Sustaining the Natural Resource Base and Increasing the Productivity of the Vertisols of Central India

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INTRODUCTION

The past experience of the Central Research Institute for Dryland Agriculture (CRIDA) in the implementation of the watershed programme has shown that farmers usually tend to follow the improved technology for soil and water conservation measures and cropping systems only as long as the implementing agency works in the watershed area. They revert back to their previous methods after the implementing agency leaves. At best, use of improved varieties and some fertilizers and plant protection measures may still be continued. If any water bodies are created, they may be taken care of. However, the incidental benefits of groundwater recharge are sometimes overexploited. This normally is due to lack of interactive participation among the farming community. It is now widely recognized that the farmers must be involved at every stage of watershed development including resource inventory preparation, identification of problems, selection of sites, and formulation of action plans incorporating appropriate technologies including the interventions based on refinements of indigenous technical knowledge. Efforts should be made to involve farmers in decision making even in case of sharing and utilization of harvested rainwater. There should be a concerted effort to wean farmers away from growing high input crops like rice and wheat. The implementing agency should establish a continuous dialogue with the farmers regarding any operational problems that may be encountered during the implementation of the watershed. The final product, evolved from this participatory approach, should take into account the practical problems and shortcomings of the farming community, their priorities and needs. Such a system, developed with the involvement of farmers, would stay with them for a long time to come.

Although they have a rich and ancient wisdom, Indian farmers are mostly shy and do not wish to contradict any scientist or project personnel. Hence, it is better to first seek their views and discuss the various options subsequently. Final decisions then emerge through a consensus. Only then will the project be successful and form a nucleus for adoption in similar agroeco regions. Thus, interactive and voluntary participation of the farmers is crucial and must be the chief priority in such endeavours. Based on lessons learnt over the past two decades, farmers have been involved, since the inception, in every phase of this project. Detailed plans including the resource inventory have been prepared in consultation with the farmers.

CRIDA, Hyderabad, has been designated by the Indian Coucil of Agricultural Research (ICAR) to coordinate the activities of NARS institutions in India participating in the project "Improving Management of Natural Resources for Sustainable Rainfed Agriculture" executed by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad, India and funded by the Asian Development Bank (ADB). The Indian Institute of Soil Science (IISS), Bhopal, and Jawarharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Jabalpur are the implementing institutes. At Kothapally, CRIDA's involvement has been further enhanced in the implementation and monitoring of the programme. The watershed at Lalatora in Vidisha district of Madhya Pradesh, India is the MSEC site. The project is implemented by an NGO, Bhartiya Agro Industries Foundation (BAIF) in participatory

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mode with the farmers with technical backstopping provided by ICRISAT and CRIDA. The broad objectives of this project are to enhance the productivity and sustainability of the medium and high water holding capacity soils in the intermediate rainfall ecoregion and develop environmentally-friendly resource management practices that will conserve soil and water resources.

The JNKVV, with its headquarters at Jabalpur, provides the expertise for the two watersheds at Indore. CRIDA, which has had considerable experience for more than two decades in the field of soil and water conservation through a watershed approach is the NARS nodal agency. The experience of CRIDA has been that the active and committed participation of stakeholders is absolutely necessary for they may eventually revert back to their traditional systems. It is imperative that farmers should be involved in all phases of problem identification, planning, execution, and implementation of the watersheds. The IISS is the primary institute dealing with chemical, physical, and biological aspects of soil management. In this report only Lalatora Watershed is discussed.

GOALS AND OBJECTIVES

The goal of this project is to evolve sustainable farming practices that lead to the conservation of land and water resources, at the same time ensuring optimal productivity of a soybean-based cropping system. Madhya Pradesh is the largest soybean growing state in India where more than 5 million ha produce about 4 million tonnes of soybean, which amply supports the project objective of analyzing the sustainability of agriculture in the rainfed tropics. The project aims to develop and apply environmentally friendly techniques to increase the productivity of these lands, with a medium to high water holding capacity. The objectives of the project are:

- Conduct investigations to select the appropriate components for sustainable land, water, and crop management practices compatible with existing and/or viable systems.
- Strengthen the capability of watershed level farmers' institutions to develop their own technologies and to adapt technologies generated by ICRISAT and consortium institutions using a partnership approach.
- Enhance capacity building of farmers' groups by providing training personnel and provision of other needed resources.
- Facilitate dissemination and sharing of information by conducting co-sponsored seminars, conferences, and workshops as necessary.

