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WATERSHED DEVELOPMENT AND MANAGEMENT IN ARID WESTERN RAJASTHAN

Balak Ram
Former Principal Scientist, Central Arid Zone Research Institute, Jodhpur (Raj.) India
Email: dr.brmayank@gmail.com

Abstract: *Watershed development programme in India was launched in 1983-84 in a big way to conserve and utilise natural resources for higher productivity, employment generation and better livelihood. Arid western Rajasthan has 30398 micro-watersheds out of which 7771 are sanctioned, 3064 are completed and 4707 are in progress. However, due to physico-climatic constraints expected results/impacts are not obtained. In recent past several studies are undertaken to assess the impacts and outcome of watershed development and management programme but could not came up with appropriate solution to major challenges. The present study tries to focus district wise present status of watershed programme in arid western Rajasthan. The status and characteristics of surface and ground water resources as well as of various climatic parameters are discussed. Both positive and negative impacts are worked out. Major constraints of the region are highlighted and important challenges are pin pointed. Based on watershed development work carried out by different organizations/institutions as well as research outcome on management of natural and agricultural resources, technologies and management practices are suggested for efficient watershed development and management.*

Key words: Arid Region, Water Conservation, Agriculture, Crops, Impact Assessment

Introduction

Water is most vibrant form of the natural resources. The need of water is obvious for every living organism for its very existence. This unique commodity can never have an alternative. A watershed is a geo-hydrological unit from which all water drains into a common point making it an attractive unit for technical efforts to manage water and soil resources for production and conservation (Kerr, 2002). Watershed development refers to the conservation; regeneration and the judicious use of all the natural resources particularly land, water, vegetation and animals and human development within the watershed (Teri, 2018). Main aim of watershed management is to conserve the soil, plant and water resources of a catchment while benefitting humanity. All environmental, social, economic concerns are combined to treat watershed in an integrated manner (Mander, 2008). Arid Rajasthan is characterized by low and high erratic rainfall, poor river basin system (covering 43143.25 Km^2 or 20.67 percent area) with ephemeral rivers/streams. The drainage density is as low as 0.3 km/ km^{-2}. Under such hostile condition the conservation, rational use and management of water resources becomes most challenging task. The present study aims to bring out district level status of watersheds taken up under different projects/programme and their performance and impacts. Climatic parameters and characteristics of natural resources which have direct impact on performance of watershed, are described. Historical outline of Watershed Development and Management Programme in India, has been given and government initiatives and policies are highlighted. Findings of impact assessment studies carried out by several organizations/ institutions, are al discussed. Constraints and challenges emerged out from the watershed management activities over the time, are worked out. Proven technologies and management practices are suggested for efficient management and sustainable development of watersheds in arid Rajasthan.

Arid Western Rajasthan: Environment and Resources

Location: Hot arid zone in India occupy about 31.7 mha areas of which 61.9 percent is concentrated in 12 western districts of Rajasthan with a total geographical area of 208,751 $km^{2.}$ The region extends from 24° 37′ 00″ to 30° 10′ 48″ north latitudes and between 69° 29′ 00″ and 76° 05′ 33″ east longitudes (Fig. 1).

