Global Theme on Agroecosystems

Report no. 10

Adarsha Watershed in Kothapally

Understanding the Drivers of Higher Impact

International Crops Research Institute for the Semi-Arid Tropics

Comprehensive Assessment of Water Management in Agriculture

Citation: Sreedevi TK, Shiferaw B and Wani SP. 2004. Adarsha watershed in Kothapally: understanding the drivers of higher impact. Global Theme on Agroecosystems Report no. 10. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 24 pp.

Abstract

A new science-based farmer participatory consortium model for efficient management of natural resources and for improving the livelihood of poor rural households was evaluated in Adarsha watershed, Kothapally, Ranga Reddy District, Andhra Pradesh, India by ICRISAT and partners. The salient impacts that resulted due to the implementation of this model were substantial reductions in runoff and soil loss, improvement in groundwater levels, reduction in pesticide usage, improvement in land cover, increase in productivity and high incomes to the farmers. Compared to the pre-project situation, average household incomes from crop production have doubled. The drivers of this success were: (i) selection of the watershed on a demand driven basis; (ii) higher farmer participation in the watershed program; (iii) good local leadership; (iv) integrated approach to watershed management; (v) team effort and collective action by the consortium partners; (vi) social vigilance and transparency in financial dealings; (vii) increased confidence of the farmers; (viii) choice of low-cost conservation structures that provide benefits to large segments of the community; (ix) constant participatory monitoring; (x) knowledge-based entry point activity; and (xi) concerted local capacity building efforts by all the partners.

This case study contributes to the Comprehensive Assessment of Water Management in Agriculture (CA), and was funded in part through a grant from the Government of Netherlands to the International Water Management Institute in support of the Assessment. It is also part of the project "Participatory Watershed Management for Reducing Poverty and Land Degradation in the Semi-Arid Tropics" (RETA # 6067) funded by the Asian Development Bank (ADB) to ICRISAT.

Global Theme on Agroecosystems
Report no. 10

Adarsha Watershed in Kothapally

Understanding the Drivers of Higher Impact

TK Sreedevi, B Shiferaw and SP Wani

ICRISAT

International Crops Research Institute for the Semi-Arid Tropics
Patancheru 502 324, Andhra Pradesh, India

Asian Development Bank
0401 Metro Manila
0980 Manila, The Philippines

Comprehensive Assessment of Water Management in Agriculture
PO Box 2075, Colombo, Sri Lanka

2004

About authors

TK Sreedevi Scientist (Watershed Development), Global Theme on Agroecosystems, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India

B Shiferaw Senior Scientist (Resource & Development Economics), Global Theme on SAT Futures, ICRISAT, PO Box 39063, Nairobi, Kenya

SP Wani Principal Scientist (Watersheds) and Regional Theme Coordinator (Asia), Global Theme on Agroecosystems, ICRISAT, Patancheru 502 324, Andhra Pradesh, India

Acknowledgments

We would like to first thank the people of Kothapally for their hospitality, cooperation and support toward the case study. Special thanks are due to Ms Lakshmi, SHG leader and trainer for vermicomposting, M/s Narsimha Reddy, President, WSA, Anjaiah, Secretary, WSC, Osman, Azam Ali and other farmers for spending time with us and providing the nuances of watershed implementation in Kothapally. Special thanks are due to the villagers who made it a point to attend the *Gram Sabha* (village assembly) and provide insights into the watershed development based on their indigenous knowledge and for their unrelented support to the consortium. We would like to thank M/s Jayachandra Reddy, Ramlinga Reddy of Drought Prone Area Program, Ranga Reddy for the cooperation and logistical support. We also gratefully acknowledge the contributions of all the consortium partners for their inputs in developing Adarsha watershed. We are indebted to Ms Sheila Vijayakumar for editing the manuscript and Mr KNV Satyanarayana for incorporating the editorial corrections and page-setting the manuscript.

