Jour. Geol. Soc. India (2023) 99:743-746
https://doi.org/10.1007/s12594-023-2380-3

EDITORIAL

Watershed Management, Green Environment and Rural Resurgence

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Received: 31 March 2023 / Revised form Accepted: 15 April 2023

The runaway success of the 'green revolution' of the seventies in the water-rich north Indian plains, did not sustain in the rain-deficient plains of extra-peninsula and Peninsular India, rather proved unsustainable in many ways. By and large, the benefits of major irrigation projects, and poverty alleviation schemes did not reach the poor and rural population who constitute nearly 70% of country's population living in the rainfed areas, spanning nearly 60% of country's arable area frequently visited by droughts. Uncovered by irrigation these areas support only one crop in a year, that too depending on rainfall. After years of drought or deficit rainfall (once in three years), these areas face famine, severe food scarcity and endemic drinking water shortages with dried up rivers and surface water bodies, dried up wells, utter poverty, dwindling greenery and desertification, lack of livelihoods and employment. Rajendra Singh, the Water Man of Alwar and leader of Tarun Bharat Sangh (TBS) working on the concept of harmony of man, water, and nature famously propagated the pioneering idea of watershed development and management integrating water science, climate science, social science, ecological and environmental sciences combining with ancient knowledge system in the dry Arwari basin of Rajasthan for all round development and economy growth. His famous 'Ped Bachao Ped Lagao Padayatra' for forest conservation was also a part of watershed development campaign. Success of this endeavour in Arwari and other watersheds in the country has established micro watersheds as key to the National Model of inclusive growth and economic stability. Integrated watershed development will unlock enormous potential of rainfed areas bypassing the need for interbasin transfer of surplus water as contemplated in the grandiose project of 'Interlinking of Rivers', and ameliorating the impacts of climate change and global warming

WATERSHED CONCEPT

A watershed is defined as a pear-shaped small catchment, bounded by topographic divides, from which all precipitation (i.e., rainfall) is drained through a common point, flowing into a stream. It is synchronous with drainage basin. A natural hydrological unit, it is not only a physical entity, but an ecosystem encompassing all its elements like environment, physiography, pedology, geology, hydrology, agroforestry, biodiversity, and the services they provide in their entirety. Hence any development plan should integrate all these components for inclusive growth. The principal aims of the watershed development are optimal utilisation of the land according to its endowments or capability, harvesting and conserving every drop of rainwater, artificial recharge of depleted aquifers, controlling soil erosion, increasing soil moisture and recharge, conjunctive use and optimization of water resources, maximizing productivity per unit area and per unit water; livestock rearing, increasing cropping intensity, adopting crop water planning, increasing greenery and forest cover; stabilizing income of the rural households despite weather adversities; and thus sustainability of the overall ecosystem and a green environment.

Further, agriculture and water being key to food and drinking water security, and green environment constitute the foundation of the rural development and economy. But in the arid-semiarid areas surface water is a scarce commodity. However, aquifers hold substantial storage of groundwater, which is not susceptible to temporal rainfall vagaries, and is a common pool resource easy to handle by the public. Integrated or conjunctive management of all available water resources including rainwater, surface water, groundwater, is, therefore, crucial for water resource sustainability, rural prosperity and economic growth, and for green environment in a watershed. Groundwater management – its development, conservation and augmentation – is, therefore, the principal component of the water cycle in these areas. The following paragraphs illustrate the water resources conservation and augmentation measures, especially rainwater harvesting (RWH), artificial recharge (AR) and soil conservation which are the chief drivers of watershed development and management, holding key to food and drinking water security, the basic needs for sustainable ecology and environment.

WATER HARVESTING AND CONSERVATION

Rainwater harvesting augments groundwater through artificial recharge bringing rainfed areas under irrigated agriculture with crop water planning and increasing cropping intensity. Soil conservation and moisture retention facilitate cultivation and crop growth.

Principles and Practices

In the arid and semiarid areas, traditionally, the rainwater used to be harvested and stored in small surface reservoirs like tanks, farm ponds etc. Advent of Science and Technology has brought in manifold innovations in rainwater harvesting such as moisture conservation measures like bench terracing, contour bunding, mulching etc., and technically simple, cost-effective structures like percolation tanks, check dams, 'johads' etc. Knowledge of topography, aquifer capacity for storage and transmission, source water availability, soil texture, infiltration capacity, hydrogeologic boundaries, and lastly response of water table in the neighbourhood of proposed groundwater recharge basin is vital for watershed management. Materials, designs, and skills are indigenously available. These innovations enhance natural recharge rate replenishing depleted aquifers or creating subsurface storage under favorable hydrogeological conditions serving as groundwater sanctuary (Das et al. Natl. Persperspective, Plan for recharge etc. CGWB, 1996).

