

# Integrated development of natural resources in hill and valley eco-system through rain water management technology

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## ABSTRACT

The watershed area of 2216.83 ha was treated with peripheral bund/ marginal bund, submergence bund, check dam, water storage structure and masonry structure from 1997-98 to 2000-01 with different soil and water conservation measures, thereafter, the holistic management approach diffused in the operational area. The uncultivated area changed into cultivation of groundnut and other crops during rainy season and 1992.00 ha area changed into double cropping system. The cropping intensity increased from 89.95% to 188.21%. Area under, groundnut cultivation increased upto 1910 ha and covered 87.61 % area of pilot project during rainy season. The farmer's dugout 611 stony open dug well in pilot area of six villages for collection of recharged ground water. Ground water table rose up to the extent of 3.22 m. The recharged ground water is available for protective irrigations up to mid March. The 99.98 % cultivated land has been saturated under protective irrigation facility from recharged and harvested rainwater. The area under groundnut, urd and maize during rainy season and wheat, gram, mustard, potato and winter vegetables during winter season has increased whereas the area under jowar and, sesame declined due to diffusion of groundnut. The initial productivity of groundnut, maize, wheat, gram, lentil, mustard, radish, tomato, carrot, onion and potato were raised from 7.0 to 27.5 q/ha, 9.0 to 27.0 q/ha, 7.0 to 40.5 q/ha, 0 to 18.7 q/ha, 6.5 to 11.0 q/ha, 0 to 21.5 q/ha, 0 to 187.0 q/ha, 90 to 295.5 q/ha, 0 to 155.5 q/ha, 0 to 307.0 q/ha and 0 to 300.0 q/ha, respectively. Thus the average productivity of watershed enhanced appreciably from 8.46 q/ha to 35.21 q/ha. The transport facilities improved from bullock carts to tractors and motorcycles. The conservation practices generated through rainwater management technology are being followed by most of, the farm families on cultivable land of six pilot villages. In addition to this the village situated in the vicinity of project area also followed the generated technologies. Number of tractors increased from 17 to 103 in the pilot area. Likewise, diesel operated pump sets increased from 11 to 709 in the operational area of watershed for lifting of water from water-impounded structures. The demography of cows increased from 2110 to 5379, buffaloes 2205 to 4328 and goats from 1848 to 3567 in the watershed area during 2003-04 over the base year of 1997-98 with the development of natural pasture land of *Digitaria biformis*, *Digitaria trifoliata* and *Paspalum*.

**Key words** : Climatologically, Edaphically, Topography, Precipitation, Hillocks, Water shed area, Rain water management

## INTRODUCTION

More than 70 per cent population of India derives its livelihood and environmental securities directly from natural resources like soil, water, vegetation, livestock and village enterprises. Escalating demographic pressure has reduced per capita cultivated land from 0.48 ha in 1951 to 0.14 ha by now. Livelihood needs of rural communities are expected to be realized from increased productivity without degrading qualities of natural resources. The management of natural resources in hilly area of Bundelkhand is very difficult task because it is a part of great Central Indian Plateau, consisting mostly of valleys all round hills, ravines and crags. These odd situations is highly confined the crop production. Climatologically, edaphically and socially this zone is quite different from other zones of Uttar Pradesh. It is characterized by semiarid climate, undulating topography, residual soil of erodible nature, deepwater strata underlain with hard impermeable rocks, poor crop husbandry including low fertilizer use and irrigation. The annual precipitation is of the order of 1014 mm, which is largely concentrated from mid June to mid September. The total rainy day is about 60. During rainy season, the residual nature of soil and

rocks reduce the infiltration rate and consequently leads to high runoff. Since the irrigation facilities are available only in 30 per cent of the cultivated area and rest of the 70% area is rainfed in the region, the only approach which can take to improvement of dry land agriculture in the zone is rain water management approach in which the rainfall received during the rainy season is conserved in soil and excess runoff is harvested, stored and recycled for life saving irrigation followed by improved crop production technology.

