Watershed Management for Sustainable Agriculture in Indian Perspectives

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Abstract: The effect of watershed management programme was studied with introduction of new crop-cultivars including six rainy season crops namely direct seeded rice (drilled rice), transplanted rice, arhar, groundnut, sesamum and maize and two winter season crops namely mustard and wheat. The crop demonstration programme were undertaken for consecutive four years during 1988 to 1991 to utilize different land situations and for effective use of created irrigation potential at a drought prone tract of West Bengal (India). Radhamanpur watershed having a total geographical area of 364 hectare with rolling and undulating topography, had no chance of growing second crop(s) after harvest of rainy season tall indica rice cultivar under below optimum production level less than 1 ton/hectare before commencement of the project. The watershed was one, out of the twenty watersheds idientified initially during early eighties to undertake experimentation for development of rainfed agriculture under National Watershed Development Projects in India. The watershed was located in the district of Bankura at the western end of West Bengal, continuation of Chottonagpur plateau lies between 22º38' to 23º30' N latitude and 86º36' to 87º46' E longitude having an elevation of 90 m to 120 m above the mean sea level. The soil contained 0.35% to 0.38% organic carbon, 60 kg to 65 kg available P_2O_5/hectrare and 100 kg to 105 kg exchangeable K_2O/hectare having pH of 5.5 to 6.0 (1:2 soil:water suspension). The results of the crop demonstration revealed that with selection of crops and its suitable varieties, adopting improved agronomic practices including scientific management of fertilizers and irrigation water, plant protection measures, the productivity of both land and crops markedly increased. The crop production strategy on the basis of land capability classification changed the land use, cropping pattern and crop intensity in the watershed area. The scenario of rainfed agriculture got a dramatical change with creating irrigation potential, harvesting and reclying the excess rain water. Watershed approach appeared to be most effective and integrated management of all natural resources like soil-plant-water-animal and human to uplift to socio-economic status of the farmers disseminating the location specific proven agro-technologies in massive scale for sustainable agriculture in rainfed areas. The scope left for development of agro-forestry, silvipasture, agri-horticulture, animal husbandry, fisheries and building up several agro-based industries with abundant supply of raw materials. The programme was found cost effective, generated employment opportunities of the rural people through out the year and increased individual family income of each beneficiaries of the adopted villages. The success gave encouragement and impetus to the fellow farmers to keep the process on towards further improvement the different activities through formation of various Wateshed Level Committees.

1 Introduction

In India, National Watershed Development Project for Rainfed Areas (NWDPRA) was launced to generate all available and possible natural resources and its effective utilization for sustainble agriculture and the effective management of soil-water resources to uplift the socio-economic status of the rural people wherein emphasis was applied on rain water conservation for development the ares under rainfed conditions. With a view to develop suitable agro-technology for soil water conservation, cropping systems, agro-forestry and livestock production and for its effective transfer under massive scale, the

Operational Research Projects for Resources Development and Management on Watershed Basis was formulated to meet the location-specific need along witth need based research programme. At present, out out of 141 million hectare net area sown, about 100 million hectare of land was remained rainfed (Tripathi *et. al*.,1990) which contributed about 42% of the total food grain production in the country. Most of the land occupied under rainfed conditions was predominantly based on monocropping where after harvest of rainy season crop(s), nothing could be grown and remained fallow during winter months due to lack of irrigation water or adequate rainfall in these areas (Zaman,1993). Growing second crop(s) with necessary soil and water conservational practices was possible with varying degree of success in such areas (Zaman and Mallick, 1987). Watershed was appeared as integrated management of all possible natural resources like soil-water-plant-animal and human to maximize agricultural production on sustainable basis (Zaman,1993).The performances of various watershed located at different agro-climatic zones in India revealed that the production of food, fodder, fuel, fibre and fruits along with the animal components increased considerably (Bhardwaj and Singh,1990). The achievement of all these watersheds operated in the country were quantified on the basis of results obtained under the Operational Research Projects for Resource Development and Management. With a view to increase the agricultural production on sustainable basis and to bring more area under crop cultivation specially introducing second crops during winter months under appropriate soil and water convervational measures along with increasing or creating irrigation potential collecting run-off, harvesting and recycling of excess rain water, the programme was undertaken at location-specific watershed under red and laterite tract of West Bengal.

2 Methodology

Out of twenty such operational projects run experimentally during eighties in the country, Radharamanpur watershed was one, comprising the villages like Radharamanpur, Bara-kalaijharia and Bankati in the district of Bankura in West Bengal of Eastern India. Bankura district was located at the western end of West Bengal, continuation of Chottonagpur plateau lies between 22º38' to 23º30' N latitude and 86º36' to 87º46' E longitude having an elevation of 90 m to 120 m above the mean sea level. The crop demonstration programme was carried during 1988 to 1991 for a period of four years. The soil contained 0.35% to 0.38% organic carbon, 60 kg to 65 kg available P_2O_5/hectrare and 100 kg to 105 kg exchangeable K_2O/hectare having pH of 5.5 to 6.0 (1∶2 soil:water suspension). Some of the important physical-chemical properties of the soils were given in Table 1. The climate of the region was sub-tropical humid having an annual rainfall of about 1,200 mm confined mainly during rainy season that occurred June to August. The uneven distribution of annual rainfall throughout the year caused a drough spell usually starting from the month of November. The maximum temperature during summer months went upto 45º C and minimum temperature came down in winter upto 3º C.

