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Impact of Soil and Water Conservation Measures on Hydrology of Micro Watersheds in Madhya Pradesh

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ABSTRACT

Soil and water conservation measures are meant to reduce soil erosion and utilize rainwater. The measures include construction of contour bunds, contour trenches, graded terraces, check dams, dugout ponds, open wells, and similar other works. Some of the works done by the agencies of the Madhya Pradesh Govt. are analyzed and discussed in the paper. The data analyzed pertain to the catchments of the Narmada river and the analysis indicates that there has been increase in the base flow from 181 to 336 cumecs before and after the implementation of watershed programs by Raiiv Gandhi Mission for Watershed Management in Madhya Pradesh. The paper also deals with some suggestions for effective implementation of the on-going watershed programs.

INTRODUCTION

Making water available to meet the demands of growing population without disturbing the environment has emerged as one of the primary resource issues that need to be addressed. This concern is based on the uncertainties stemming from the vagaries of monsoon, a growing population and more recently the prospect that green house induced climate changes that is apprehended to alter the hydrologic cycle in uncertain ways.

The irrigation sector consumes the largest amount of water. The annual per capita availability of water now is at a comfortable level of 2100 m^3. However, it overlooks the uneven spatial and temporal distribution of water resources in the country. The estimates of water requirements based on population growth, food demand, agricultural, industrial and civic needs, have been made for the years 2010, 2025 and 2050 at the national level. The total water requirement, thus, would be 694 to 710, 784 to 850 and 973 to 1180 km^3 by the years 2010, 2025 and 2050, respectively, based on low-demand and high-demand scenarios (Sharma, 2002). According to these estimates, in 2050, the country's utilizable water availability of 1056 km^3 will barely match the low-demand scenario (973 km^3). A useful strategy to augment the available water resources may be to harness the large amount of monsoon surplus water through suitable watershed development programmes.

The watershed approach is the principal vehicle for transforming the rainfed agricultural technology into a remunerative vocation. It enables a holistic development of agriculture and allied activities in the watershed area through various kinds of land uses and supporting such land use activities by the water augmented through watershed

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Table 1. Perspective plan for land reclamation under watershed development programs and funds requirement for next four Five-year plans

Five year plan	Area to be covered mha	Estimated cost of development Rs/ha	Total cost (A)	Cost sharing ratio*	Cost sharing (A)		
					Centre	State	People
X plan (2002-07)	15.0	5000-7000	9000	50:25:25	4500	2250	2250
XI plan (2007-12)	20.0	6000-8000	14000	40:30:30	5600	4200	4200
XII plan (2012-17)	25.0	7500-9500	21250	30:30:40	6375	6375	8500
XIII plan (2017-22)	28.5	9000-11000	28500	25:25:50	7125	7125	24250
Total	88.5		72750		23650	19950	29200

Source: Sharma, 2002; * Cost sharing ratio between centre, state and people. (A): Rs. in crores

development programmes. The watershed development activities directly interact with the local hydrology and results in improved ground water storage, base flow and surface storage, all of which can be exploited for irrigation.

A perspective plan was prepared by the Planning Commission for the implementation of watershed programmes during next four Five-year plans. Under this plan, it is proposed to treat 88 million hectares (Mha) land, which includes 62 Mha of rainfed area and 26 Mha of degraded forestland (Table 1). The total outlay proposed for the X plan is about Rs 90 billion to treat an area of 15 Mha with cost sharing ratio among Centre: State:local community as 50:25:25.