## MATERIALS AND METHODS

The site of the operational area of Rain Water Management Project is located in Babina block of Jhansi district of Uttar Pradesh between the catchments area of Pahuj river and Dongri dam. The operational area of rainwater management typically represents soil, climate and socio-economic condition of Bundelkhand region. Water surplus is 168.11 mm mostly available from July to September. Water deficit in operational area is 766.15 mm. It measured by the amount of which the actual evapotranspiration (AET) falls short of the potential evapotranspiration (PET) and expressed as  $WD = (PET$

-AET) from the average monthly data of 20 years of operational area. Water surplus is the amount of water supply (Rainfall) that exceeded the water need WET). The excess water either drained off as surface runoff or lost by deep percolation after satisfying the field capacity of soil. The computation of annual water deficit and annual water surplus was done as per procedure introduced by Thornthwaite (1948) and Thornthwaite and Mather (1955). The moisture availability period for the crop growth in the pilot area is 122 days. The soils of operational area developed over alluvium and occur hillocks and valleys. Watershed land belong to class II, III and IV of the land capability Class and were suitable for cultivation. The watershed area is composed of highly eroded rakar soil. The whole watershed area was treated with different soil and water conservation measures. The 734 farm families involve in the rain water management technology having 2180.00 ha land under cultivation of different crops and 36.83 ha area under natural pasture land, forest, orchards etc.

## RESULTS AND DISCUSSION

### *Treated area under different soil engineering measures for soil erosion and runoff control:*

The selected area of watershed was hillocks and ravinous. Soil and water conservation measures followed in the pilot area along with their catchments area are given

**Table 1: Treated area under different soil engineering measures for moisture conservation**

Sr. No.	Soil and water conservation measures	Catchments area (ha)
1.	Peripheral/ marginal bund	370.00
2.	Submergence bund	744.00
3.	Check dam	640.00
4.	Water storage structure	426.00
	Total	2180.00
5.	Masonry structure	97 Nos.

in Table 1.

The main purpose of different type bunding is to reduce the high velocity of runoff from hillocks to valleys and gullies. The check dam and masonry drainage structures were constructed for safe disposal of excess water from field to field. As results of these soil and water conservation measures, runoff has been fully controlled. The plant nutrients and silt are being trapped in fields along with peripheral/marginal bunds, submergence bunds and check dams.

### *Monthly rainfall in the watershed area:*

The rainfall plays a decisive role among all the weather parameters in the strategies of crop planning under dry farming agriculture, The monthly rainfall has been recorded in the watershed area and shown in Table 2. Mostly onset of monsoon was observed in the June and withdrawal of monsoon was noted in October during all the years. August is the wettest month (273.6 mm) of the year followed by September (244.9 mm) in respect of total rainfall. The rainfall received during the month of January, February, March, April, May, October, November and December was not found notable.

### *Alimentation of rainwater and its exploitation for protective irrigation:*

The rain water harvested in water storage structures is being used for protective irrigation to different rabi season crops, and late maturing kharif season crops to some extent. Prior to start of rainwater management project, the ground water Table in the area was about 10.0 m deep. Now land treatments employed for rainwater conservation and runoff control have helped in improvement in ground water table which has risen to the extent of 3.22m.

Since the water availability in the watershed has increased tremendously due to alimentation and recharging of rainwater. The irrigated area has increased from 719.60 ha (32 %) during base year to 2179.60 ha

**Table 2: Monthly rainfall in the watershed area**

Years	Months												Total
	Jan.	Feb.	Mar.	Apr.	May	Jun	July	Aug.	Sept.	Oct.	Nov.	Dec.	
1997	0.0	0.0	0.0	21.2	3.9	109.0	295.0	295.0	94.7	53.8	9.0	81.3	962.9
1998	0.0	0.0	0.0	0.0	0.0	54.7	263.0	733.0	87.1	0.0	0.0	0.0	1137.8
1999	0.0	0.0	0.0	0.0	0.0	18.6	171.0	216.0	570.0	35.5	0.0	0.0	1012.1
2000	0.0	0.0	0.0	0.0	0.0	84.1	289.0	119.0	69.4	35.6	0.0	0.0	597.1
2001	0.0	0.0	5.2	4.0	22.4	93.2	260.8	154.2	46.1	55.8	0.0	0.0	641.7
2002	3.2	49.8	0.0	0.0	56.2	41.4	25.6	269.2	393.8	1.8	3.6	0.8	845.4
2003	12.1	40.8	0.0	39.8	10.0	50.4	334.0	129.2	453.6	0.0	0.0	36.0	1105.9
Mean	2.1	12.9	0.7	9.2	13.2	64.4	234.0	273.6	244.9	26.2	1.8	16.8	900.0

**Table 3: Impounded rain water in water storage structure**

Sr. No.	Water impounded structures	Harvested water (Hectometer)	Remarks
1.	Water storage structures	37.30	-
2.	Check dams	70.60	-
3.	Mini earthen storage reservoirs	14.00	-
4.	Stony dug wells	114.60	Through ground water recharge
	Total	236.50	

(99.98%) during 2003-04 due to alimentation of 236.50 hectometer water in the operational area (Table 3).