Ideally from ridge to valley the distribution of feasible water harvesting structures are as: (a) First & second order streams: Contour bunding, gully plugging, trenching, oil conservation, afforestation. (b) Second & third order streams: Cement plugging, nallah bunding, percolation tanks. (c) Throughout watershed: Injection well, Recharge shaft, Trench, Dug well recharge. (d) In discharge areas: Weirs & Groundwater Dams to arrest baseflows (Manual for Artificial Recharge, CGWB, 2007). To ensure good recharge rate and retention of recharged water for sufficient time to enable its use in lean period, formations should have moderate permeability. Gully plugs, nalla bunds, bench terracing, contour bunds, percolation tanks obstruct seasonal overflow and runoff of streams and rivulets of ephemeral nature for in situ percolation. Subsurface dykes or groundwater dams are constructed across narrow gently sloping valleys, to obstruct flow of groundwater out of the basin, which may be stored below the land surface behind the dyke or dam. Experiments have been successfully conducted by CGWB in the drought prone states of India. Hydrogeologists, remote sensing experts and agricultural scientists/ engineers have a big role in the selection of suitable sites, and methods as also in designing water harvesting structures, and crop water planning. Cadastral maps (1:8000) showing all relevant hydro-geological and hydrological features help in preparing blueprint of actions. Fig.1 depicts a typical watershed with water harvesting structures. With the availability of water resources follow agriculture and economic activities, and all-round development and growth.

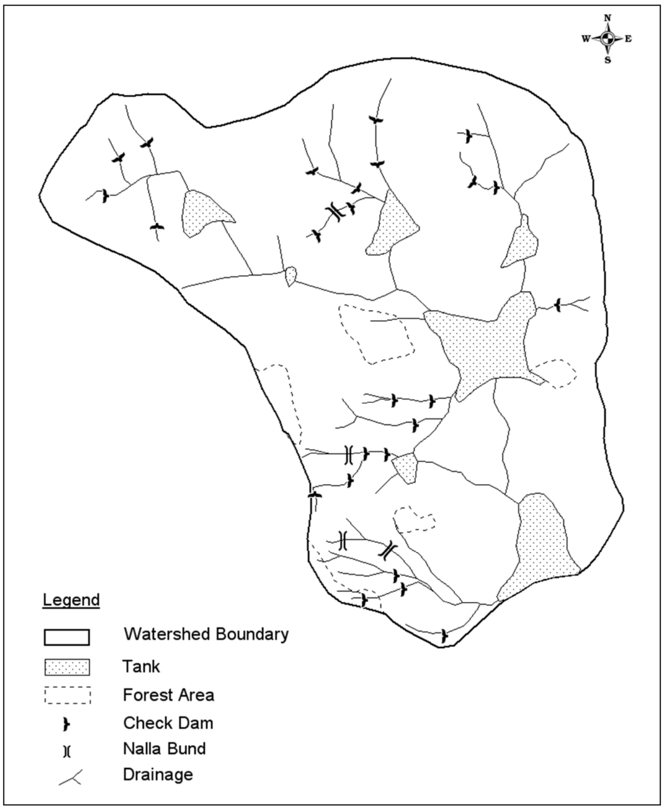

Fig.1. Water harvesting structures in Honnarghata watershed (Farooqi et al. 'Integrated Water Resource Management'. 7th Intl. Groundwater Conf, NIH & CGWB, 2017).

Climate change and global warming mitigation technology, too, focuses on water harvesting and conservation. Afforestation and increased vegetation coverage cut down greenhouse gases in the atmosphere and helps in CO_2 sequestration with reduction of temperature.

Linkage with technical and research Institutions, as also with financial institutions, and various government schemes can make the implementation of the schemes and maintenance of structures free from hindrances. Participation of the village community promotes success of the programs through formation of self-help groups (SHGs) and their training about the water conservation measures . Tarun Bharat Sangh, an NGO of Alwar, Rajasthan, became pioneer in community driven watershed management and governance in the Arwari basin of Alwar district.

