basins together cover about 47 percent area of the country, they contribute to about 60 % of the annual groundwater resources in the country and provide about 63 % of available surface water resources, but only about 46 % of utilizable surface water resources in the country(Ratio of utilizable to available surface water resources is only 27 %). Peninsular rivers occupying about 28 % area of the country have about

16 % of available surface water resources but about 30 % of utilizable surface water resources in the country. (Ratio of utilizable to available surface water resources is 68 % which is quite high).Surface water availability per capita per year (as per 1991 census) in Peninsular rivers ranges from 2050 to 690 cum. As in 2005, the availability might be less than 800 cum on an average, indicating overall water- scarce conditions as per 'Falconmark Indicator'. It has been proposed to highlight the issue of implications of releasing water from storage reservoirs to ensure fair weather environmental flows in these water-scarce rivers in particular.

Table 1 – Availability of water resources in India

Basin	Area	Groundwater resources	Available surface water resources	Utilizable surface water resources
	As a percentage of the country			
Indus & Ganges	47	60	63	46
Peninsular rivers	28	27	16	30

Rainfall characteristics –Major part of the country receives precipitation from South-West monsoons during about 3 ½ months, commencing from start of June to mid July and receding by mid September to mid October. Some Southern states along East coast also receive North-East monsoon from mid October to mid December. About 85 % of annual rainfall is received in the monsoon season. Rivers are in spate only in monsoon season because of the seasonal rains. Riverflow reduces appreciably after monsoons. Part of precipitation permeates below root zone into substrata to recharge groundwater aquifers and what the substrata cannot hold, flows back to streams & rivers gradually during fair weather, to constitute base flow of the rivers. Land under forests has the capability to increase retention of rain water to augment natural recharge of groundwater. Base flow of a pristine river in the subtropical semi-arid climate as experienced in Peninsular India varies each year depending on precipitation pattern & magnitude, evapotranspiration from natural ecosystems, evaporation from soil & aquatic ecosystems, type of substrata in the basin & extent of forest cover. When man started replacing forests i.e. natural ecosystems by man-

made ecosystems by bringing the land under agriculture & pasture, there was corresponding reduction in groundwater recharge and base flows of rivers.

Water Resources Development –Inadequacy & uncertainty of rainfall had induced human beings to exploit groundwater by digging wells and lifting the water by muscle power or draft animal power, to provide irrigation to crops and to increase land productivity. Groundwater exploitation was the start of reduction in the base flow of rivers in fair-weather. Though groundwater use was on a low key in Peninsular India till mid twentieth century, gradual reduction in the size of land holdings per family due to partition of lands (as per Succession Law, all sons are entitled to equal share in land) pressed for the need to increase land productivity by resorting to irrigated agriculture in order to maintain the level of family income from land. Average land holding in the country reduced from 0.53 ha per person in 1950 to only 0.15 ha /person by the year 2000.

Spread of network of electric lines and energisation of wells, promoted the activity of groundwater development in the Peninsular States and more so in the drought prone area in the rain shadow zone towards East of N-S running Sahyadri mountain. Soils in Peninsular India are formed by in-situ decomposition of parent rock which is predominantly basalt or granite. Alluvial soils are located close to riverbanks but are extensive in the deltaic regions of main rivers. Hence groundwater in hinterland is confined to the decomposed strata below the soil, duly supported by groundwater seeping into cracks, crevices, joints, fissures and joint plains in the underlying rocky strata. Groundwater is hence limited, confined and discontinuous, making it difficult to locate a successful well. Even then, inadequacy of rainfall has resulted in exploitation of 44% of groundwater resources upto 1993 to support 6.07 M ha of land in Peninsular States, as shown in Table 2 below

Table No.2 - Status of groundwater Potential in five Peninsular States of India (As in 1993)

Peninsular State	Ultimate Irrigation Potential due to			Potential created from (exploitation level)		Balance Potential
	Natural recharge M ha	Canal irrigation recharge M ha	Total Million ha	Natural recharge M ha	Canal irrigation recharge M ha	
1	2	3	4	5	6	7
Maharashtra	3.26	0.39	3.65	1.15	0.14	2.36
Karnataka	2.22	0.35	2.47	0.63	0.10	1.84
Andhra Pradesh	2.91	1.05	3.96	1.42	0.51	2.03
Tamil Nadu	2.03	0.80	2.83	1.41	0.55	0.87
Kerala	0.73	0.15	0.88	0.13	0.03	0.72
Total	11.15	2.74	13.89	4.74	1.33	7.82
Percentage		20 % of col.4		43 % of col.2	49 % of col.3	56 % of col. 4

Source- GW resources of India- Central Ground Water Board, GOI 1995

Groundwater potential exploited to end of 2004 would be appreciably more than the figures shown above and has further depleted fair-weather flows in the rivers.

There had been extensive disforestation in Peninsular India during the second world war period. In the first 3 decades after independence in 1947, disforestation continued because of encroachments on forest land for agriculture by tribals, illegal tree cutting for commercial use of wood and for firewood. With the result, forest cover had been appreciably reduced during the twentieth century. Disforestation had been checked during last two decades of the 20th century due to enactment of stringent Forest Land Conservation Act in 1980. Even then, on account of sizeable reduction in forest cover upto 1980,coupled with large scale groundwater exploitation practiced during last 4-5 decades, winter flows (Nov-Feb) had been appreciably reduced and there had been

practically no flow in summer (March- June) in most of the Peninsular rivers. This would be evident from the fact that diversion weirs constructed many centuries before, to provide irrigation to rice fields in vast deltaic regions of major rivers along East coast, had been facing acute shortage of riverflow in fair weather during last 2-3 decades. Water had to be released from storage reservoirs on the upstream to augment riverflows and maintain irrigation.

