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Watershed Based Technology: Experiences and Lessons

K.G. Kshirsagar and R.D. Ghodake*

In India about 70 per cent (143.8 million hectares) of arable land is rainfed and depends on monsoon rains. About 45 per cent of these drylands will continue to depend on natural precipitation even after realising the full irrigation potential. Agricultural growth in these rainfed areas has been quite low. More than 50 per cent of the area had less than 2 per cent of agricultural growth during 1956-57 to 1978-79 (Jodha, 1987). The main source of instability in the overall agricultural production in India is due to instability in dryland agriculture. This dismal picture of dryland agriculture is a major cause of concern because it is a natural habitat of most of the pulses and oilseeds which are in short supply and are vital for the Indian economy.

No doubt efforts have been underway and continue at various Research Institutes to develop appropriate technologies for increasing and stabilising crop production in dryland areas. As a result of these efforts, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has developed a micro-watershed based technology for Semi-Arid Tropics (SAT) of India (Walker *et al.*, 1989).

This paper delineates the micro-watershed based technology conceived, designed and developed by ICRISAT and reviews its performance at ICRISAT Center and on farmers' fields. We view retrospectively our earlier results and draw lessons for solving the difficult problem of spread of this technology in dryland regions of India.

THE MICRO-WATERSHED BASED TECHNOLOGY

In the micro-watershed based technology an area of about 3 to 25 hectares (ha) is being developed to enable farmers within the watershed to improve their management of soil, water and crops. On the watershed, broadbed and furrows are made with a constant grade of 0.4 to 0.6 per cent across the natural slope to increase the moisture storage capacity of soil, facilitate run-off of excess water, improve drainage and reduce soil erosion and degradation.

In this system, the crops are sown on broadbeds made between furrows with the help of a bullock drawn wheeled tool carrier. In areas of dependable rainfall (> 750 mm per year) this technology enables farmers to grow two crops in a year (during rainy and the post-rainy season) under sequential cropping or add three months to the growing season under intercropping. More *kharif* cropping also yields social benefits in reduced soil erosion.

The main components of the watershed based technology are: (1) post-harvest cultivation following the post-rainy season crop before the soil hardens; (2) land levelling and shaping, construction of field and community drains and the use of graded broadbeds and furrows; (3) dry seeding before the monsoon; (4) use of improved seeds and moderate amounts of fertiliser; (5) proper placement of seeds and fertiliser; and (6) timely plant protection.

The pre-requisites for the success of this technology are dependable early season rainfall to support dry seeding and deep soils with enough moisture holding capacity to grow two

* Senior Research Associate, Resource Management Program, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Andhra Pradesh and Team Leader and Economist, Lowlands Farming Systems Research Team, Bubia Agriculture Research Centre, Lae, Papua Guinea, respectively.

Maharashtra, larger watersheds under Dry Land Development Board (DLDB) of Karnataka meticulously planned by a senior economist. Apart from these, World Bank-financed operation research projects operate at locations in Karnataka, Andhra Pradesh, Maharashtra and Madhya Pradesh; the famous experiment of Sukhomajri planned by Central Soil and Water Conservation Research and Training Institute (CSWCRTI) and other ICAR planned operation research projects; community participatory experiments of Adgaon and Ralegan-Siddi (Maharashtra), Mysore Resettlement and Development Agency (MYRADA) and Participative and Integrated Development of Watersheds (PIDOW) projects in Gulbarga.

5. See CSWCRTI's various documents on ORP projects at different locations.

6. The economic rate of returns (ERR) in the World Bank projects are 45 per cent in Kabbalnala (Karnataka), 26 per cent in Maheswaram (Andhra Pradesh), and more than 50 per cent in Manoli (Maharashtra). The sensitivity analysis also indicates encouraging ERR (based on the discussions with various project authorities).

7. Karnataka project has raised hopes about watershed experiment and their regular interaction sessions showed extremely encouraging results (see DLDB, Government of Karnataka documents). The Maharashtra programme evaluations (Centre for Development Studies and Activities, 1991; Deshpande and Reddy, 1990) indicate fairly good results.

8. The Ministry of Agriculture, Government of India (1990) incorporated various suggestions in the guidelines circulated recently to the State Governments.

9. Evaluations indicate exemplary results. See Deshpande and Reddy (1990).

10. The sample of 60 farm households falling in each watershed in the districts of Solapur, Aurangabad and Akola was selected after taking a list of the farm households from the village/s falling in the watershed.

11. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has been continuously working in Kanzara and Kinkheda villages of Akola district. The watershed chosen by us is in the same region of the district.

12. See various documents on World Bank Projects.

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crops without irrigation. The area in India for which this watershed based technology may be suited is estimated between 5 and 12 million hectares spread in the States of Karnataka, Andhra Pradesh, Maharashtra, Madhya Pradesh and Gujarat (Ryan *et al.*, 1982).

PERFORMANCE OF TECHNOLOGY AT ICRISAT CENTER

The watershed based technology was tested at ICRISAT Center for eight agricultural years (1976-77 to 1983-84) where improved cropping systems were compared with existing practices and cropping systems on farmer's fields. The long-term results are quite consistent over time. The improved cropping systems yield 3.9 to 4.4 tons per ha against 0.5 to 0.7 ton with the traditional cropping systems (Table I). On an average, the watershed technology gave about 3 tons per ha of cereal output and 1.2 tons of pulses. The average gross returns of the improved options were 4 to 5.4 times higher than those of the traditional systems. The technology requires additional operating costs, which range between Rs. 1,400 and Rs. 2,100 per ha above the operating costs for the existing system. The additional gross benefits generated by the watershed based technology were in the range of Rs. 3,300 to Rs. 5,400 per ha. This amounts to marginal rates of returns of 160 to 300 per cent. In these experiments it was found that the watershed technology promises to reduce risk as compared to the existing cropping system of a single post-rainy season crop.

TABLE I. ECONOMIC PERFORMANCE OF WATERSHED TECHNOLOGY AT ICRISAT CENTER: AVERAGES OF ANNUAL PERFORMANCES FROM 1976-77 TO 1983-84

Technology/ Cropping systems (1)	Mean yield (kg./ha) (2)	Gross returns (Rs./ha)[a] (3)	Operational cost[b] (Rs./ha) (4)	Gross profits (Rs./ha)[c] (5)	CV of gross profits[d] (per cent) (6)	Marginal rate of return (per cent) (7)
Watershed technology						
Maize-pigeonpea intercrop		6,765	2,060	4,705	28	272
Maize	2,712					
Pigeonpea	1,121					
Maize-chickpea sequence		7,021	2,757	4,264	43	159
Maize	3,205					
Chickpea	1,164					
Sorghum pigeonpea intercrop[e]		8,875	2,471	6,404	26	304
Sorghum	2,887					
Pigeonpea	1,088					
Traditional technology						
Rainy season fallow						
Post-rainy season sorghum and chickpea		1,643	682	961	43	-
Sorghum	567					
Chickpea	718					

Source: Ryan *et al.* (1982) for results of 1976-77 to 1980-81, and von Oppen *et al.* (1985) for 1981-82 to 1983-84.

a. Includes value of grain, fodder and other by-products.

b. Costs include all material, human and animal labour, and annual costs of implements. ICRISAT wage rates were used to value human labour.

c. Gross profit is calculated as gross returns minus operational costs. Overhead costs such as land revenue, depreciation on buildings, etc., have not been deducted hence the use of the term gross profits.

d. Variation over years.

e. The results are averages of three years, *i.e.*, 1981-82 to 1983-84.

PERFORMANCE IN ON-FARM VERIFICATION TRIALS

In order to verify the promising performance of the watershed based technology at ICRISAT Center, on-farm trials were carried out during the years 1981-82 through 1983-84 at different locations in dependable rainfall vertisol areas in India. These trials were collaboratively conducted by ICRISAT and the Departments of Agriculture and other institutions in the States of Andhra Pradesh, Karnataka and Madhya Pradesh. After initial trials in 1981-82 in Andhra Pradesh, the State Departments of Agriculture in Andhra Pradesh, Karnataka and Maharashtra initiated their own trials. In 1982-83, these trials covered 116 ha involving 40 farmers. The national tests were expanded in 1983-84 to cover 2,122 ha and involved 1,406 farmers. An economic evaluation of these on-farm trials is based on data collected from seven trials in which ICRISAT collaborated.

The results of the verification trails indicated that the watershed based technology performed best in Taddanpally and Sultanpur (Table II). An additional investment in operating costs of about Rs. 600 per ha generated incremental returns between Rs. 1,500 and Rs. 2,250 per ha during 1981-82 and 1982-83. In Farhatabad, differences between the operational costs of traditional and improved technologies were too small to compute meaningful marginal rates of returns, but the average results for the years 1982-83 and 1983-84 showed that gross profits under the improved technology were about one and one-and-half to two times higher than the profits under the traditional system.