SAGA OF RURAL RESURGENCE AND PEOPLE'S PARTICIPATION

The following are stories of three of the driest areas of the country where watershed treatment has ushered in a sea change in rural development, and prosperity.

Arwari River Basin, Alwar District, Rajasrhan

It is an undulating hilly terrain with Proterozoic rocks and alluvium. Reeling in droughts and monsoon failures, water crisis crippled development and growth in the region, leaving the people in abject penury. Rivers were dry, so also water bodies and wells. With critical shortage of water for drinking and farming, agriculture was abandoned, people migrated for alternative livelihoods. Illegal mining destroyed forests, riverbeds and water bodies. The villagers were compelled to fetch water from kilometers away. Large tanks and johads or check dams, the most common structures once used for harvesting water to successfully withstand few years of droughts, recharged the wells, and dotted the desert lands, were rendered derelict due to neglect with disastrous consequences on rivers and wells drying up. Whatever precipitation occurred was lost as flash floods.

Under the leadership of Tarun Bharat Sangh (TBS) 9000 water harvesting structures (Johads, checkdams & anicuts) have been constructed with people's participation, replenishing depleted groundwater reserve with spectacular improvement of agriculture and economy (Singh. 'Indigenous knowledge of water management'. Mem Geol. Soc. India, no.82, 2013, pp.218-213) (Fig.2a). Dilapidated wells were restored. Production of food grains and fodder were substantially increased. Scarcity of drinking water was mitigated; livestock and milk production, household incomes, and employment opportunities increased phenomenally, with increased enrollment in schools. Fisheries too provided employment. Marketing facilities followed automatically. Planting of trees was also a part of the watershed development. Increased forests and overall greening resulted in carbon sequestration, temperature lowering, better rainfall, reduction of greenhouse gases, - a model of climate change mitigation technology. Another significant achievement of the Project was the revival of the five dry rivers in the Arwari basin, – Ruparel, Arvari, Sarsa, Bhagani, Jahajwali with perennial flows consequent to groundwater augmentation (Fig 2b). The financial investments, labour and materials all came from the people in the beneficiary villages. Siting, designing and skills were based on their traditional wisdom /intuitive knowledge. No government agency was involved in the process. The dry parched lands of Alwar turned to lush green fields and green environment all around.

People's Participatory Approach and River Basin Parliament

Water and vegetation being common pool resources, prompted community centered water management through formation of village

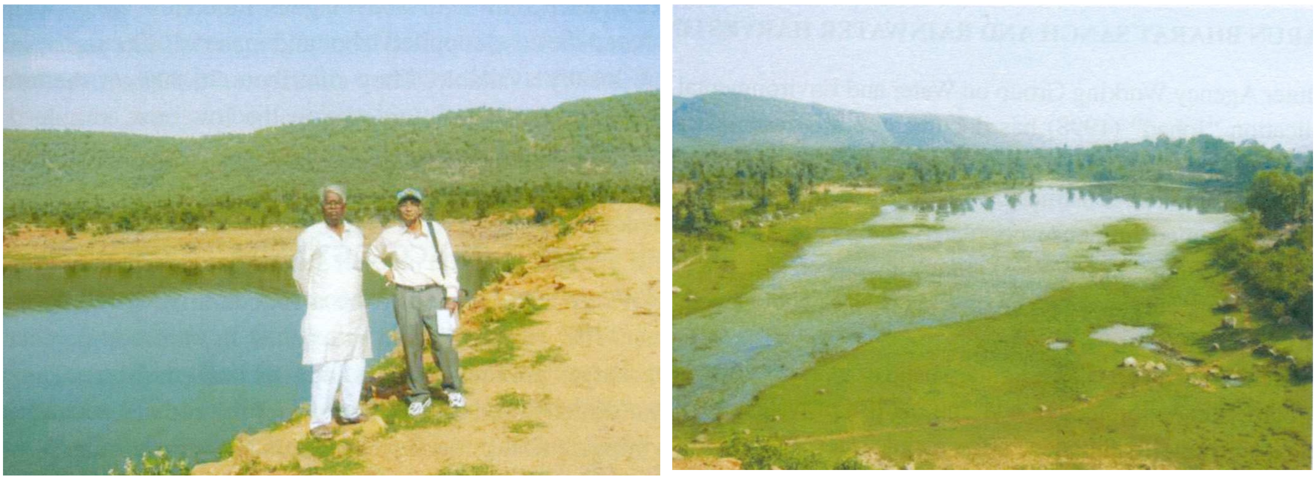

Fig.2. (a) A typical Johad in Arwari basin. **(b)** Rejuvenated River Arwari (Das. 'Johads of Alwar'. Mem Geol. Soc. India, no.82, 2013, p.235 & 236)