Impact of Rajiv Gandhi Mission (RGM) for Watershed Management in Madhya Pradesh

Madhya Pradesh, with a geographical area of 30.8 Mha, has varying topography with an average annual rainfall of 1200 mm. The sate has created irrigation potential of 3.3 Mha out of which 2.1 Mha have been utilized. There are 22 major, 134 medium and 6910 minor irrigation projects in the state but these are inadequate to supply water to much of the cropland. Due to limited irrigation development and uncertainty of rainfall, the Government of Madhya Pradesh has implemented watershed development programme through Rajiv Gandhi Mission (RGM). The mission started working since 1994, initially in the most drought-affected districts. Later, it was extended to cover all the districts with major emphasis on construction of bioengineering structures like check dams, farm ponds, groundwater recharge structures, soaking pits, contour trenches, contour bunds and gully plugging structures in the Narmada Valley. In the western Madhya Pradesh, RGM has undertaken massive soil and water conservation measures covering about 83864 ha area (Table 2) in the drought-affected districts of Dhar, Khandwa and Khargone (Fig. 1). The normal annual rainfall of the above districts varies from 920 to 1010 mm.

In order to see the impact of soil and water conservation measures in terms of runoff and sediment yield, the stream gauging data at Mandleshwar was collected from CWC, Bhopal for the years 1993-94 and 1998-99. The hydrographs for these two years are

Table 2. Watershed areas treated with soil and water conservation measures under Rajiv Gandhi Mission in the districts of Narmada valley contributing to Mandleshwar stream gauge station

Name of the district	Program of funding	Number of watersheds selected		Area treated from 1994-2000, ha	
		Milli	Micro	Target	Achieved
Dhar	DPAP	10	39	19578	7253
Khargone		5	41	27814	6698
Dhar	EAS	17	178	1,37,743	18539
Khargone		12	87	52983	11628
Khandwa		22	127	97602	30419
Indore		7	42	20475	9327
Total		73	514	356195	83864

(Source: Anonymous, 2002)

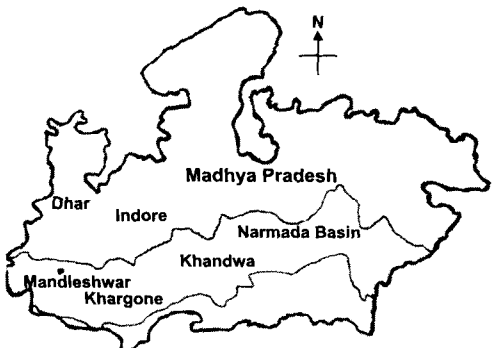

Fig. 1. Mandleshwar stream gauging station in Narmada basin of Madhya Pradesh covering the selected districts.

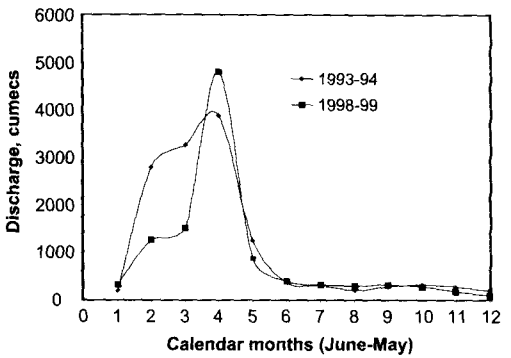

Fig. 2. Hydrograph at Mandleshwar stream gauging station in Narmada basin.

given in Fig 2. From the hydrograph, the monthly average base flow was estimated and found increasing from 181 to 336 cumecs i.e., an 85 % increase in 1998-99 over the pre-project year 1993-94. The data showed the evidence of decrease in annual runoff in the year 1998-99 with runoff rainfall ratio of 0.32 as compared to 0.586 of 1993-94, though the annual rainfall was higher in the year 1998-99 (Table 3). The annual silt load estimated at Mandleshwar stream gauge station decreased from 54.02 Mt in 1993-94 to 34.42 Mt in 1998-99.

The RGM for Watershed programme was funded by Drought Prone Area Programme (DPAP), Employment Assurance Scheme (EAS) and Integrated Watershed Development Programme for Rainfed Agriculture (IWDPRA). The RGM has been extended to cover all the districts of Madhya Pradesh with the following objectives.

i) To restore ecological degradation and improve the environmental resource base.

ii) To develop a repository of scientific and technological inputs especially for the field level implementing agency, which could facilitate detailed and area specific planning.