#### **Improvement in crop production technology:**

Reduction in runoff and soil losses and improvement in production technology have been achieved through proper land management practices, selection of suitable crops and varieties, cropping system, cultural and associated agronomic practices such as mulching and crop residue management.

#### **Land management:**

The maximum emphasis was given to contour ploughing on slopy field for conserving the soil and water. The small stones available on surface of soil were collected and used for making the loose bunding. The available local grasses and bushes were also used for vegetative hedge.

#### **Diffusion of new crops and their varieties:**

The urd, moong, groundnut etc. have been deployed as soil conserving crops in the operational. area. In addition to these crops some new and important grain, vegetable and condiment crops like maize, mustard, gram, potato, tomato, colocasia, rataloo, onion, garlic, ginger, turmeric, radish, carrot, coriander etc. have also been chosen and introduced in the project for enhancing the total productivity.

Improved and input responsive varieties of different crops were introduced in the watershed area (Table 4).

#### **Cropping system:**

The availability of rain water for irrigation and seed of improved cultivars, use of agro-chemical, and on spot technical guidance to the farm households have motivated to them to adopt the double/multiple cropping systems at operational area of rain water management. The existing mono cropping systems have been replaced with valuable

**Table 4 : Improved varieties of different crops deployed in the project area**

Sr. No.	Crops	Varieties
1.	Maize	Sweta
2.	Groundnut	Dh-86, Kaushal
3.	Moong	Narendra moong-1
4.	Urd	PU -35
5.	Wheat	UP-2338, Deva, PBW-343, WH-147
6.	Mustard	Varuna
7.	Gram	Fusa 256, Radhey, KPG-59, Awrodhi
8.	Turmeric	Barua sagar, Pandrauna, Rashmi
9.	Ginger	Barua sagar, Chakarati
10.	Colocasia	Barua sagar, Chinhat
11.	Rataloo	yderabadi
12.	Carrot	Fusa keshar, Fusa meghali
13.	Radish	Fusa raishmi, Kalyanpur No.1
14.	Tomato	Azad T-2, Kalyanpur T-1, Fusa rubi, Hybrid-I, Hybrid-2
15.	Onion	Kalyanpur red round, Fusa red round, Fusa ratnar
16.	Potato	Kufari badashah

and new inter cropping system. The earlier cropping systems like

- Fallow-wheat/barley
- Sesame-fallow
- Fallow-taramira
- Fallow-linseed/gram/field pea
- Groundnut-fallow, has been substituted by following

productive and soil protective cropping system.

- Groundnut-wheat
- Groundnut-mustard
- Maize-wheat
- Maize-mustard
- Ginger+colocasia-vegetables
- Groundnut-lentil
- Groundnut-potato
- Groundnut-gram
- Groundnut-onion
- Groundnut-vegetables
- Groundnut-coriander (green leaves)
- Paddy-onion
- Groundnut + rataloo-vegetables

#### **Use of agro-chemicals for higher production:**

The farm families of pilot area were not conscious about the use of agro-chemicals in crop production. The utility of its application in dry land agriculture has been discussed in training, meeting, field visit and field day programmes organized at the site. The farm families were

convinced for the use of agro chemicals through adaptive and innovative research. Now, the majority of the farmers are using recommended doses of fertilizers in different crops. Likewise, the farmers are also using pesticides to check the incidence of insects, pest and diseases of different crops.

*Year wise agricultural land use by different crops:*

After the land treatment with suitable soil and water conservation measures, use of arrested rain water for irrigation and adoption of conservation agronomic practices a major area has been brought under double and multiple cropping. The data depicted in Table 5 display

that there is tremendous increased in area under groundnut, urd and maize during rainy season, wheat, gram, mustard, potato and winter vegetables during winter season whereas the area under jower and sesame has declined considerably due to diffusion of groundnut in rainy season.