councils and River Basin Parliament for conserving water resources, equitable sharing and resolving conflicts (Rathor, Community Management of Ground Water, Mem. Geol. Soc. India, no.82, 2013, pp 239-265). Former President K.R. Narayanan in 2000 visited Arwari basin to felicitate the gramsabhas (councils) for the spectacular work on community- driven water conservation, a unique experiment in the third world countries.

Ichalahalla Basin, Gadag District, Karnataka

A chronically drought affected, basaltic and granitic country with an annual rainfall of 450-550 mm. Based on the experience in Arwari basin, Krishi Vigyan Kendra (KVK) at Hulkoti in the Ichalahalla watershed organized marginal and small farmers, and landless laborers to harness social capital to cross poverty line in the quickest possible time. A total of 1985 waste weirs, 160 farm ponds, 137 boulder checks, 18 rubble checks, 56 gully checks and 27 loose boulder checks were constructed for water harvesting apart from introduction of soil moisture conservation technologies, commercial crops, and agrohorticulture systems etc. (Hiregoudar et al., Geol. Soc. India Sp. Publ., no.5, 2016, pp.18-23). As a result, between pretreatment and post treatment periods cropping intensity changed: Single cropping: 3067 to 1236 ha, Double cropping: 1423 to 2474 ha, Relay cropping: 910 to 1290 ha. The productivity of major crops increased by 5.80 to 40.46 Qtl/ha. The employment potentials for men increased from 58 to 105-man days/annum, and for women from the 72 to 278 man days/ annum respectively. The annual income levels of families significantly increased. Drinking water shortage was solved. Because of enhanced soil moisture holding capacity, long dry spells of 30-35 days during the crop growth period do not affect the crops adversely. Nonfunctional dug wells and bore wells were reduced in number. New bore wells were also drilled. The stream flow duration changed from 6-7 months in pre rejuvenation to 10-12 months in post rejuvenation periods. KVK also popularized the use of organic manures, bio-fertilizers, compost etc., in lieu of chemical fertilizers.

Jain Watershed in Jalgaon district, Maharashtra.

Jain watershed, a part of the Girna valley, is a typically water deficit, drought prone, hilly, undulating wasteland on the Deccan plateau with low rainfall (650 mm), and covered by layers of basaltic flows. Groundwater, the only water source is overexploited. Devoid of soil layer and strewn with boulders and stones, the area enjoyed no agriculture, no economic activities either (Jain : 'A Telling tale', Pub., Jain Agri Inst., 2011). Under the leadership of The Jain Agricultural Institute at Jalgaon watershed development and integrated water management was taken up with the wholehearted participation of the community**.** From ridge down the valley, the runoff generated has been harvested in percolation tanks (Fig.3), storage tanks, polylined (plastic lined) tanks. Check dams, boulder checks, gully plugs were also constructed for water harvesting and groundwater recharging etc. Contour and graded bunding, bench terracing, afforestation, underground bandharas, bore blast and hydrofracturing techniques were also employed. Soil health is ensured through organic manuring, green manuring, vermicost application, crop rotation practices. The area has now become self-sufficient in irrigation and drinking water availability. The borewell yield has increased from 70m^3/day (1992) to 250m^3/ day (2002). In a normal rainfall year, the water availability is 7.8 lakh cumec, while the peak requirement may be 8.6 lakh cumec. To meet the deficit, especially in drought years 10-20% of the wastewater generated from fruit and vegetable processing is reused after treatment. Vigorous agroforestry and plantation activities have led to carbon sequestration and decrease of Greenhouse gases. The watershed has become home to a variety of plants, birds, and animals.. The Institute has established a training center, with teaching and training and extension aids for farmers. The Institute buys back the produce from the farmers, adds value to their produce by processing and marketing the same in domestic and international markets. The barren wastelands were transformed into a productive agroforestry center.