Profitability of improved technology computed over all field trails was lower in the Begumgunj watershed in Madhya Pradesh in 1982-83 and 1983-84 than in the other regions. This was partly because of adverse climatic conditions at Begumgunj. However, some encouraging signals emerged from the Madhya Pradesh experience of 1982-83. For instance, some improved cropping systems, particularly the soyabean-pigeonpea intercrop, performed well with profits over Rs. 3,300 per ha, while traditional practices netted profits of only about Rs. 800 per ha. On the other hand, farmers trying to grow chickpea and/or wheat as second crops without irrigation found it difficult to get the crops established. Crop establishment is a critical factor for the success of *rabi* crops.

The results for 1983-84 from Begumgunj considerably improved over those for 1982-83. With an additional operating cost of about Rs. 1,100 per ha for the watershed based technology, farmers got an additional profit of about Rs. 1,150, or a marginal rate of return of 106 per cent.

The average profits from the use of improved practices in the other watersheds in Andhra Pradesh and Karnataka were about twice as high as those in Madhya Pradesh, or even higher. Thus there appears to be substantial room for reducing the relatively high operational costs of the technology in the deep black soils of Madhya Pradesh compared to the generally much lower costs for somewhat similar agro-climatic and soil areas in Andhra Pradesh and Karnataka.

All sites consistently showed a lower variability (coefficient of variation) in gross profits in watershed plots than the traditional ones indicating reduced risk with the watershed technology (von Oppen *et al.* 1985).

TABLE II. ECONOMIC PERFORMANCE OF WATERSHED TECHNOLOGY AT ICRISAT COLLABORATIVE ON-FARM TEST SITES, 1981-82 TO 1983-84

(Rs./ha)

State/ Test site/ Year	Watershed technology		Traditional technology		Marginal rate of return
	Operational cost	Gross[a] profits	Operational cost	Gross[a] profits	
(1)	(2)	(3)	(4)	(5)	(6)
. Andhra Pradesh					
Taddanpally,					
1981-82	1,181	3,055	595	1,625	244
1982-83	1.035	3,957	448	1,722	381
CV of gross profits (per cent)		42		50	
Sultanpur,					
1982-83	1,062	3,576	448	1,722	302
CV of gross profits (per cent)		37		50	
2. Karnataka					
Farhatabad,					
1982-83	1,194	3,323	1,142	2,186	*b*
1983-84	1,226	4,494	1,188	2,207	*b*
CV of gross profits (per cent)		23		31	
3. Madhya Pradesh					
Begumgunj,					
1982-83	2,348	1,172	866	786	26
1983-84	2,321	2,743	1,250	1,611	106
CV of gross profit (per cent)		76		89	

Constructed from Walker *et al.* (1989); Ghodake (1985).

a. Profitability is measured in gross profits.

b. The differences in operational cost are too small to get a meaningful value for marginal rate of return.

EXPERIENCES AND LESSONS

Since 1981 when this technology was taken into farmers' fields we learnt a lot through these experiences which are important for translating the full potential of the watershed based technology into substantial income advantages to dryland farmers. Some of the important experiences and the lessons we learnt are as follows:

1. Watershed Development

The development cost of the on-farm watershed test sites ranged from about Rs. 200 to Rs. 1,000 per ha. The higher cost (Rs. 1,000 per ha) in Begumgunj in Madhya Pradesh reflected the need for greater drainage associated with a higher rainfall environment and the substitution of more expensive tractors for cheaper bullocks in forming the watershed (Walker *et al.*, 1989). This has important implication for financial requirements for the watershed development.

Even Rs. 1,000, the cost of watershed development, is attractive when compared to investment in irrigation. For example, the Sixth Five Year Plan implies an average capital cost of about Rs. 15,000 per ha (in 1979-80 prices) of surface irrigation potential created (Abbie *et al.*, 1982).

Development of watershed requires grid surveying, land levelling, shaping and constructing main and field drains. These are of differential benefits to the farmer as an individual and to watershed participants as a group. For example, those in the upper reaches where drains are smaller stand to gain less than those in the lower reaches where drains are larger and benefits from improved drainage are greater. Thus it is difficult to apportion costs among beneficiaries. Hence, either full subsidy or group financing through a new line of medium-term to long-term credit would be required.