Strategic on-farm research

- Land and water management systems, broad beds and furrows (BBF)
- Groundwater studies
- Fertility and nutrient management
- Integrated pest management
- Improved crop varieties

Action plan

We propose carrying out the following studies in this region.

- o A baseline study through a techno-economic survey.
- o A baseline study through a study of crop practices prior to initiation of this project.
- o A topographic and complete soil survey and profiling of the project region.
- o Crop-based trials in the rainy season and postrainy season with the provision of vital inputs

like improved seed, seed treatment material, advice on the best bet package of practices etc.
- o Evaluation of land surface configurations (BBF and flat).
- o Hydrological studies at the watershed level.
- o Fertility and nutrient studies.
- o Check dams, farm ponds, percolation tanks, gully plugging, and stone bunding.
- o Monitoring microclimatic conditions of the region through an automatic weather station.

Before the project was initiated, all the agricultural operations relating to a crop and cropping season were recorded through village meetings. This gave an insight into the level of advancement of the agricultural practices here.

METHODOLOGY

The methodology includes selecting an appropriate site for the implementation of the watershed in consultation with the farming community. After the site is identified the physical surveying of the watershed is undertaken to identify the catchment area for the watershed. Implementation of soil and water conservation structures to arrest soil and water loss is the next step. This also leads to collection of water at an appropriate place for later use and also for groundwater recharge. Subsequently, efficient crops and varieties suitable to the area are identified and suitable management practices are implemented to optimize the crop productivity. At all stages of the watershed implementation, concerned farmers are involved and their views are given due importance.

Site selection

ICRISAT/BAIF chose Lalatora village (of the Lateri II Watershed) of Vidisha district in Madhya Pradesh after careful deliberation. Lalatora village is located in an extensive watershed totalling about 10,525 ha, lying between lat 28°8'3" and 24°16' long, 77°20'45" and 77°30'15" at a height of 415 m asl. This watershed is being managed by BAIF. This region has been receiving over 1,200 mm of rainfall over the last decade. For this project a subwatershed of 750 ha was selected out of the 10,000 ha watershed managed by BAIF. A sum of Rs 4.0 million has been earmarked for this watershed by the government of India.

BAIF is a voluntary organization which has championed the concept of community development over the past three decades by taking into consideration the rich indigenous knowledge of the rural community. Drawing inspiration from the pragmatic development-oriented approach and philosophy of its founder, the late Dr. Manibhai Desai, a Ramon Magsaysay awardee, this professionally managed organization is implementing a multidisciplinary programme in rural development through cattle development, tree-based farming systems, watershed management, community health, and women empowerment. BAIF provides valuable services to over a million rural families in over 8,000 villages through an extensive network spread over seven states

BAIF selected an area of about 10,000 ha in Vidisha District of Madhya Pradesh in Lateri Block for the introduction of an improved rainfed agricultural production system through watershed development. The area is predominantly located in the soybean production zone. The soils are Vertisols and associated Vertic soils. The average rainfall is around 1,200 mm received mainly from June to September. The land is characterized by sheet erosion and to some extent gully erosion.

A microwatershed of about 75 ha has been initially earmarked for the proposed project studies. In this microwatershed 20 contiguous farm families were identified and they have been actively involved in the drawing up of watershed plans. At this site 16 farm ponds and eight check dams have been planned. One farm pond of 4,000 m^3 capacity has already been excavated. A check dam has been constructed. The watershed has been provided with an automatic weather station and runoff recording equipment. The farmers concerned have been trained to look after the safety of the equipment. Besides automatic weather stations, manual rain gauges have also been installed for recording the rainfall.

Biophysical and socioeconomic characterization

Detailed benchmark surveys of the selected watersheds have been conducted to assess the state of the soil resources, determine the topography of the watersheds, and to map them with regard to drainage lines and the location of the existing water bodies. Socioeconomic appraisal has been done adopting the modern participatory and action learning tools by a multidisciplinary team of scientists. Present practices and constraints to the adoption of the new technologies by farmers have been identified. This information has been used while formulating the detailed action plans in consultation with the participating farmers.

Identification and characterization of microcatchments

This field level study has been completed successfully in the selected villages. The creation of the database remains to be done after which firm conclusions may be drawn. BAIF have also added a questionnaire on the landless labour who are also among the groups of people affected by cropping practices.