Contents

Background

Water, the very basis of life and the single most important feature of our planet, is the most threatened resource today. In rainfed areas watershed management is the approach used for conservation of water and other natural resources as well as for sustainable management of natural resources. A watershed is a hydrologically defined area that is drained by a network of streams, which meet together in such a way that the water leaves through a common point. A watershed is made up of soil, vegetation and water along with the people and animals who are the integral part of the system. Sustainable management of a watershed thus entails the rational utilization of land and water resources for optimum production but minimum hazard to natural and human resources. Therefore, watershed management is the process of guiding and organizing land use and use of other resources in a watershed to provide desired goods and services to people while enhancing the resource base without adversely affecting natural resources and the environment (Wani et al. 2001). Embedded in this concept is the recognition of the interrelationships among land use, soil and water, and the linkages between uplands and downstream areas.

Drought-prone areas are categorized by land degradation, low and erratic rainfall, low rainwater use efficiency, high soil erosion, inherently less fertile soils and subsistence agriculture. The farmers in these areas are very poor and their ability to take risk and invest necessary inputs for optimizing production is low. There is a general tendency to exploit groundwater for food crops by few resourceful farmers. Dryland areas are repeatedly prone to drought because of their geographical location. Also these areas are prone to waterlogging situations during the cropping season due to torrential downpours interspersed with long dry spells. Efforts of development managers, non-governmental organizations (NGOs) and leaders do not show the expected benefits and impacts due to the compounding effect of the aforesaid problems in the drought-prone areas.

Watershed programs in India so far have mainly focused on natural resource conservation and interventions such as soil and rainwater conservation and to some extent afforestation in the government forestlands. Sufficient emphasis and efforts were not targeted to build up stakes of the community for sustainable development of the natural resources. The issues of gender equity have not been addressed adequately. Natural resource management progress has largely remained a water storage structure-driven investment giving only wage labor benefits to deprived sections of the society which is of a very transient nature.

Emphasis on efficient water management, sustainability, monitoring and evaluation has not been adequate. However, it is a well known fact that watershed projects should move from purely soil and moisture conservation and water harvesting interventions to a wholesome community-based integrated watershed management approach which creates a voice and stake for the landless, poor and women. Poverty alleviation through processes that evolve and empower the poor and women will sustain. People-centered development requires convergence of initiatives and efforts to be accompanied by decentralization of decision-making (Wani et al. 2003). For establishing a successful watershed program it is necessary to involve the primary stakeholders right from the beginning and build up their capacities to take the program towards a sustainable initiative. The interventions in the project design should aim at empowerment of the community.

Adarsha Watershed, Kothapally

Adarsha watershed is located in Kothapally village (longitude 78°5’ to 78°8’ E and latitude 17°20’ to 17°24’ N) in Ranga Reddy district, Andhra Pradesh, India nearly 40 km from the International Crops

Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru. It covers 465 ha of which 430 ha are cultivated and the remaining area is wasteland. The watershed is characterized by an undulating topography with an average slope of about 2.5%. Soils are predominantly Vertisols and associated soils (90%) (Fig. 1). The soil depth ranges from 30 to 90 cm and has medium to low water-holding capacities. The total population in Adarsha watershed is 1,492 belonging to about 270 cultivating and 4 non-cultivating families. The average landholding per household is 1.4 ha (Shiferaw et al. 2002).