2. Sustainability

It is acknowledged that without the wise and rational use of soil and water resources, the development of the semi-arid tropics (SAT) would not be possible. Therefore, there is a need to transfer and spread the technology which helps to sustain as well as increase agricultural production in dryland areas. The watershed based technology reduces erosion, increases the water table and gives stability to production (Walker *et al.*, 1989; Virmani and Eswaran, 1990). Hence, the watershed based approach, in general, will be important in creating a sustainable development of dryland agriculture.

Apart from the financial benefits of the watershed based technology, which accrue directly to farmers, the technology does have social benefits, *e.g.*, through reducing the loss of top soil and deep infiltration of water to recharge groundwater. Measurement and quantification of social benefits of attaining sustainability through soil and water conservation would be important as this could help justify an amount of subsidy for enhancing the introduction and spread of watershed based technology.

3. Employment

A higher rate of productive employment through the improved technology would certainly be desirable for achieving overall growth of incomes in the backward regions of dryland areas. Poverty and under-employment are positively related (Dantwala, 1979) and more employment would therefore benefit the poor. Farm labour employment is substantially high under the watershed based technology compared to that under the traditional technology (Table III). Watershed based technology employs about twice as many labourers as compared to traditional practices. In absolute terms employment increases by 300 to 400 person hours per ha. Moreover, the watershed based technology is likely to provide a more stable employment than the existing technology and stability in employment would help reduce the seasonal under-employment prevalent in dryland areas.

4. Credit

If development costs of the watershed are not totally subsidised by the State Department of Agriculture, then these expenses will have to be financed through new lines of medium-term to long-term credit. Long-term credit is also needed for the purchase of the wheeled tool carrier, its attachments and spraying equipment. New lines of credit need to be opened to finance the purchase of tool carriers and its attachments.

The watershed based technology options require additional cash on hand to meet variable crop expenses. Our trials at Taddanpally and Begumgunj sites have shown that short-term cash requirements are more than double (seed, fertiliser and human labour) for the watershed based technology compared to traditional technology. The additional requirement is in the range of Rs. 600 to Rs. 1,300 per ha (Table III). Only at Farhatabad cash requirements of the new technology were similar to traditional systems because there were no major changes in cropping systems and cropping intensity.

This indicates that the demand for both investments and short-term credit will increase with the watershed approach and may likely to impose serious constraints to adoption of technology if they are not met by adequate credit supply. Hence, new lines of credit are required, lending norms should be made flexible and repayment performance will have to be carefully monitored.

5. *Wheeled Tool Carrier*

The wheeled tool carrier costing around Rs. 10,000 is beyond the reach of the small farmers whose average income per family may be around Rs. 3,400 to Rs. 5,000 per year (Walker *et al.*, 1989). An alternative may be co-operative or contractor owned implements which are hired out to farmers on a daily basis; but these options pose problems of timely access and enhanced vulnerability to machine damage and difficulties or expense involved in getting it repaired. Moreover, the efforts may continue to develop the low cost versions of or alternatives to the wheeled tool carrier.

6. *Infrastructure*

One of the key elements in the success of the watershed technology is the availability of rural infrastructure facilities in dryland areas for supplying important inputs such as seeds, fertiliser and plant protection inputs. The levels of these inputs for the watershed technology compared to the existing technology are very high (Table III). This implies the need for considerable improvement of infrastructure to ensure the supply of quality seeds, additional fertiliser and plant protection material.

7. *Farmer Participation*

Technically it is desirable and in many cases essential that all farmers participate in the development of the watershed in the first year when the main and field drains are constructed. However, in any watershed not all farmers are willing or capable of collaborating due to various reasons. Hence, government policies should be designed to cope with such problems and research by scholars in the field of policy and public administration is called for.