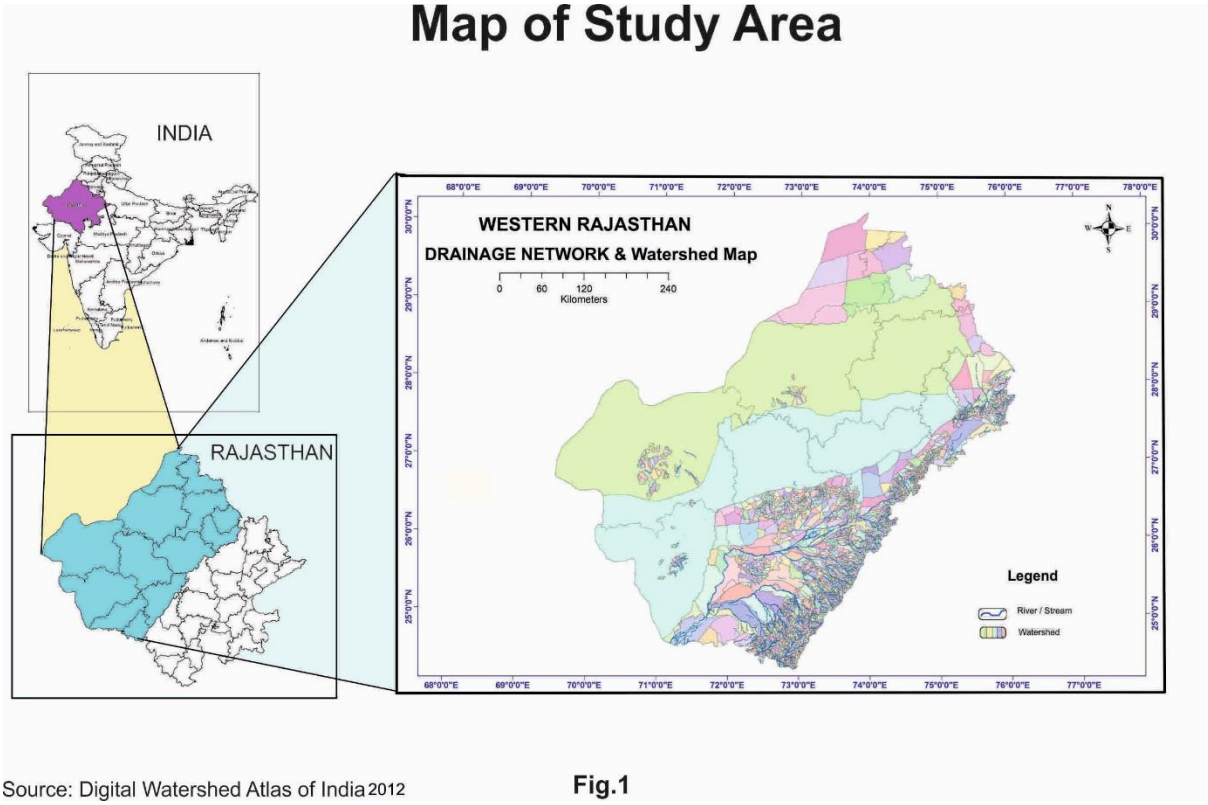
Climate: The region is characterized by low and high erratic rainfall, high evaporation loss and extremes of diurnal and seasonal temperatures. The average annual rainfall varies from 456 mm in north east to less than 100 mm in western most part of Jaisalmer district. The coefficient of variability of annual rainfall varies from 36 percent to 65 percent. Temperature during long hot summer days goes as high as 50° C while in cold winter it falls below – 6° C. Mean maximum temperature is 33.35° C and mean minimum 18.53° C. Mean aridity index is 78 percent. Probability of occurrence of drought varies from 50-60 percent. Mean moisture index varies from -59.5 in Sikar to -88.9 in Jaisalmer. The length of crop growing period varies from 8-15 weeks. Mean relative humidity during July and August ranges between 75-80 percent and during winter from 46-56 percent. Frequency of drought comes to once in 2-3 years in Barmer, Jaisalmer, Jodhpur and Pali districts; once in 3-4 years in Jalor, Nagaur, Bikaner, Sikar, Ganganagar and Hanumangarh districts and once in 4-5 years in Churu and Jhunjhunun districts (Narain et al, 2006).

Land Resources: Dominant landforms of the region are sandy plains with varying degree of hummocks and sand dunes. These are encountered with hills and outcrops, saline depressions and buried channels. Light textured sandy soils cover major part of this region. Desert soils are lower in fertility status, water holding capacity, very low in organic matter and high in pH values. The soils have high infiltration rate. Vegetation is quite sparse with limited number of xerophytic plants and thorny bushes. The drainage, except the ephemeral rivers of the Luni, Sekhawati, and Sabi basins, is mostly internal.

Surface Water: Central Arid Zone Research Institute (CAZRI 1990, 2000) worked out 1361.21 MCM as total surface water resources and identified 550 storage tanks (ranging from less than 1.51 to 208 x 106 m^3 capacity) in 12 districts in western Rajasthan. Mean surface water resources in the region are estimated to 2846.32 Mm^3/year (Beg and Ahmad, 2015). Western Rajasthan has 2 major dams (Jawai and Sardar Samand), 33 medium bunds and 62 small bunds with total capacity of 811.963 MCM. (Water Resources Rajasthan Portal, 2019). Water to these reservoirs is drains through a number of rivers and streams (mainly Luni and its tributaries). However, the water storage varies from year to year depending on rainfall. District wise details is given in table 1. Imported water (through irrigation canals) accounts 14765.65 Mm^3/year.

