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Water Scarcity and its Management in Arid Rajasthan

Water is life and rain is the main source of water on earth. India though fortunate to receive 350 mm annual rainfall yet seems helpless in its management due to uneven distribution. Arid region in Rajasthan covers 20.88 mha (62% arid area of India), receives low and erratic rainfall, is under permanent scarcity of water and thus highly vulnerable to drought. The annual rainfall of 12 arid western districts of Rajasthan is 338 mm, ranges from 100-450 mm (Fig.1). A 400% increase in human and 200% in livestock population since 1950, have resulted in over-exploitation of water resources especially the groundwater and induced desertification together with frequent droughts. Hence all out efforts are needed to meet the challenge of water scarcity in arid region.

Surface water resources: A gross surface water potential of arid Rajasthan excluding Indira Gandhi Nahar Pariyojna (IGNP) is 1486 mcm. It lies in the eastern Zone running parallel to Aravalli ranges that comprises drainage basin of Luni river. Large number of tanks, reservoirs, minor irrigation dams and check dams are located in Luni basin to store runoff during monsoon. About 550 storage tanks and reservoirs (Fig.2) of less than 1.50 to 208 mcm store 1169.28 mcm (Table 1) water to irrigate over 1,00,000 ha. Besides Jawai dam is main source of drinking water as well.

Table 1: Major and medium tanks and reservoirs in western Rajasthan

District	Nos.	Storage capacity (mcm)
Pali	91	608.4
Sirohi	42	156.2
Jalore	95	187.1
Barmer	62	42.8
Nagaur	59	44.1
Jodhpur	56	107.3
Jaisalmer	139	17.9
Bikaner	6	5.7
Total	550	1169.3

Groundwater resources : Groundwater is the reserved treasure in arid region. It is less vulnerable to evaporation and pollution and supports agriculture, domestic and industrial activities. This precious resource is over-exploited exceeding 100% in Barmer, Jalore, Jhunjhunu, Jodhpur, Nagaur, Pali and Sikar districts. An annual withdrawal of 4597 mcm against 3323 mcm annual recharge results in permanent negative balance of 1234 mcm. Out of 85 blocks 48 are over-exploited, 13 are critical, and 2 semi-critical leaving only 23 blocks safe for withdrawal (Fig.3).

Potential for groundwater recharge : The average annual decline in groundwater level during 1984-2003 ranged 0.01 to 0.54 m in western Rajasthan. The decline in Jalor and Pali districts was more than 0.50 m whereas, in Jodhpur, Jhunjhunu and Nagaur districts it was 0.44 -0.48 m and in Barmer, Churu and Jaisalmer districts the decline was less than 0.20 m. On the other hand, groundwater level in Bikaner, Ganganagar and Hanumangarh districts is rising due to intensive canal irrigation. Over drafting of groundwater since 1984 has created an empty space to hold 29,718 mcm water in aquifer. The depleted aquifer may be rejuvenated by recharge structures and rainwater harvesting. Bilara limestone, Lathi and Jodhpur sandstone and alluvium aquifers covering large area in western Rajasthan are most suitable for adopting artificial groundwater recharge.

Fig.1. Distribution of normal rainfall (mm) over western Rajasthan (1901-2004)

Fig.2. Kailana lake : main source of water supply to Jodhpur city

Fig.3. Status of ground water resources in arid western Rajasthan

Groundwater Quality: In more than 45% (95,292 km^2) area of western Rajasthan groundwater is highly saline and not potable. Fluoride levels beyond permissible limit (>1.5 mg/l) is a major health hazard in all the districts excepting Hanumangarh. Jaisalmer, Nagaur and Jalore districts having more than 40 % area under high fluoride are worst affected (Fig.4). Some districts are also affected by nitrate and selenium etc. Potable groundwater is limited to areas covered with sandstone, lime stone, Lathi series tertiary.