Table 1 Physical-Chemical properities of the soil

Particulars	Range (0 cm—30 cm soil depth)
Bulk Density (g/cc)	1.47—1.67
Particle Density (g/cc)	2.50—2.65
Field Capacity (0.1 bar, %)	25.0—30.0
Permanent wilting point (%)	6.4—11.2
Infiltration rate (cm/hr)	1.12—1.52
Hydraulic Conductivity of undisturbed soil (cm/hr)	0.25—0.45
CEC (meq/100g)	
EC (milimhos/cm)	12.35
Average Slope (%)	0.04
Soil Class	3.0—5.0
Soil Type	Laterite
Soil texture	Light in nature
Soil Order	Sandy-loam
	Oxisol

The total geo-graphical area of the watershed was 364 hectare. Out of which 139 hectare was under crop cultivation mainly with tall indica rice following traditional practices with below optimum production level of less than 1 ton/hectare before commencement of operational project. The rainy season crops such direct seeded rice (drilled rice), arhar, groundnut and maize were sown under medium to upland situations whereas sesamum and transplanted high yielding rice cultivars were given under medium to low land situations with recommeded agronomic practices during July-August and the crops like mustard and wheat were sown during winter months in medium to low land situations with minimal irrigation facilities created under the programme. The soil and water conservational measures to improve land situations and to create irrigation potential renovating farm ponds were taken as continuous process. Introduction of high yielding varieties, new crops and adaptibility of different cultivars were carried on. The programme was undertaken on the basis of land capability classifications. All these attempts were taken to motivate the farmers at massive scale to adopt location specific improved agro-technologies as a part of effective transfer of proven technology to the farmers, which wre found encouraging to build up and increase the confidence level of the farmers be associated themselves with the modern hi-techs.

3 Results and discussion

Land productivity: The Land use pattern before and after commencement of operational projects were shown in Table 2. The results of the programme revealed that crop production was increased due to increased in gross cropped area and cropping intensity. The results also revealed that there was an appreciable increase in crop yield under demonstration programme adopting improved agro-technologies and soil-water conservational measures (Table 3).

Table 2 Change in land use, crop pattern and cropping intensity as influenced by the watershed programme

Particulars	Before Project		After Project	
	Area (ha)	(%)	Area (ha)	(%)
Land use pattern				
Area under crop cultivation	139.0	100	194.0	140.0
Area under irrigation	0.0		33.0	20.0
Area under double crop	0.0		30.0	18.3
Gross cropped area	139.0		224.0	161.0
Crop Pattern				
Cereals (rainy season)	139.0	100	118.0	72.0
Oiseeds (rainy season)	0.0		20.0	12.2
Pulses (rainy season)	0.0		12.0	7.3
Others	0.0		14.0	8.5
Cererals (winter)	0.0		24.0	18.6
Oilseeds (winter)	0.0		20.0	12.2
Other	0.0		25.0	26.6
Cropping intensity		100		150

Table 3 Crop yield under demonstration, non-demonstration and district average with per cent increase

Crop(s)	Yield (q/ha) in ORP area				
	Demo	Non-demo	% increase	District Average	% increase
Rainy Season					
Drilled rice	29.0	22.0	32.0	17.0	71.0
Transplanted rice	32.0	25.0	28.0	19.5	64.0
Arhar	10.0	8.3	20.5	5.8	72.0
Groundnut	18.0	12.0	50.0	10.0	80.0
Sesamum	12.0	9.4	27.7	6.0	100.0
Maize	28.0	23.0	21.7	14.5	93.0
Winter Season					
Mustard	13.0	11.5	13.0	10.0	30.0
Wheat	20.0	16.7	19.7	15.0	33.0

3.1 Crop productivity

The impact of watershed programme particularly land levelling, field channelling, bunding, terracing and improved agronomic practices including proper time of sowing, seed rate and application of fertilizers, introduction of irrigation, weed control along with other appropriate plant protection measures increased the crop yields under demonstration (Table 3). Mittal and Dhruvanarayana(1989) also reported the similar results from integrated watershed management in Himachal Pradesh and Hazra (1989) reported the successful implementation and dramatical increase in crop yield in Tejpura watershed in Jhansi district of Uttar Pradesh. All rainy season crops gave the higher yield at least 20% to 50% under demonstration over non-demonstration which was obviously higher than that of the district average.

3.2 Crop pattern

The alternative crops like arhar, maize, groundnut, sesamum were introduced to utilize medium to upland situations were found effective though these measures decreased the rice area during rainy season. The replacement of tall rice varieties with high yielding rice cultivars and introducing all these new crop which increase the cropping intensity from 100% to 150%. The crop demonstration programme gave impetus to the farmers to grow pulses, oilsedds and fodder. The area under these crops increased from 0 to 19%, 0 to 20% and 0 to 15%, respectively during winter months.

3.3 Land use

The rolling and undulating topography that enhanced the soil erosion and caused land degradation before commencement of the project. Land levelling, bunding, terracing, gully puging and other convervational works carried out in the projected area resulted increased area about 40% under crop cultivation from 139 to 194 hectare. Wherein under created irrigation potential on harvesting the excess rain and its reclying helped to grow second crop(s) in the watershed area.

Thus the programme on watershed management was found successful and accepted as pivotal for improvement of crop yields in rainfed areas that left the tremendous expansion possibilities including development of agro-forestry, agri-horticulture, silvipasture and animal husbandry along with fisheries. Selection of suitable crop(s) and its appropriate varieties, introduction of new crops with proper

sequences at different land situations the areas through proper utilization of all possible natural resources increased the crop as well as land productivity. The watershed management programme was proved both labour and capital intensive and benefit cost ratio was found as high as 7:1. So the programme offered high avenues for employment generation in the rural areas which augmented the average income of all the benefiaciaries of the adopted villages.

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