Ground Water: Ground water is deep, scares and over exploited. Ground water in 45 percent area is saline to very saline and in 40 percent moderately brackish. Estimated total Ground Water Resources in the region are 62171.12 Mm^3/year (Fresh 31228.65 and saline 30942.4 Mm^3/year) while availability of total ground water resources comes to 23880.64 Mm^3/year and total GW requirement 37395.0 Mm^3/year (Beg and Ahmad, 2015). As per CGWB (2019) assessment the total annual GW recharge comes to 4.01 BCM, total annual extractable GW resources 3.63 BCM and current annual GW extraction 5.59 BCM respectively. The stage of GW extraction comes to 161.6 percent. Per capita water availability in Rajasthan was 857 M^3 /year in 2010 which will come down to 457 M^3 /year in 2045.

Human and Livestock Resources: As per 2011 census the region has 27.12 million human populations. The density of population varies from 17 in Jaisalmer to 361 in Jhunjhunun district. Total livestock population as per 2012 census, was 30,177,959. Of this cattle constitute 20.48 percent, buffaloes 13.08 percent, sheep 22.79 percent, goat 42.38 percent camel 0.92 percent, horse & ponies 0.06 percent and others 0.29 percent respectively.



Source: Digital Watershed Atlas of India 2012

Fig.1

Method and Materials

District wise information and data on micro watersheds, their implementation and management through various agencies, expenditure incurred and their present status are gathered from reports of Min. of Rural Dev. (2019, 2020), Watershed Atlas of India (2114), Central Water Commission, Water Resources Dept. Government of Rajasthan (2019b), Ground Water Dept. and CGWB etc. Data are analysed and maps are prepared. Information on natural resources are based on the research work done at CAZRI. Climatic parameters are analysed from the studies conducted by Gupta et al. (2016), Poonia and Rao (2018) and Yadav et al. (2018). Achievements and impact of watershed development and management projects, are squeezed from the studies of Kerr (2002), LNRMI (2010), Shah (2010), Singh et al. (2011), Reddy et al. (2012), Painuli et al. (2014), Grey and Srinidhi (2014), Smyle et al. (2014), NDC, (2016), Dagar and Meena, (2016), James. 2017), TERI, (2018) and Rao, 2020. Technologies and strategies for watershed development and management are taken out from the work of Sharma, (2005), Eldheo et al. (2011), Goyal et al. (2013), Wang et al. (2016), Bhati et al. (2017) and TERI (2018) respectively.

RESULTS AND DISCUSSION

Review of Watershed Development Programme

Watershed development activity in our country was first taken up in 1942 in State of Maharashtra (then Bombay State) as a scarcity relief work during drought year through contour bunding for conservation of moisture and control of soil erosion. After independence, “Soil Conservation Work in the catchments of River Valley Projects (RVP)” was launched in 1962-63. This was followed by Drought Prone Area Programme (DPAP) in 1972-73 and Drought Development Programme (DDP) in 1977-78. During the 1980s, several successful experiences of fully treated watersheds, such as Sukhomajri in Haryana and Ralegaon Siddhi in western Maharashtra, were reported. In 1980-81, Ministry of Agriculture started a scheme of Integrated Watershed Management in the Catchments of Flood Prone Rivers (FPR). In 1982-83 a scheme for propagation of water harvesting/conservation technology in rainfed

areas was launched in 19 identified locations. This approach was further adopted in 22 other locations in rainfed areas in October 1984.