Fig.4. Fluoride affected area (>15 mg/l) in western Rajasthan

Human impact on water resources: Out of 25,46,075 ha irrigated lands 54.8% is irrigated by wells and tube wells and only 44.6% by the IGNP canal. Intensive agriculture and cultivation of high water demanding crops has caused steady increase in number of wells and tube wells in past two decades resulting in 133% rise in well irrigated area at the cost of over exploitation of ground water (Fig. 5) in past two decades. As of now the rate of ground water decline is 20-40 cm annually against only 4-5 mm recharge thus threatening sustainability of this precious resource. Considering 3.2% annual growth in groundwater utilization, it is estimated that against the annual recharge of 35,157 mcm, the groundwater utilization by the year 2010, 2015, 2020 and 2025 will be 5,686 (161.7%), 6,657 (189.3%), 7,792 (221.6%) and 9,121 mcm (259.4%), respectively, which is a serious concern.

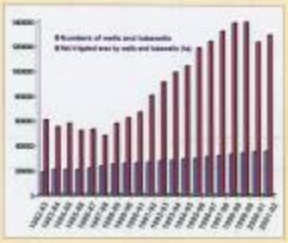

Fig. 5. Increase in wells/tube wells and well irrigated area in arid western Rajasthan

Water transfer and lessons learnt: IGNP (Fig.6) is mega effort to de-decertify north-western part of Rajasthan through transfer of 9.4 bcm of water a year from the Harike Barrage, Punjab by a 204 km feeder canal in Ganganagar, Hanumangarh, Bikaner, Jaisalmer and Barmer districts to commad 186 million ha under irrigation in two phases (Table 2).

Table 2:Culturable command area (ha)

Stage	Flow	Lift	Total
Phase-I	242,000	0	242,000
Phase-II	237,000	0	237,000
Lift	0	62,000	62,000
Total Staqe-I	479,000	62,000	541,000
Total staqe-II	876,000	443,000	1,319,000
G, total staqe I & II	1,355,000	505,000	1,860,000

Since 1982-83 irrigation to 0.165-0.99 m ha and allocation of water for drinking and industries (1,073 mcm) is achieved. In wide spread drought years (1988-89 and 2002-03) allocation to IGNP was drastically reduced from head works which resulted reduction in of cropped area (Fig.7).

Fig.6.Satellite image IRS LISS III of a part of IGNP area in Hanumangarh district

Water logging and salinization: Although, water resources development has promoted socio-economic development in the region but at the same time it has induced severe environmental issues. Overuse of water, intensive irrigation, high water allowance, seepage from canal system, and presence of sub-surface clay lenses have resulted in water logging, soil salinization, making 21,000 ha, out of cultivation (Fig.8). It has caused loss of biodiversity and health hazard. A rise in groundwater was recorded from 0.2 to 1.4 m per year (Fig.9), which declined in drought years (1999 to 2002) due to reduced water allowance.

In anticipation of Sardar Sarovar water reaching Jalore district by 2007, proactive measures are required based on lessons learnt from IGNP.

Measures to optimize canal water use

- Regulation of water allowance from 5.23 to 3.0 cusecs per thousand acres
- Avoiding flood irrigation and adopting check basin and boarder strip methods
- Efficient irrigation techniques such as drip and sprinklers
- Adoption of sub surface drainage with sump and pumping water back to canal
- Vertical drainage by constructing shallow tube wells and pumping water in canal
- Bio-drainage by planting tree species like eucalyptus, Acacias etc.
- Introduction of metering at farm gate, modifying outlets and draining excess water
- Education and extension of economic water use training to farmers

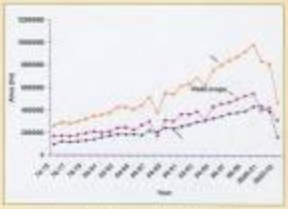

Fig. 7. Process of development of irrigated area in IGNP

Water Pollution : About 36 million litre per day (MLD) domestic and industrial effluents from 767 dyeing and printing units of Pali, 17 MLD from 632 industries of Jodhpur and 11 MLD from 399 textile units of Balotra and Jasol are discharged in Bandi, Jojri and Luni rivers, respectively. These effluents largely contain alkalis, residual dyes, starches, cellulose, soluble salts mainly sodium and calcium, silicate, oils and other impurities deteriorating quality of groundwater, and land and water resources along the rivers (Fig. 10). The polluted water at times sewerage water is utilized for growing vegetables and fodder crops in pari-urban area causing health hazards.