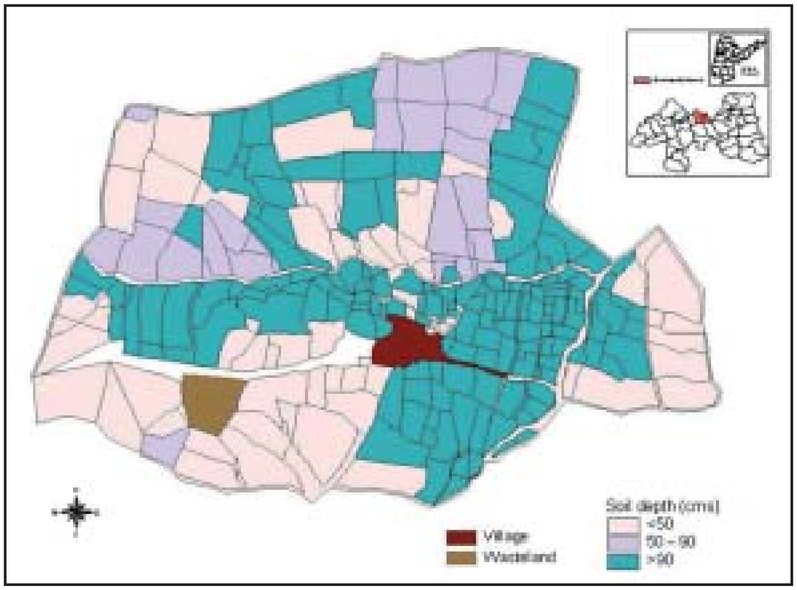

Figure 1. Soil depth map of Adarsha watershed, Kothapally, Ranga Reddy district, Andhra Pradesh.

Approach

A new farmer participatory consortium model for efficient management of natural resources emerged from the lessons learned from long-term watershed-based research led by ICRISAT and national partners. The important partners are the Central Research Institute for Dryland Agriculture (CRIDA), National Remote Sensing Agency (NRSA), and District Water Management Agency (DWMA) in Hyderabad, Andhra Pradesh. The important components of the new model, which are distinctly different from earlier models are described by Wani et al. (2002, 2003).

The new model is distinctly different model as it has brought the farmer in the center of the initiative. This farmer-centric integrated watershed management model has the components of use of new science tools for development where there is effective continuous transfer of knowledge and technology from on-station to on-farm. The approach is holistic participatory based on farming systems and diversified livelihood opportunities to cater to the needs of socially marginalized and landless along with dryland farmers. The interventions are so designed recognizing the needs of individual farmers. The in situ conservation that brings tangible benefits to farmers precede the community-based interventions. This enhances the scope of participation. Continuous monitoring and evaluation provides space for reflection, refinement and development of need based, concurrent technologies. The aim is empowerment of community and stakeholders. Hence, on the institutional front a consortium is put in place comprising research organizations, university, development workers, policy makers and farmers. This vehicle provides the required technical backstopping in the model.

Interventions to enhance productivity and income

Soil and water conservation measures

The Watershed Committee identified sites for soil and water conservation structures and other measures. Community-based interventions were implemented on common resources. Fourteen water storage structures (one earthen and 13 masonry) with a capacity of 300 to 2000 m^3 were constructed (Fig. 2). Ninety-seven gully control structures, 60 mini percolation pits, 1 gabion structure for increasing groundwater recharge, a 500-m long diversion bund and field bunding on 38 ha were completed.

Soil and water conservation measures implemented by farmers in individual fields (Figs. 3 and 4) (Wani et al. 2002) were broad-bed and furrow (BBF) landform and contour planting to conserve in situ soil and

Figure 2. Community-based masonry check-dam.

Figure 3. Broad-bed and furrow landform prepared with the tropicultor.

Figure 4. Gliricidia plantation on field bunds to produce N-rich organic matter and to conserve soil and water.

water, use of the tropicultor for planting, fertilizer application and weeding operations, field bunding (38 ha), and planting *Gliricidia* on field bunds to strengthen bunds, conserve rainwater and supply nitrogen (N)-rich organic matter for in situ application to crops.

Several farmers evaluated BBF and flat landform treatments for shallow and medium-depth black soils using different treatment combinations. Farmers obtained 250 kg more pigeonpea and 50 kg more maize per hectare using BBF on medium-depth soils than from the flat landform treatment. Furthermore even on the flat landform treatment farmers harvested 3.6 t maize and pigeonpea using improved management options compared to only 1.72 t maize and pigeonpea grain from their normal cultivation practices (Table 1).

Table 1. Productivity in on-farm trials at Adarsha watershed, 2001[1].