The geo-hydrology of this area was studied through an analysis of the area on a watershed basis through water runoff recorders. Treating the entire selected project area as a watershed has been facilitated with the presence of major natural drains, which help carry excess water into the seasonal Kaandai river. Water runoff recorders help in recording the amount of water that is being wasted. It is proposed that a sediment sampler should be installed since the problem of vandalism has been identified and controlled.

Complete soil survey and profiling of the project region

This basic study has been done with the help of ground level as well as satellite studies keeping in view the virgin unexploited state of the soils. Soil tests reveal that these soils are lacking in sulphur and boron for which micronutrient studies have been designed and experiments are being carried out in soybean fields. The results of these investigations are yet to come. However, as an interim observation the farmers think that the addition of both the nutrients has led to more vigorous growth of the plants. Crop-based trials are being conducted in the rainy and postrainy seasons with the provision of vital inputs like improved seeds, seed treatment material, packages of practices, and on the nitrogen fixation ability of soybean compared to maize.

Instrumentation of microcatchments and data collection

The Lalatora Watershed is equipped with an automatic weather station for monitoring of rainfall, minimum and maximum temperatures, solar radiation, wind speed and direction, and soil temperature at different depths. The weather station is looked after by a person chosen from a farmers' group. The watershed also has runoff recording equipment with necessary facilities to sample the runoff water for nutrient analysis later. Three manual rainfall gauges have also been installed in the field. Table 1 provides monthly rainfall values for the watershed.

RESULTS AND DISCUSSION

Implementation of the watershed project at Lalatora

This project intends to improve the family income of the farmer through advances in crop science. A large Indian multinational company has shown interest in buying back soybean-based products. Another interesting fallout of this project has been the enthusiasm shown by progressive

farmers from the neighbouring areas (especially the district of Rajgarh) whereby islanding of development works is avoided. The watershed approach has led to substantial increase in the productivity of rainy season (soybean) as well as the postrainy season (chickpea) crops (Table 2).

Table 1. Rainfall in millimeters (collected from India Meteorological Department at block level).

Month	1989	1990	1991	1992	1993	1994	1995	1996
J	28	264	71	8	94	244	26	478
J	276	333	346	281	278	444	238	630
A	407	377	388	650	288	333	280	28
S	92	339	19	133	564	166	128	60
O	-	33	-	-	-	-	-	-
N	-	-	-	-	-	-	-	-
D	-	9	-	-	-	-	-	-
Total	**803**	**1,355**	**824**	**1,072**	**1,224**	**1,137**	**672**	**1,136**

Data for 1997–2000 is being collated.

Table 2. Impact of integrated watershed management on soybean and chickpea yields in the watershed at Lalatora during 1999.

Rainy season 1999; soybean crop (variety JS 335)				
No. of farmers	Area covered in ha	Yield in kg ha^{-1}	Average yield with traditional practices in kg ha^{-1}	Interventions
27	40.50	Av. 1275	Av. 950	Supply of seed, seed treatment, and other related information
Postrainy season 1999; chickpea varieties (ICCV 2, ICCV 10, and ICCV 37)				
44	11.25	Av. 957-1471	Av. 923*	Improved seed, seed treatment, reduced tillage, and other related information

*Productivity in the neighbouring region.

Evaluation of the broad bed and furrow (BBF) system of cultivation

As the black soils in Lalatora are prone to waterlogging, the BBF technology is being evaluated here. Initial resistance was due to slow germination, probably due to poor sowing practices. This situation can be improved if adequate training is offered to the farmers for the next season. The main reason is the lack of appropriate machinery to make BBF and which can also simultaneously sow and place fertilizers. The planter for planting on beds need to be provided to improve the efficacy of BBFs. Broad beds and furrows that had initial problems, are showing good results (Table 3).

Table 3. Evaluation of land treatments and management on the crop productivity during the rainy season 2000.

Land surface configurations (BBF and flat)	No. of farmers	Area covered in ha	Interventions
Broad bed and furrow	8	6	Layout of BBF, topographic survey and BBF maker
Micronutrients (Boron and sulphur)	12	6	Micronutrients in the form of borax (@ 10 kg ha^{-1}) and gypsum (@ 200 kg ha^{-1})
Soybean var. JS 335	45	45	1. Seed treatment 2. Maize markers to study the quantity of N fixed by the soybean crop.