TABLE III. MEAN LEVELS OF IMPORTANT INPUTS FOR WATERSHED TECHNOLOGY AND TRADITIONAL TECHNOLOGY AT ON-FARM RESEARCH SITES

Site/year (1)	Input (2)	Traditional technology (3)	Watershed technology (4)	Per cent change (5)
Taddanpally/ Sultanpur 1981-82 to 1982-83	Human labour (person hr/ha)	345	638	85
	CV of fortnightly employment (per cent)	170	110	-35
	Short-term cash (Rs./ha)	497	1,098	121
	Seed (Rs./ha)	33	130	294
	Fertiliser/manure (Rs./ha)	117	479	309
	Plant protection (Rs./ha)	-	53	-a-
	Weed control (Rs./ha)	70	84	20
Farhatabad 1982-83 to 1983-84	Human labour (person hr/ha)	427	832	95
	CV of fortnightly employment (per cent)	142	217	53
	Short-term cash (Rs./ha)	1,165	1,210	4
	Seed (Rs./ha)	124	90	-27
	Fertiliser/manure (Rs./ha)	237	267	13
	Plant protection (Rs./ha)	206	200	-3
	Weed control (Rs./ha)	106	109	3
Begumgunj 1982-83 1983-84	Human labour (person hr/ha)	157	565	260
	CV of fortnightly employment (per cent)	187	126	-33
	Short-term cash (Rs./ha)	1,044	2,369	127
	Seed (Rs./ha)	306	534	74
	Fertiliser/manure (Rs./ha)	24	687	2,762
	Plant protection (Rs./ha)	-	58	-a-
	Weed control (Rs./ha)	-	65	-a-

Source: von Oppen *et al.* (1985).

a. Because the values are negligible under the traditional technology, no meaningful percentage change can be obtained.

8. Training

The watershed technology demands timely and location-specific information and skills to which the technology is highly responsive. This points to the need for practical training to farmers, surveyors, extension workers and bankers for the better management of the watershed technology.

CONCLUSION

ICRISAT has assembled a watershed based technology of dependable rainfall regions of SAT India. The long-term experiments at ICRISAT Center confirmed that the application of improved technology results in considerable improvements in yields and profitability. The on-farm watershed trials in a few agro-climates of the Indian semi-arid tropics with moderate but dependable rainfall showed that gross profits from improved technology were one and one-and-half to two times higher than those from the traditional technology as long as management support and adequate inputs were made available. The experience shows that the continuing need for management support for watershed development, credit supply, wheeled tool carriers, infrastructure facilities for supply of seeds, fertilisers and the need of farmer's participation and their training are some of the constraints which seems to impose narrower limits on the technology spread than had earlier been anticipated. The lessons learned from these experiences suggest that these barriers can be removed by close co-operation of researchers, administrators, extension workers and bankers with active participation of the farmers in order to realise the full potential of the watershed based technology for increasing and providing the much sought stability to agricultural production in SAT India.

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Determinants of People's Participation in Watershed Development and Management: An Exploratory Case Study

Katar Singh*

INTRODUCTION

People's participation has become a rhetoric these days in India and other developing countries. Participation connotes different things to different people. In common parlance, it is used to mean an 'act or fact of partaking' or 'sharing in'. According to Banki (1981, p. 533), participation means "a dynamic group process in which all members of a (work) group contribute, share, or are influenced by the interchange of ideas and activities toward problem-solving or decision making." In this paper, we use the term to mean the act of partaking (by farmers) in all stages of watershed development and management programmes right from designing of various soil and water conservation structures through monitoring and evaluation of their performance.

Such participation requires, among other things, that the target group of farmers voluntarily spend their time, energy and money on the programme and adopt the recommended watershed development measures and practices and maintain them in good condition on a sustained basis.

There is no universally acceptable measure or index of people's participation that could be used to evaluate development programmes in terms of people's participation. One could use as crude measures of participation such parameters as proportions of the target group of people who participated in various stages of a programme, who adopted various recommended measures and practices, and who expended their time and money on participation in collective action required for watershed development and management on a sustained basis. We have measured people's participation in terms of these parameters.

People's participation in watershed development and management programmes is crucial for their successful and cost-effective implementation. This is so because the watershed approach requires that every field/parcel of land located in a watershed be treated with appropriate soil and water conservation measures and used according to its physical capability. For this to happen, it is necessary that every farmer having land in the watershed accepts and implements the recommended watershed development plan. There are some components of a watershed development plan such as bunding, levelling, etc., which can be implemented by the farmers involved acting individually and there are many other items such as check dams, waterways, etc., that can be implemented only through collective action of the farmers. This means that for successful implementation of watershed development plan, people's participation is necessary for action on their individual farms as well as on common property land resources in the watershed. Like most other agricultural and rural development programmes in India, watershed development programmes also have suffered due to inadequate people's participation. It is therefore necessary for successful implementation of watershed development programmes that the factors affecting people's participation are identified and necessary measures for securing the needed participation are adopted.

* Professor, Institute of Rural Management, Anand (Gujarat).