With experience gained from all these and realising 1987 worst drought situation in India, the concept of Integrated Watershed Development was first institutionalised with the launching of the National Watershed Development Programme of Rainfed Areas (NWDPRA) in 1990, covering 99 districts in 16 States. In 1994 Hanumantha Rao Committee was appointed. It has formulated a set of "Common Guidelines", bringing five different programmes under the MoRD, viz. DPAP, DDP and Integrated Wastelands Development Programme (IWDP), as also the Innovative- Jawahar Rozgar Yojana (I-JRY) and Employment Assurance Scheme (EAS). In April 1999 Dept. of Wasteland Development was renamed as Deptt. of Land Resources (MoRD) to act as Nodal Agency for all land based development programme and land reforms. Later DPAP, DDP and IWDP were consolidated as the Watershed Development Component of Prime Minister Krishi Sinchayee Yojna (WDC-PMKSY). In 2000, the Ministry of Agriculture revised its guidelines for NWDPRA, making them "more participatory, sustainable and equitable". These were called WARASA – JAN SAHABHAGITA Guidelines. The Common Guidelines of 1994 were revised by MoRD in 2001 and then again modified and reissued as "Guidelines for *Hariyali"* in April 2003. 'Neeranchal' is a World Bank assisted National Watershed Management Project designed to further strengthen and provide technical support to watershed component of PMKSY. In Rajasthan State, the Watershed Development and Soil Conservation Dept. is implementing the watershed projects sanctioned by MoRD and Min. of Agriculture and Cooperation since 1991.

STATUS OF WATERSHED DEVELOPMENT PROJECT

Government Documents: Integrated Watershed Management Programme (IWMP) is implemented by Department of Land resources, Min. of Rural Development, Govt. of India. The main objectives of IWMP is to restore ecological balance by harnessing, conserving and developing degraded natural resources such as soil, vegetative cover and water. In total there are 30,398 micro watersheds in western Rajasthan as per DoLR document on ''Watershed Status of Rajasthan, 2009-10". Out of them 6459 watershed projects covering an area of 33694.83 Km^2 have been taken up. This includes 4852 watersheds under Pre-IWBP Project (DPAP+DDP+IWDP), 1028 watersheds by other Ministries and institutions and 579 ongoing watershed projects under IWMP. 824 watersheds are proposed to be taken up. District wise details are given in table 1. As per document on Perspective and Strategic Plan for Development of Rainfed and Watershed Areas in Rajasthan for 18 years' period (Anon. 2018), total 7771 watershed projects are sanctioned. Of them 3064 are completed and 4707 projects are going on. District wise position is shown in fig. 2. Out of these total projects 3938 are under DDP, 3098 under Command Area Development (CDP), 5 under IWDP, 450 under NWDPRA and 280 under EAP/others.

External Funding Agencies: Externally aided watershed projects are being done through agencies like World Bank, European Economic Committee (EEC), German Bank for Reconstruction and Development (GBRD), Danish International Development Agency (DANIDA), Swiss Development Corporation (SDC), Official Development Assistance (ODA) in 16.5 mha area. From 2009-10 to 2013-14, total 447 watershed projects were sanctioned under IWMP covering an area of 28010.67 Km^2 as per report of Watershed Development and Soil Conservation Dept., Rajasthan. Under European Union State Partnership Programme, a total of 5883 watersheds under DDP, are taken up in western Rajasthan. District wise status of watersheds is given table 1. No project has been sanctioned from 2015-16 onward. At present the main emphasis on qualitative and timely completion of the ongoing watershed projects. Instead, some projects are entirely given to State Govt. and Central Govt. stopped funding.