Management of Polluted Water

- Treatment of effluents at the source point and safe discharge in to the river with stringent regulations
- Irrigation with untreated effluent water should be avoided
- Addition of amendment, leaching of salts and planting of salt tolerant species is recommended on degraded lands

Rainwater Conservation : *In-situ* and *ex-situ* water harvesting and conservation of each drop of rainwater is paramount importance in arid region. Traditional rainwater harvesting structures like *tanka, nadi, khadin* (Fig. 11), roof water harvesting and their innovations of CAZRI should popularized.

Flood Water Harvesting : Drought prone western Rajasthan is subjected to flash floods and local inundation atleast once in 5-10 years. The recent (2006) flood in Barmer district generated nearly 165 mcm excess water impounded in depressional areas (Fig. 12). Presence of thick impervious gypsum, clay lenses and bentonite in substrata, and absence of proper drainage system has compounded the problem of natural calamity. There is potential to divert a part of this water in depleted aquifer by adopting suitable artificial recharge technology, recycling for vegetating barren sand dunes and for crop production.

Strategies for Water Management:

- An authoritative water resources management system is necessary for planning and management of water resources.
- Developing Decision Support Systems using remote sensing data in GIS for water resources planning considering spatially distributed demand and ground water status.
- Ensuring equi-distrbution of water to avoid conflict amongst stake holders.
- Improvement and utilization of traditional systems of water harvesting like *baori, jhalara, nadi, tanka, khadin* etc using improved designs developed by CAZRI.
- Popularization of artificial groundwater recharge structures such as percolation tank, sub-surface barrier, anicuts, recharge /injection wells etc. to rejuvenate depleted aquifers.
- Roof water harvesting and ground water recharging in cities be made mandatory.
- Enactment of groundwater law for judicious use and to check over-exploitation.
- Inter-basin water transfer through interlinking rivers to de-desertify the arid regions and to meet annual water demand of the region on sustainable basis.
- Integration of water and soil conservation through agronomic and engineering measures.
- Harvesting and conservation of floodwater to rejuvenate depleted high-capacity aquifers.
- Adoption of eco-friendly water saving technology such as drip and sprinklers on large scale and education and extension of technology effectively.
- Involvement of public and stakeholders in planning, development and participatory management of water resources.

Fig. 8. Water logged area in along IGNP main canal

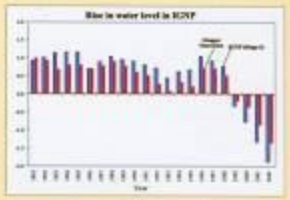

Fig. 9. Rise and fall in ground water level in IGNP

Fig. 10. Impact of Industrial effluant on Natural Resoueces in Balotra, along Luni River

Fig. 11. *Khadin* system of water harvesting for crop production

Fig. 12. Flood water in Barmer district

ENVIS SDNP Project: A Database on Flora of Indian Desert

Under ENVIS SDNP Project a database on Flora of Indian Desert was prepared considering M.M. Bhandari (Flora of the Indian Desert/Rev. Ed. 1990) as the base book. The database contains 694 records which provides a brief summery of the Desertic Plants in India under Scientific Name; Local Name; Family; Description (Flowering & Fruiting and field notes); Herbarium Specimen; Uses; and Key Words.