Table 3. Impact of soil and water conservation on runoff and sediment in Narmada valley, measured at Mandleshwar stream gauge station.

Year	Annual rainfall, mm	Annual runoff, mm	Runoff rainfall ratio	Annual sediment yield, mt
1993-94	822.8	482.2	0.586	54.02
1998-99	1233.4	382.6	0.32	34.42

Source : CWC. 1995a, 1995b, 2000 and 2001

Table 4. Impact of Rajiv Gandhi Mission for Watershed Management (RGMWM) on ground water and irrigation in Madhya Pradesh over pre project period.

Sl.No.	Item description and results with respect to each	
1	Total area selected for treatment, m ha	3.5
2	Area treated upto 2002, m ha	1.7
3	Water harvesting structures created, no.	1,75,581
4	No. of villages in which ground water levels increased	5634
5	Increase in dug wells with water throughout the year	66.1%
6	Increase in tube wells with water through out the year	64.4%
7	Decrease in dug wells getting dry in summer	40%
8	Decrease in tube wells getting dry in summer	41%
9	Increase in irrigated area during kharif	31.4%
10	Increase in irrigated area in rabi	48%
11	Increase in irrigated area in summer	108%

Source: Anonymous, 2002

iii) To maximize people's participation in concept development, planning, implementation and maintenance of soil and water conservation activities in watershed areas to make scheme effective and transparent in working.

iv) To focus on disadvantaged communities through equitable distribution of resources and sharing of benefits.

Out of 3.5 Mha rainfed area selected for treatment under the above mission, 1.7 m ha was treated with soil and water conservation till 2002. The number of water harvesting structures created were 0.175 million. The benefits of such measures include increased groundwater recharge leading to an increase in the number of dug and tube well and a consequent increase in the irrigated area during *kharif* (31.4 %), *rabi* (48 %) and summer (108 %), over the pre project period (Table 4). The impact of RGM was felt on agricultural production during all the seasons, increasing fodder production by 121%, plantation by 82.7% and fuel wood availability by 58% (Table 5). Besides RGM, looking into the severe drought situation prevailing in Madhya Pradesh in year 2001, Government of MP has taken a community based soil and water conservation programme under '*Pani Roko Abhiyaan*'. The Government had spent Rs. 7.92 billion for the construction of new tanks, dug wells, recharge structures, soak pits, contour trenches, field bunds, farm ponds and dugout pits on agricultural land with public contribution of Rs.1.51 billion in the form of labour (Table 6). All these measures resulted in creation of additional impounding capacity of 1439 million cubic meters of water.

Table 5. Impact of RGMWM on bio resources in Madhya Pradesh

Sl. No.	Item description and achievement on each	
1	Increase in agricultural production in kharif	43.8%
2	Increase in agricultural production in rabi	49.3%
3	Increase in agricultural production in summer	36.9%
4	Increase in fodder production	121%
5	Increase in plantation	82.7%
6	Increase in fuel wood availability	58%

Source: Anonymous, 2002

Table 6. Progress of soil and water conservation works under '*Pani Roko Abhiyaan*' in Madhya Pradesh during 2001- 02

Sl.No.	Particulars of work done	Progress
1	Construction of new tanks	22815
2	Construction of new dug wells	65996
3	Arrangements for recharge:	
	i) Dug wells	238758
	ii) Tube wells	70364
	iii) Hand pumps	131201
4	Construction of farm ponds, dug out ponds	94455
5	Construction of dug out pits on agriculture land	1519753
6	Construction of field bunds around the field, km	15204
7	Construction of contour trenches on wastelands, km	7474
8	Construction of soak pits in inhabited areas, km	336
9	Additional impounding capacity created, MCM	1439