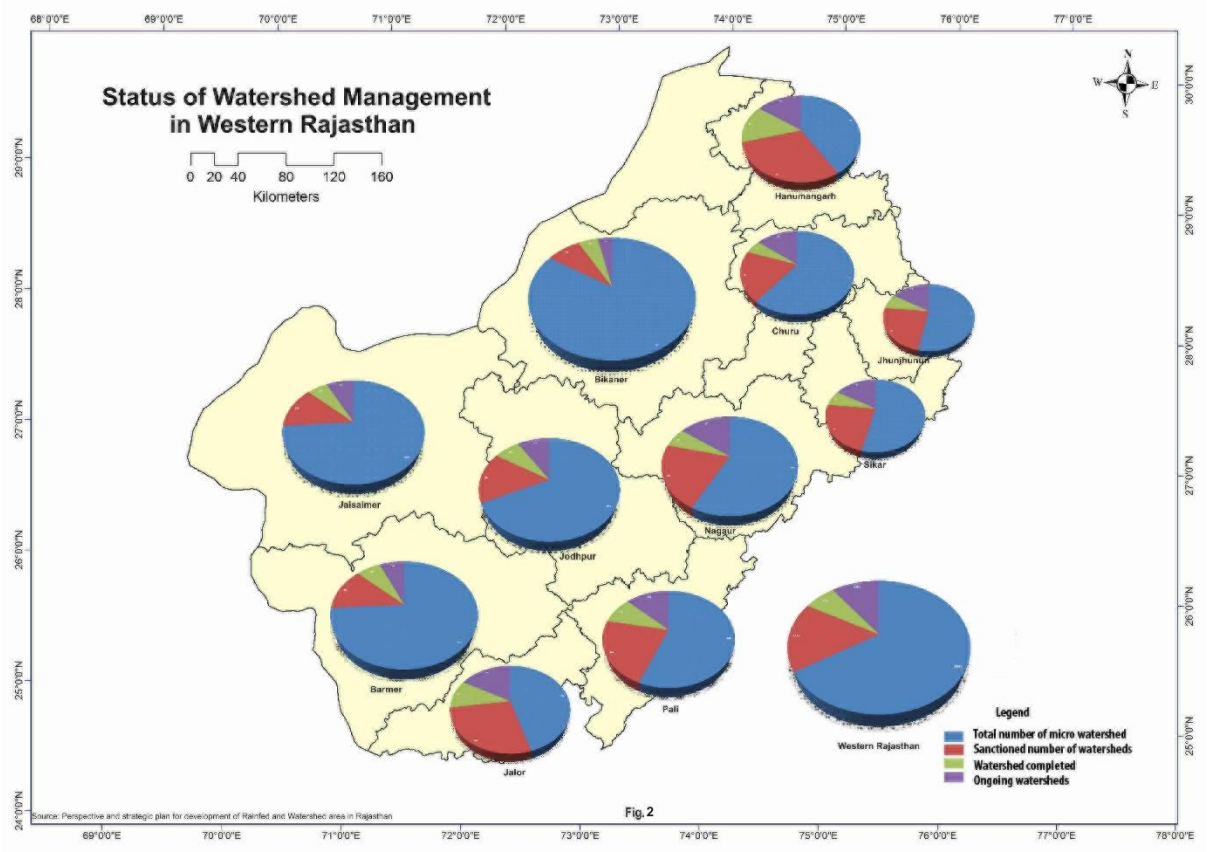
Neeranchal Project: Under this programme 10 watersheds are sanctioned in Rajasthan State. Of them 5 are located in Jodhpur district each one in Balesar, Bhopalgarh, Bilara,

Bawari and Osian CD Blocks and covering a total area of 32804 ha (Annual Report 2019-20, WDSCD).

Table 01: District wise Surface Water Resources and Status of Watershed Projects in Western Rajasthan

District	Mean surface water resources Mm^3/year	Number of large, medium and small tanks/bunds	Total nos. of Micro-watersheds	No. of watershed sanctioned	Percent total watersheds taken up	IWMP Projects 2009-10 to 2013-14
Barmer	351.2	0+1+0	5635	989	15.1	75
Bikaner	99.06	0+0+2	5007	575	9.6	55
Churu	99.06	0+0+0	2238	725	38.3	42
Ganganagar	108.8	0+0+0	00	00	00.0	5
Hanumangarh	108.8	0+0+0	250	178	85.6	6
Jaisalmer	351.2	0+0+0	5334	945	9.9	57
Jalor	277.9	0+5+6	1731	1046	24.0	29
Jhunjhunu	192.8	0+2+0	1130	499	30.8	20
Jodhpur	351.2	0+4+1	4011	949	20.0	76
Nagaur	445.2	0+1+8	2653	970	23.5	48
Pali	252.2	2+18+33	1086	424	47.7	35
Sikar	208.9	0+2+12	1323	571	55.1	29
Total W. Raj.	2846.32	2+33+62 =97	30398	7771	21.2	477

Source: 1. Dept. of Land Resources, Min. of Rural Dev. GOI
2. Watershed and Soil Conservation Dept. Rajasthan 3. Beg and Ahmad, 2015