System	Soil	Landform	Yield (kg ha^{-1})		Total system productivity (kg ha^{-1})
			Cereal[2]	PP	
Maize/PP	Shallow	BBF	1750	380	2130
Maize/PP	Shallow	Flat	1680	290	1970
Maize/PP	Medium	BBF	2830	1070	3900
Maize/PP	Medium	Flat	2780	820	3600
Maize	Medium	BBF	3000	-	3000
Maize	Shallow	BBF	2030	-	2030
Sorghum	Medium	BBF	3000	-	3000
Local farmers' practice					
Maize/PP			1600	115	1715
Sorghum/PP			470	115	585
Sorghum			1010	-	1010

1. PP = Pigeonpea; BBF = Broad-bed and furrow.
2. Main crop: maize or sorghum.

Wasteland development and tree plantation

Common wasteland treatment was done by planting custard apple saplings, *Gliricidia* saplings and avenue plantation as a part of village afforestation program (Wani et al. 2003).

Integrated pest management

Integrated pest management (IPM) was adopted to optimize crop productivity along with integrated soil, water, crop and nutrient management in the watershed. The following IPM activities were implemented by the project:

- Crop surveys carried out revealed that farmers use chemical pesticides to control insect pests. *Helicoverpa* is the key pest on many crops.
- IPM practices such as use of pheromone traps, shaking of pigeonpea plants for controlling pod borers, use of pest tolerant varieties, use of *Helicoverpa* nuclear polyhedrosis virus (HNPV) and bird perches were adopted.

Integrated nutrient management

The integrated nutrient management (INM) approach was adopted to enable good crop growth with conserved soil and water. Detailed characterization of the soils showed that they are deficient in available phosphorus (P), available N, zinc (Zn), boron (B) and sulfur (S). Amendments with B, S and B+S treated plots resulted in 13 to 29% increase in sorghum grain yield and 20 to 39% increase in maize grain yield (Table 2) (ICRISAT 2002).

Table 2. Total productivity of sorghum and maize with boron and sulfur amendments at Adarsha watershed, Kothapally, 2001.

	Sorghum yield (kg ha^{-1})			Maize yield (kg ha^{-1})		
Treatment	Grain	Stalk	Total	Grain	Stalk	Total
Control	1460	2800	4260	1960	2360	4320
Boron (B)	1650	3030	4680	2360	2640	5000
Sulfur (S)	1890	3320	5210	2730	2840	5560
B+S	1800	3490	5290	2580	3060	5640

Nutrient budgeting

Nutrient budgets were studied using stratified random sampling by dividing the watershed into three toposequences and farm holdings. The N, P and potassium (K) nutrient uptake by maize/pigeonpea intercropping system and sole maize was greater in the improved BBF system compared to that on the flat landform, which resulted in more crop yield on the BBF landform. The balances also showed that all systems were depleting N and K from soils, and that more P is applied than removed by crops (Table 3) (ICRISAT 2002).

Table 3. Nutrient budgeting studies in farmers' fields, Adarsha watershed, Kothapally, 1999–2000.

	Total input (kg ha^{-1})			Total output (kg ha^{-1})			Balance (kg ha^{-1})		
Landform	N	P	K	N	P	K	N	P	K
Maize/pigeonpea									
BBF	28	16	17	85	11	58	–57	+5	–41
Flat	32	14	21	80	9	50	–48	+5	–27
Sole Maize									
BBF	21	10	0	75	14	71	–54	–4	–36
Flat	9	10	0	33	7	40	–24	+3	–36
Sole Sorghum									
Flat	18	9	11	42	10	64	–24	–1	–53

In situ generation of N-rich green manure

On-station watershed studies at ICRISAT have shown that *Gliricidia* loppings provided 31 kg N ha^{-1} yr^{-1} without adversely affecting crop yield (ICRISAT 2002). Farmers have planted about 50,000 *Gliricidia* saplings on bunds for generating N-rich organic matter.