Productivity of different crops, total production and average productivity of watershed area: After the soil and water conservation measures, use of arrested rainwater for protective irrigations and adoption of conservation agronomic practices, a major area has been brought under double/multiple cropping. The data depicted in Table 4 display that the improved packages Of practices

**Table 5 : Area under different crops (ha)**

Sr. No.	Crops	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04
1.	Groundnut	294	300	750	1850	1900	1900	1910
2.	lower	235	231	209	15	15	15	15
3.	Moong	5	5	5	10	10	12	12
4.	Sesame	240	240	38	20	22	22	22
5.	Urd	-	-	-	-	15	20	25
6.	Maize	4	4	1	8	10	15	20
7.	<i>Kharif</i> vegetable	10	11	9	10	10	12	12
8.	lower green fodder	41.8	40.8	20	30	45	48	50
9.	Wheat	4.95	3.50	558	1505	1815	1820	1835
10.	Gram	-	0.45	5	15	20	25	30
11.	Lentil	2	2	8	10	10	12	15
12.	Mustard	-	-	20	60	65	70	72
13.	Potato	-	-	8	15	15	20	20
14.	Winter vegetables	5	5	15	20	20	20	20
15.	Berseem + Rai (GF)	-	-	10	25	30	35	45

**Table 6: Productivity of important crops, total production and productivity of watershed**

Sr. No.	Particulars	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04
A.	Crop productivity Q/ha							
1.	Wheat	7.00	7.50	18.00	32.50	35.60	38.00	40.50
2.	Gram	-	6.50	9.80	16.80	17.50	18.50	18.70
3.	Lintel	6.50	6.50	8.50	10.00	10.00	10.00	11.00
4.	Groundnut	7.00	7.30	12.50	22.85	23.50	24.20	27.50
5.	Maize	9.00	9.00	11.00	20.40	28.00	27.00	27.00
6.	Mustard	-	-	18.40	20.70	21.25	21.30	21.50
7.	Radish	-	-	-	170.00	187.00	187.00	187.00
8.	Tomato	90.00	100.00	165.00	216.00	251.50	265.00	295.50
9.	Carrot	-	-	-	140.00	155.50	155.50	155.50
10.	Onion	-	-	-	200.00	285.00	290.00	307.00
11.	Potato	-	-	215.00	280.00	300.00	300.00	300.00
12.	Jowar for green fodder	285.00	290.00	390.00	400.00	400.00	400.00	406.00
B.	Total food grain production (t/ha)	677.415	707.800	2907.925	10222.420	12100.485	12906.94	14114.99
C.	Productivity of watershed (q/ha)	8.46	8.82	17.88	28.89	30.81	32.56	35.21

**Table 7: Animal population and milk production in watershed area**

Sr. No.	Particulars	Unit	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04
A.	Animal population								
1.	Cows	No.	2110	2613	3008	4815	5014	5214	5379
2.	Buffaloes	No.	2205	2804	3308	3897	4106	4216	4328
3.	Goats	No.	1848	1835	2310	2905	3127	3354	3567
B.	Total milk production from animals	000 lit	683.040	688.080	1029.480	2514.000	2668.200	2852.400	3027.000

**Table 8: Position of improved agricultural implements in the pilot area**

Sr. No.	Particulars	Unit	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04
1.	Tractor	No.	17	34	73	89	103	103	103
2.	Tractor cultivators	No.	17	33	70	85	98	98	101
3.	Thresher	No.	3	10	12	19	21	29	32
4.	Tractor trolleys	No.	15	30	70	85	95	95	98
5.	Seed drills	No.	5	5	9	11	14	21	33
6.	Diesel operated pump sets	No.	11	19	167	513	651	671	709

applied in cultivation of different crops have increase the productivity by 2 to 5 times at pilot area of rain water management. The total production of operational area increased with increase in productivity from 8.46 q/ha to 35.21 q/ha (Table 6).

#### **Animal husbandry for better cash flow system:**

Milch cattle and goat raring were started after achieving increased crop productivity, better availability of palatable green and dry fodder through natural pasture and cultivation and market facilities. The major problems of the disposal of animal by product has been solved through better management which boosted the meat and milk productions and whereby the population of animals has also increased in the pilot area (Table 7).

#### **Movement of farmers towards the mechanize farming:**

In the initial stage, watershed farmers were used only the local implements. With the improvement in financial position of the farmers due to increased production in watershed area, the farmers are fully convinced about the uses of improved agricultural implements: The farmers have started the purchase of the high value agricultural implements and are using them for sustainable agricultural production. The positions of different type improved agricultural implements are in

given in Table 8.

These results are in line with those of Hazra and Singh (1989), Singh. *et al.* (1989) and Singh (1995).

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