Contribution of CAZRI: CAZRI has taken up development work in 1200 ha Jhanwar Watershed (Jodhpur) during 1885-86 and 870 ha Baorli-Bambore watershed (2000). Under National Agricultural Technology Project (NATP) in Arid Agro-ecosystem, agricultural interventions were undertaken in 8 watersheds covering an area of 3195.5 ha in arid zone of Rajasthan, Punjab, Haryana, Gujarat and Tamil Nadu, during 2001-2004. These include Salori

(Jodhpur), Shishoo (Sikar), Changeri (Udaipur), Kukma (Bhuj), Gangadara (Banaskantha), Sirrapur Theri (Thoothukudi), Ludas (Hissar), Ghari Bhagi (Bathinda). Based on 230 field experiments soil site suitability criteria was developed for 28 crops (Balak Ram *et al.* 2004a, 2004b, Patidar et al. 2005).

Involvement of NGO: Non-Government Organizations contributed in watershed development programme in western Rajasthan are URMUL in Bikaner; GRAVIS, Arpan Sewa Sansthan and Jal Bhagirathi Foundation in Jodhpur; Bhoruka Charitable Trust in Churu; Watershed Trust Organization (WOTR), CAIRN India Limited (2018) and BAIF Development Research Foundation in Barmer; WASCO in Jalor; Indo-German Watershed Development Programme (IGWDP) implemented by NABARD. Indo-German Watershed Development Programme is implemented by NABARD, and European Union State Partnership Programme.

Funds Released: Total funds released by Centre from 1995-96 to 2007-08 to DPAP, DDP and IWDP was 7738.6 crores. An amount of Rs. 6688.16 crores were released from 2014-15 to 2017-18 under IWMP. Up to May 2018, watersheds covering an area of 166667 ha has been treated. From 2009-10 to 2014-15, 1025 watersheds covering 5.764 Mha area with cost of Rs.7808.86, are sanctioned and funds of 1673.3 crores are released. The total cost of 477 watershed projects of western Rajasthan under IWMP from 2009-10 to 2013-14 comes to 420159.99 lacs.

Impacts of Watershed Management Programme
Organizations/Institutions Involved in Impact Studies on Watershed:

1. 56 watersheds by Taylor Nelson Sofres Mode Pvt. Ltd. (2002)
2. Agro-economic Research Centre, Sardar Patel University (V.D. Shah, 2010)
3. 30 watersheds in Barmer, Bikaner, Jaisalmer and Jalor districts Livelihood and Natural Resources Management Institute (LNRMI, 2010)
4. 4 watersheds by Centre for Rural Studies, Lal Bahadur Shastri National Academy of Administration (Singh, P. Behera, H.C. and Singh, A., 2011).
5. 30 watersheds in Jaisalmer district by Central Arid Zone Research Institute (Painuli *et al.* 2014).

Besides, Kerr (2002) from International Food Policy Research Institute, Sharma (2005), Dagar and Meena (2016), Grey and Srinidhi (2014), Guangyu Wang *et al.* (2016), Smyle *et al*. (2014) and Rao (2020) also assessed the performance of watershed projects and came out with valuable suggestions. Govt. has now entrusted the monitoring and evaluation of watershed projects in arid districts of Rajasthan to Water and Power Consultancy Service (India) WAPCOS and NABARD Consultancy Services (NABCONS).

Positive Impacts: Important positive impacts emerged from the watershed management programme are reduction in soil erosion, improvement in ground water level and soil moisture, increase in net sown area, crop production/productivity, crop diversification, availability of fodder & fuel and number of livestock. Income of community members has increased and out migration declined. At some watersheds good quality watershed structures are created. Creation of additional employment, reduction of workload for women in fetching drinking water, and increase in awareness about such development projects as well as improved technologies among the inhabitants are other positive impacts.

Negative Impacts:

1. Unevenly distribution of benefits from poor residents in upstream to wealthiest farmers in irrigated downstream part.
2. Offer more benefits to landowners while landless get benefits from peripheral activities. This class is denied access to resources that contribute to their livelihood.
3. Improper and ineffective implementation of guidelines
4. Absence of external evaluation and monitoring
5. Improper equipped extension machinery

6. Lack of equity in benefits
7. Lack of sustainability in maintenance of project after cessation
8. Lack of community participation and scaling up methods and models
9. Improper and less utilization of funds
10. Less involvement of poor in planning and decision making process as compared to large and medium farmers
11. Most of the watersheds got below average score in environment, economic and institutional/social indicators.
12. Over all, the performance of WSD does seems to be constrained due to adverse climatic conditions.