Forthcoming Conferences and Events

Fifth Session of the Committee For the Review of the UN Convention to Combat Desertification (Cric-5): 1 September 2006. Bucnos Aires, Argentina.

e-mail: secretariat@unccd.int;

Internet: http://www.unccd.int

Global Conference on Renewable Energy Approaches For Desert Regions: 18 September 2006-22 September 2006.

Amman, Jordan.

Internet:http://www.ju.edu.jo/confernces/gcreader/index.htm

Eighth Session of the Conference of the Parties to the Un Convention to Combat Desertificaton (Cop-8): 1 November 2007. Spain e-mail: secretariat@unccd.int;

Internet: http://www.unccd.int

Fifth FRIEND World Conference: Water Resource Variability: Processes, Analyses and Impacts. Havana, Cuba. 27 November - 1 December 2006 Internet: http://www.friend-amigo.org/conferenciaZ006/index.php

3rd APHW conference "Forest Hydrology and Integrated Watershed Management" 16-18 October 2006. Bangkok. Internet:http://www.es.lancs.ac.uk/people/nickc/FHIWMregistration.doc

Third AHPW Conference: Wise Water Resources Management Towards Sustainable Growth and Poverty Reduction. 16-18 October 2006. Bangkok, Thailand. Internet: http://thridaphw.org/

Recent CAZRI publications

Potential of Water Conservation and Harvesting Against Drought in Rajasthan, India. Eds. Pratap Narain, M.A. Khan and G. Singh. 25p. international Water Management Institute, Colombo, Sri Lanka, 2005

Improved Sheep & Goat Farming in Arid zone(in Hindi). Eds. B. L. Jangid, Khemchand and Y.V. Singh. 22p. CAZRI; 2005

Shrubs of Indian Arid Zone. Eds. Pratap Narain, Manjit Singh, M.S. Khan and Suresh Kumar. 176p. Arid Agro-ecosystem Directorate/CAZRI; 2005

Wastelands Management in Arid Western Rajasthan. Eds. Balak Ram, Pratap Narain, J.R. Sharma, R. Nagaraja, S. Jayanthi . 6p. CAZRI; 2005

Medicinal Plants in the Indian Arid Zone. Eds. Suresh Kumar, Farzana Parveen and Pratap Narain. 64p. CAZRI;2005

Drought in Western Rajasthan: Impact, Coping Mechanism and Management Strategies. Eds. Pratap Narain and Amal Kar. 104p. CAZRI; 2005

Heena Cultivation, Improvement and Trade. Eds. Manjit Singh, Y.V. Singh, S.K. Jindal & Pratap Narain. 56p. CAZRI;2005

Production Technology for Cowpea. Eds. D. Kumar and Pratap Narain. 36p. CAZRI;2005

Foreign Visits

Pratibha Tiwari, Durban, South Africa, 19-23 September 2005, Participated in 18th International Nutrition congress.

O.P. Yadav, Rome, Italy, 24-28 September 2005, Attended the 2nd International conference on Integrated Approaches to Sustain and Improve Plant Production under Drought Stress.

R.S. Mertia, Islamic Republic of Iran, 10-18 November 2005, High Level Meeting Under Indo-Iran work Plan 2004-05.

Pratap Narain, Beijing, China, 15-28 February 2006, Participated in the Meeting of International commission for Dry land Development & 8th International Conference on Dry land Development.

Pratap Narain, Dubai, 8-9 June 2006, Attended Inception Meeting for Launch of GEF Sponsored Development Stage Project.

M.A. Khan, Niger, 16-30 June 2006, Preparation of a Feasibility Study /Project Report for Cooperations between India and Niger in the field of Agricultural Development/Research.

O.P. Yadav, INRA, Montepellier, France, 3-12 July 2006, Attended the Training Course on "Phenotyping and Water Deficit".

N.M. Nahar, Granda, Spain, 12-16 July 2006, Participated in the International Conference on Solar Cookers and Food Preservation.

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