Evaluation of zero tillage for chickpea

In rainfed sequential cropping where irrigation facilities are not available, soil moisture plays an important role in the establishment of a postrainy season crop. Farmers generally prepare the land after harvesting rainy season soybean for sowing chickpea. Based on the results from on-station watersheds at ICRISAT, we observed that by direct seeding chickpea after harvesting, soybean not only helped in better crop establishment, but also reduced the incidence of *Sclerotium* rot in chickpea and increased the chickpea grain yields. We suggested to the farmers to evaluate zero tillage for a postrainy season chickpea crop. In the postrainy season for chickpea cultivation, zero tillage planting (planting chickpea soon after harvesting soybean without ploughing) was evaluated on a 4 ha farm by one farmer. The zero tillage and normal tillage practice plots received 37.5 kg diammonium phosphate (DAP) ha^{-1}, seeds were inoculated with *Rhizobium,* and phosphate solubilizing bacteria. The farmer harvested 1,423 kg ha^{-1} chickpea (27% higher) in the zero tillage plots as compared to a grain yield of 1,125 kg ha^{-1} from normal tillage plots, and in addition reduced land preparation operations and two irrigations.

Socioeconomic evaluation of the potential impacts

The farmer is ultimately guided by the economic returns he gets from farming. Therefore it is imperative that socio economic evaluation of the potential impacts the watershed project need to be evaluated. The economic costs and the benefits involved at Lalatora were worked out for soybean crop. Profitability of improved practices over traditional practices in the watershed worked out to Rs 3,150.(Rs 7750 - 4600 = Rs 3150). It can be seen that even if the additional Rs.650 had been spent, the comparative advantage would remain Rs 2500, the details of which are given in Table 4.

Table 4. Comparative cost of cultivation of soybean per hectare (an approximation).

#	Cultivation aspect	Cost of cultivation as per improved methods (Rs)	Yield ha^{-1} (kg)	Cost of cultivation as per traditional methods (Rs)	Yield ha^{-1} (kg)
1	Land preparation.	1,350.00		1,350.00	
2	Seed	1,200.00 (80 kg)		1,800.00 (100 kg)	
3	Seed treatment	150.00		-	
4	Chemical fertilizers	900.00		500.00	
5	Sowing	450.00		450.00	
6	Irrigation	- *	1,600	- *	1,200
7	Weed control	1,000.00		500.00	
8	Pesticides	- **		- **	
9	Harvesting	800.00		800.00	
10	Threshing	700.00		700.00	
11	Storage	100.00		100.00	
Total		**6,650.00**		**6,200.00**	

*' Irrigation—if necessary in the rainy season an additional Rs 200 needs to be spent.
** If pest or disease attack, Rs 450 on a litre of recommended chemicals needs to be spent.

Progressive farmers
Production—1600 kg
Sale proceed @ Rs 9 kg^{-1} → Rs 14,400
Gross profit = Rs 14,400—6,650 = Rs 7,750

Traditional farmers
Production—1,200 kg
Sale proceed @ Rs 9 kg^{-1} → Rs 10,800
Gross profit = Rs 10,800—6,200 = Rs 4,600

FUTURE ACTIONS

It is proposed to monitor around 60 ha of the chickpea crop in the postrainy season. For this purpose around 3,000 kg of improved seed has been procured from the farmers for distribution in the coming crop season.

Postrainy season 2000 (proposed actions)

- Effectiveness of the BBF system in the postrainy season will be studied.
- The efficiency of supplemental irrigation in the BBF system for a wheat crop will be studied in the different farmers' fields.
- A reduced tillage system will be studied at more locations

It is proposed to monitor the crop growth, development, as well as harvesting of about 100 ha for three improved varieties of chickpea; 3 tonnes of seed produced from the postrainy season 1999 crop have been purchased and stored for subsidized sale to farmers. These three varieties are ICCV 2, ICCV 10 & ICCV37.

CONCLUSIONS AND RECOMMENDATIONS

The fields surveyed by the ICRISAT staff at Lalatora Watershed have shown some sulphur deficiency. The farmers have been advised to use gypsum and borax to correct S and boron deficiency. The soybean crop is in a good condition in the watershed. The farmers are appreciative of the work carried out by BAIF, ICRISAT, and ICAR. Because of good rainfall and the water harvesting structures, sufficient water has been collected in the check dams. Farmers want to use the harvested water for the second (postrainy season) crop of either wheat or chickpea.

As this watershed is being implemented very successfully with the active participation of the farmers there is a need to develop ways and means of scientifically sharing the runoff water collected in the farm ponds. The methodology developed can also be evaluated at other watersheds.

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