Source: Anonymous, 2002

Impact of Water Harvesting Structures on Crop Production

In India, maximum area of vertisol is found in Maharashtra (29.9 Mha) followed by Madhya Pradesh (16.7 Mha). The verisols have finer particles with large surface area and poor infiltration and hydraulic conductivity. Hence, the vertisol has potential for storing water in dugout ponds, as the seepage loss will be small. Vertisol regions in Madhya Pradesh experience moisture stress during *rabi*. Two dugout ponds of 3 m depth and 2.54 ha m and 10 ha m capacity were designed and constructed in the year 1984 and 1995, respectively, across a natural stream flowing through the farm of the Central Institute of Agricultural Engineering at Bhopal, Madhya Pradesh. The water storage and utilization studies of these ponds revealed very good potential for water harvesting and recycling to stabilize crop production. The evaporation and seepage loss of water was 10 to 12 mm per day. The harvested water was utilized by pumping the water and distributing it through underground pipeline to operate sprinkler irrigation system except for rice. Rice was irrigated by gravity flow system .The yield of rice was increased by 90% with two irrigation at transplanting and grain filling stage over no irrigation in *kharif*, soybean yield was increased by 42% with one irrigation at pod formation stage. During *rabi*, two irrigations

Table 7. Impact of water harvesting structures on crop production

Irrigation stage	Crop yield, q ha^{-1}					
	Rice	Soybean	Wheat	Chickpea	Linseed	Safflower
No Irrigation	17.6	16.2	15.8	13.0	8.7	11.1
Transplanting (T)	25.4	-	-	-	-	-
Grain filling	22.7	23.5	-	-	-	-
T + grain filling	33.5	-	-	-	-	-
Pre – sowing (PS)	-	-	22.1	21.3	10.2	15.2
Pre – sowing (PS) + Flowering (F)	-	-	-	23.9	13.0	17.4
PS + Pod filling	-	-	-	24.6	13.6	16.7
PS + F + Pod filling	-	-	-	26.9	15.2	19.2
Crown root initiation (CRI)	-	-	22.6	-	-	-
PS + CRI	-	-	28.2	-	-	-
CRI + F	-	-	26.5	-	-	-
PS + CRI + F	-	-	31.4	-	-	-

Source: Bhandarakar et al., 2002

to wheat at sowing and CRI stage increased grain yield by 78%. Similarly, the grain yield of chickpea, safflower and linseed were increased by 90, 51 and 56%, respectively, with two irrigations at pre sowing and pod formation stages (Table 7).

Mechanisms for Strengthening the Watershed Management Programs

1. Scientific monitoring and evaluation of resource base created in the watersheds with respect to soil quality, ground water quality and change in the hydrologic conditions of the watersheds after the treatment.
2. Development of gauging system for quantifying the hydrologic inputs and outputs in the watersheds for proper design of bio engineering structures and scientific planning of crop production systems
3. Strengthening community participation for further maintenance and management of resources created in watersheds by establishing suitable cooperatives with financial support from *panchayats* and restructuring/ reorienting of public extension functionaries for greater responsibility to efficient management.
4. Adoption of modern and cost-effective irrigation technologies for efficient utilization of water resources and promoting on-farm water management.
5. Development of linkages between researchers, watershed implementing agencies, Central authorities and state government agencies for effective and scientific development of the watershed programs
6. Policy reforms related to pricing of water resource to the users/ community, legislation to prevent over exploitation of ground water resource and pricing mechanisms to induce suitable cropping systems

CONCLUSIONS

Watershed development programs undertaken in the mission mode by involving local communities had several beneficial effects. It increased water availability, the number of dug wells and tube wells, irrigation

intensity, cropping intensity and base flow in Narmada basin. It simultaneously reduced the runoff loss. The programs have contributed to reducing drought in several districts of Madhya Pradesh. The massive program "Pani Roko Abhiyaan" undertaken by Govt. of MP with peoples participation during 2001 to 2002 has become a model for the other states for conserving soil and water. Impact assessment studies conducted in treated watersheds have revealed that there has been: (i) recharge of ground water aquifers as evidenced by increase in water tables and rise in number of wells (ii) reduction in soil erosion and peak flows (iii) increasing cropping intensity (iv) changes in cropping pattern (v) enhancement in crop productivity (vi) rise in overall bio mass in the watershed.

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