Riverine ecosystems- Major rivers in Peninsular India used to have some flow all the year round, before beginning of the 20 th century. Flow gradually dwindled because of disforestation and increasing groundwater abstractions. These rivers had some flow in fairweather only near lower stretches upto mouth of the river. During later half of the 20th century, nearly 1500 large reservoirs (each more than 15 meter high or having more than 3 Mcum storage) were constructed in southern states, in addition to thousands of reservoirs of smaller size. Because of the seasonal monsoon and non perennial rivers, construction of reservoirs of varying sizes to conserve flood water to meet year round water demands of drinking & domestic use, industrial use and irrigated agriculture, was the only choice available to harness surface water resources.

About 85 % of the stored water is being used for irrigated agriculture (food for people) and balance being used to meet domestic & industrial demand. About 80 to 85% water used for non- irrigation purposes regenerates & flows back into rivers. About 25 to 30 % of water used for irrigated agriculture is absorbed as deep percolation into soil. Part of it recharges groundwater in the command area of canals of surface irrigation schemes & rest of it flows into streams as regenerated flow. It would be seen from Table 2 that, recharge from surface irrigation contributes to about 20 % of total groundwater potential, but because of increased groundwater abstractions by dug

wells & bore wells it is tapped before it finds way into streams & rivers. Even then it is often argued by environmentalists that, construction of reservoirs on rivers results in depletion of the base flow of rivers and it degenerates riverine ecosystems.

It is hence a ground reality that there was no possibility of flows in rivers in fair weather to support riverine ecosystems, with or without dams. Environmentalists often make qualitative statement that constructions of dams on rivers have depleted river flows and hence water stored in reservoirs must be released in fair weather to rejuvenate riverine ecosystems. Factual position explained above would make it clear that such an argument does not hold any water.

Case study of a typical river basin - Upper Bhima Basin catchment of 14,700 sqkm at Ujjani dam on Bhima river lies in Krishna river valley, having surface water availability of 1290 cum/ capita / year as per 1991 census. Bhima river rises in N-S running Sahyadri mountain range where annual rainfall near origin is about 5000 mm, but reduces to only about 700 mm within a distance of 60 km towards East. About 60 % area of the Upper Bhima Basin towards East is often subjected to drought conditions. Krishna being an Interstate river, there are restrictions on the surface water use in the Upper Bhima Basin in the Maharashtra State. Basin is having rolling topography and parent rock is basalt. In- situ soils & decomposed rock strata below provide limited, discontinuous and shallow groundwater aquifers.

Construction of reservoirs is indispensable to store river runoff from 3 ½ month monsoon season, which provides 85 % of the annual rainfall. This would be evident from Table 3 below.

Table 3 – Irrigation potential in Upper Bhima Basin

Reservoirs	Irrigation potential of each	Number of completed & in-progress schemes	Total irrigation potential in ha	Percentage with culturable area of 11,22,000 ha
Major Medium Minor	>10,000 ha 2000-10,000 ha < 2000 ha	19 4 245	3,51,500 17,000 91,500	31 % 2 % 8 %
Total		268	4,60,000	41 %
Groundwater potential (including additional recharge from canal irrigation & from watershed development)			2,46,000	22 %
Total			7,06,000 ha	63 %

Possible solution to ensure fair weather flows in rivers—

Exploiting surface water resources in Peninsular India is very costly because of cost of storage reservoirs and heavy cost of long length of canals due to the rolling topography. A very high evaporation rate (about 1.8 meters annually) takes sizeable share of the stored water. In the semi-arid, sub-tropical climate of Peninsular India, there is no flow in rivers even in major rivers in most of their length for 4 to 6 months of the year. Hence it would not be a viable proposal to release costly water from storage reservoirs into rivers to rejuvenate the otherwise non existing riverine ecosystems. However, in Peninsular rivers where growing industrial & urban demand is seriously encroaching on the availability of water for irrigated agriculture, one solution is possible which would maintain fairweather flow of fairly clean water, partly restore the reduction in water for agriculture and would prevent deterioration & degradation of the riverine and man-made ecosystems because of the pollution hazard.

In the Upper Bhima Basin, about 45 % of water stored in 5 large reservoirs located on upstream is utilised at present (2005) to meet domestic demand of Pune and Pimpri-Chinchwad cities & industrial area around it. This demand is expected to double in the next 20 years, consuming all the water which was meant for use in irrigated

agriculture. Urban & industrial use would certainly be at the cost of corresponding reduction in water allocation for providing irrigation by canals to the drought prone area on downstream in the rural sector. At present domestic & industrial effluent is untreated or partially treated & released back into the river. It has been degrading the riverine ecosystem and causing eutrophication of the man-made lake viz Ujjani dam, though in localized spots at present.

If domestic & industrial effluent is released into the river after full treatment, about 80 to 85 % of water used in Urban & Industrial area would be available as fairweather flow all the year round. Water regenerated after use of some water for irrigated agriculture, would flow back into river and there would be some flow of reasonably good quality of water in the rivers during fair weather. Instead of creating additional storages to meet irrigation demand for agriculture in the rural sector (incidentally in the Upper Bhima Basin there are no more sites left to construct reservoirs), cost of treatment of effluent and its reuse for agriculture might be comparable. This, however, requires convincing the people from cities & industries to pay for the treatment of polluted water they generate. It also requires strong political will to take hard decisions against the organized resistance of the urbanites, influencial people & industrialists, duly supported by media coverage. For want of the political will, 'User pays & Polluter pays' principle usually remains an ideal only to be voiced & cherished but not followed.

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