WATERSHED AND GREEN ENVITONMENT: A PEOPLE'S MOVEMENT

Thus, watershed development leads to the optimal use of land and water resources, all round growth and economic stability, restoration of ecological balance and green environment, and thus significant social and cultural impacts on the community. Resource development, conservation and its management do need an understanding of the relationships between land, water, soil, crop and environment. Hydrogeology and remote sensing have an important role in siting, designing and constructing water conservation structures. In fact, such poverty alleviation programs do not require any big capital investment, or sophisticated planning and imported technology, but what it needs is investment of the people's will and commitment with locally available skill and resources, traditional knowledge and practices, indigenous research and study, as also a spirited leadership and vision (Das, Jour. Geol. Soc. India, v.85(3), 2015, p.388). In essence it is a **PEOPLE'S MOVEMENT** involving all sections of the society.

Fig.3. (left) Terracing of Jain Hills. Boulders exposed along drip lines. (right) Polylined tank at Jain Hills (Jain, A Telling Tale. Pub. Jain Agri Inst, 2011, p.13 & 60).

The live models of Arwari basin (Rajasthan), Ichalahalla basin (Karnataka), and Jain Watershed (Maharashtra) have laid down several strategic goals for integrated watershed development and management.

1. Water and food security, crucial for all round growth and development, and economic resurgence to be addressed through watershed development and management.
2. Integrated use of all available water resources e.g., surface water, ground water and rainwater along with management of evapotranspiration to address water security,
3. Rainwater harvesting and artificial recharge with the revival of traditional wisdom and practices along with inputs of modern science to augment impoverished water resources.
4. Cadastral maps (1:8000) showing all hydrogeological and hydrological features to help in planning integrated watershed management.
5. Introduction of micro irrigation systems, drip & sprinkler irrigation for utmost economy in irrigation waters, the largest consumer of water.
6. Maximizing productivity per unit area and per unit water with the adoption of dryland agriculture, and double/triple cropping intensity.
7. Groundwater to be protected from overexploitation and pollution.
8. Afforestation, increasing vegetation and green cover creating home for plants, birds and animals, and establishing a symbiosis among agricultural crops, horticultural plants, many tree species and livestock rearing.
9. Promotion of watershed management, as key to climate change and global warming mitigation technologies.
10. Improvement of agricultural infrastructure regarding storage, transportation, and marketing.
11. Promotion of agro-food processing and agri-waste processing industries.
12. Increase of biomass to provide better sources of renewable energy.
13. Use of organic fertilizers, improved sanitation, reuse of treated wastewaters, and other remedial actions to ensure availability of pollution free water.
14. Participation of Stake holders and inspiring leadership in watershed management starting from planning to implementation.
15. Developing Prototype Models suiting different situations based on experiences across the country."

It is a vision which thrives on “all the advantages of agroclimatic and natural resources with the use of right dose of modern technology” (Abdul Kalam et al., ‘Beyond 2020’, Penguin. 2014), – a vision which recognizes green environment, food and drinking water security, as also stable income to live off as basic rights of the people. This approach has been accepted as the National Mandate for the rural development and economic progress in the rainfed areas of the country. The UN-Inter Agency Working Group on Water and Environmental Sanitation in its Report (UN-IAWG-WES, 'Johad: Watershed in Alwar', 1998) cited it as a unique example of self-help, worthy of emulation in all water starved areas of Southeast Asia for food and drinking water security. MGNREGA, JAL JIVON MISSION, Drought Prone Area Development Program, Atal Bhujal Yojana are some of the endeavours launched by Union Government in this direction.

I visited the catchments of Tilda, Bhagani and Jahajwali watersheds of Arwari basin in the peak summer of 2009 after consecutive droughts in previous three seasons (Das, 'Johads of Alwar'. Mem. Geol. Soc. India, no.82, 2013). The area is hilly with intermontane valleys. Fractured quartzites, schists and gneisses form the aquifers. But the johads or checkdams held stock of water stored in the last rainy season (Fig.2b), with lush green fields all around, water in wells, no drinking water scarcity as in ten years back. Farmers were tilling the soil, preparing for cultivation. There was no dearth of soil moisture. Wetlands beckoned cranes. Streams flowing with clear water, aquatic life thriving. Rainwater harvesting has transformed degraded parched lands of Arwari catchment into ‘Oasis’ in the desert.

The country is awaiting another **GREEN REVOLUTION** in its arid and semiarid terrains through community driven watershed development and management ushering in rural resurgence and economic boom.