Worm farming to boost income

Vermicomposting was undertaken by self-help groups (SHGs) as a micro-enterprise to generate income (Fig. 5). Participatory evaluation of plots with applications of 3 and 5 t ha^{-1} vermicompost resulted in increased tomato yield (4.8 to 5.8 t ha^{-1}) when compared to plots (3.5 t ha^{-1}), which received conventional compost (ICRISAT 2002).

Figure 5. Vermicomposting to promote micro-enterprises and generate income.

Village-level HNPV production

The project consortium identified farmer participants and initiated training in production, storage and usage of HNPV on different crops for minimizing pest damage. The farmers quickly adopted the technology and produced 2,000 larval equivalent (LE) of HNPV, and used it on cotton, pigeonpea and chickpea crops. ICRISAT supplied an additional 11,650 LE HNPV for use on these crops.

Adarsha watershed – A bright spot

The villagers at the beginning decided to name the watershed as "Adarsha" meaning a goal example worthy to be followed. This became true when this watershed became a site of media attraction and learning for the surrounding villagers. Soon "Adarsha" became well-known when world service British Broadcasting Corporation (BBC) selected this watershed for making a documentary. Recently, this case study has also appeared as a success story in "Research towards INRM: Examples of research problems, approaches and partnerships in action in the CGIAR" (Wani et al. 2003). Some salient impacts at Adarsha watershed, Kothapally are discussed.

Reduced runoff and soil loss

The soil and water management measures in the treated watershed included field bunding, gully plugging and check-dams across the main watercourse, along with improved soil, water, nutrient and crop management technologies. Untreated areas represent farmers' practices without any technological intervention. There was a significant reduction in runoff from the treated watershed compared to the untreated area in 2000 and 2001 (Table 4). In high rainfall year (2000) runoff from the treated watershed was 45% less than untreated area. During a sub-normal rainfall year (2001) runoff from the treated watershed was 29% less than untreated area. Daily runoff volumes during 2000 in treated and untreated watersheds are shown in Figure 6. The rainfall on 24 August alone resulted in about 70% of the total annual runoff (Pathak et al. 2002).

Table 4. Seasonal rainfall, runoff and soil loss from the sub-watershed in Adarsha watershed, 1999–2001[1].

		Runoff (mm)		Soil loss (t ha^{-1})	
Year	Rainfall	Untreated	Treated	Untreated	Treated
1999	584	16	NR	*	*
2000	1161	118	65	1.04	*
2001	612	31	22	1.48	0.51

1. Untreated = Control with no development work; Treated = With improved soil, water and crop management technologies; NR = Not recorded.

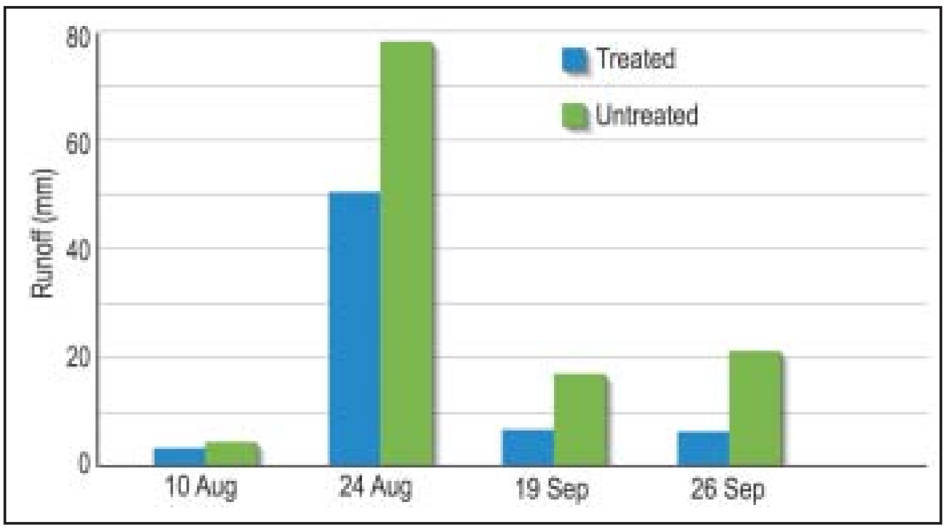

Figure 6. Daily runoff from the treated and untreated sub-watersheds in Adarsha watershed during 2000.