Constraints and Challenges

Major environmental constraints of highly fragile arid ecosystem are scarce and poor natural resources and inhospitable climate; scarce, deep, saline and highly depleted ground water; and light textured soils with high infiltration rate and limited crop growing period. Striking challenges are low agricultural productivity; degradation of land and water resources; frequent drought; desertification, burgeoning human population and climate change. Situation of surface water availability is worsening because of increasing trend of population. There exists a declining trend of inflow to surface water resources in spite of an increasing trend of rainfall (Gupta et al 2016). Catchments are deteriorated due to constant increase in population and human activities specially housing clusters, industries and mines. Natural regeneration of vegetation covers and soils in arid areas take 5-10 times longer than in favourable area. Further, if there is no water to conserve, harvest and use, all development technologies fail. Thus arid region requires special management plan and interventions to succeed under such adverse environmental conditions.

According to Parliamentary Standing Committee, watershed development project is lagging behind. Not a single out of the 8214 projects sanctioned between 2009 and 2015 at the cost of 50740 crores had been completed (Hindu July, 22, 2018). According to DoLR, 1257 projects have not even completed the initial stage. No new projects were sanctioned after 2015-16. Visible success and impact are not there. It is all about “making running to water stop and standing water to sink inside” said Dr. Ch. Radhika Rani. Delay in coordination is another problem. Govt. Can implement the project through govt. agencies and NGO but once they finish who remain to sustain it. If local Panchayti Raj leadership and watershed user associations are not strengthen and improved, any benefits will be cyclical and short term only.

Technologies and Options

Over the last 50 years in our country a lot of research based technologies and management options are developed at different levels for watershed management. For WS management in hot arid region CAZRI (Goyal *et al*. 2013) has developed proven and effective technologies. These include Ex-situ water conservation through farm pond, tanka, nadi and khadin; in-situ water conservation through contour bunding & trenching, contour furrow, mocro-catchment, sub-surface barrier and mulching. Contour bunding for arable land may be in form of vegetative barriers, graded bunds, grass water ways and shelter belt. In short, water budgeting, increase in water use efficiency and water productivity and increase infiltration of rain water are very important. In case of non-arable lands, the options are contour furrow, contour trenches, gully control and anicut/check dam. For rational resource utilization, improved agronomic practices are: tillage, improved seed variety, crop geometry & plant population, crop rotation and inter-cropping/mix cropping. Contingency planning is another option in the event of failure of monsoon and drought situation. These are life-saving irrigation, insect pest management, and differential fertilizer application. Important farming practices of alternative land use system are agro-horticulture, agro-forestry, silvi-pasture and dairying.

Conclusion

Since the onset of watershed development and management programme in 1983-84, government has continuously done all efforts and improved various components of the project for effective implementation. New guidelines provide a paradigm where role of govt. changed from governance to facilitation. In Arid western Rajasthan there are 30398 micro-watersheds. Of them 25.6 percent are sanctioned so far and from them 39.5 percent are completed. At present 4707 are ongoing projects. However, in spite of better planning of technological and management components and spending millions of rupees, the desired results are not obtained. Important impacts came up so far are, construction of water conservation/storage structures; increase in soil moisture, crop production/productivity, biomass and income of households. There is positive impact on reduction in soil erosion and runoff. Creation of employment to local people and awareness are other achievements. Lack of equity in benefits, lack of sustainability in maintenance of project after cessation, lack of community participation, improper and less utilization of funds, and lack of equal sharing of benefits to farmers are some negative impacts. Watershed in extreme arid region have shown comparatively lesser degree of positive impacts than the watershed in favourable rainfall regions. Every year access to water is highly uncertain and risky which fails all the planning efforts. Therefore, area specific and situation and need based priorities and adoption of updated/refined technologies are needed. Better linkage and cooperation from top to bottom, timely action and developing sense of liability/responsibility will yield positive results for long term sustainability of watershed.

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