Of the three years during 1999–2001, two years (1999 and 2001) were low rainfall years. Besides low rainfall, most of the rainfall events were of low intensity. This resulted in very low seasonal runoff during 1999 and 2001. Generally during the low runoff years the differences between the treated and untreated watersheds are very small. During good rainfall, ie, 2000, a significant difference in the runoff was seen between treated and untreated watersheds (Table 4). The soil loss was measured both from treated and untreated watersheds during 2001. There was a significant reduction in soil loss from treated watershed (only 1/3 soil loss) compared to untreated watershed in 2001.

Improved groundwater levels

There are 62 open wells in Adarsha watershed, most of which occur along the main watercourse. All the wells were geo-referenced, and water levels were monitored continuously on a fortnightly basis.

There were 15 bore wells before project initiation, and 55 new bore wells were dug during the project period. There was a significant improvement in the water levels of most wells, particularly those located near check-dams (Fig. 7). Due to additional groundwater recharge, a total of 200 ha in post-*kharif* season and 100 ha in post-*rabi* crops, mostly vegetables, were irrigated during the 2002/03 cropping season. Based on three years (1999–2001) of observations on groundwater levels in open wells, the estimated mean average rise of groundwater was 415 cm. Thus the average contribution of the seasonal rainfall to groundwater in the watershed could be estimated at approximately 27% of the seasonal rainfall (assuming the specific yield of the aquifer material as 4.5%) (Pathak et al. 2002).

Improved land cover and vegetation

The land cover and vegetation density in Adarsha watershed was studied using satellite images to assess the impact of various interventions on these parameters. The IRS-1C and -1D LISS-III images on April 1996 and April 2000, and the NDVI (Normalized Difference Vegetation Index) images generated from these are shown in Figure 8. A close look at the images of 1996 and 2000 revealed an increase in vegetation cover from 129 ha in 1996 to 200 ha in 2000 (Dwivedi et al. 2003).

Increased productivity

Farmers evaluated improved crop management practices (INM, IPM and soil and water management) together with researchers. With improved technologies farmers obtained high maize yields ranging from 2.2 to 2.5 times the yield of sole maize (1.5 t ha^{-1}) in 1998 (Table 5). In the case of maize intercropped with pigeonpea, improved practices resulted in a four-fold increase in maize yield (2.7 t ha^{-1}) compared with farmers' traditional practices where the yields were 0.7 t ha^{-1}. Improved practices increased sorghum yield three-fold within one year while the yield of intercropped pigeonpea increased five times in 2000 (ICRISAT 2002).

Table 5. Average yields (kg ha^{-1}) with improved technologies in Adarsha watershed, 1999–2002.

Crop	1998 baseline data	1999	2000	2001	2002
Sole maize	1500	3250	3750	3300	3480
Intercropped maize	-	2700	2790	2800	3083
(farmers' practice)		(700)	(1600)	(1600)	(1800)
Intercropped pigeonpea	190	640	940	800	720
(farmers' practice)		(200)	180	-	-
Sole sorghum	1070	3050	3170	2600	2425
Intercropped sorghum	-	1770	1940	2200	-

Of all the cropping systems studied in Adarsha watershed, maize/pigeonpea and maize/chickpea intercropping systems proved to be most beneficial. Farmers could gain about Rs 16,506 and Rs 19,457 from these two systems, respectively (Table 6). Sole sorghum, sole chickpea and sorghum/pigeonpea intercropping system also proved to be beneficial whereas sorghum, maize and mung bean traditional systems were significantly less beneficial to farmers. Cotton grown with traditional management practices resulted in a net loss (ICRISAT 2002).

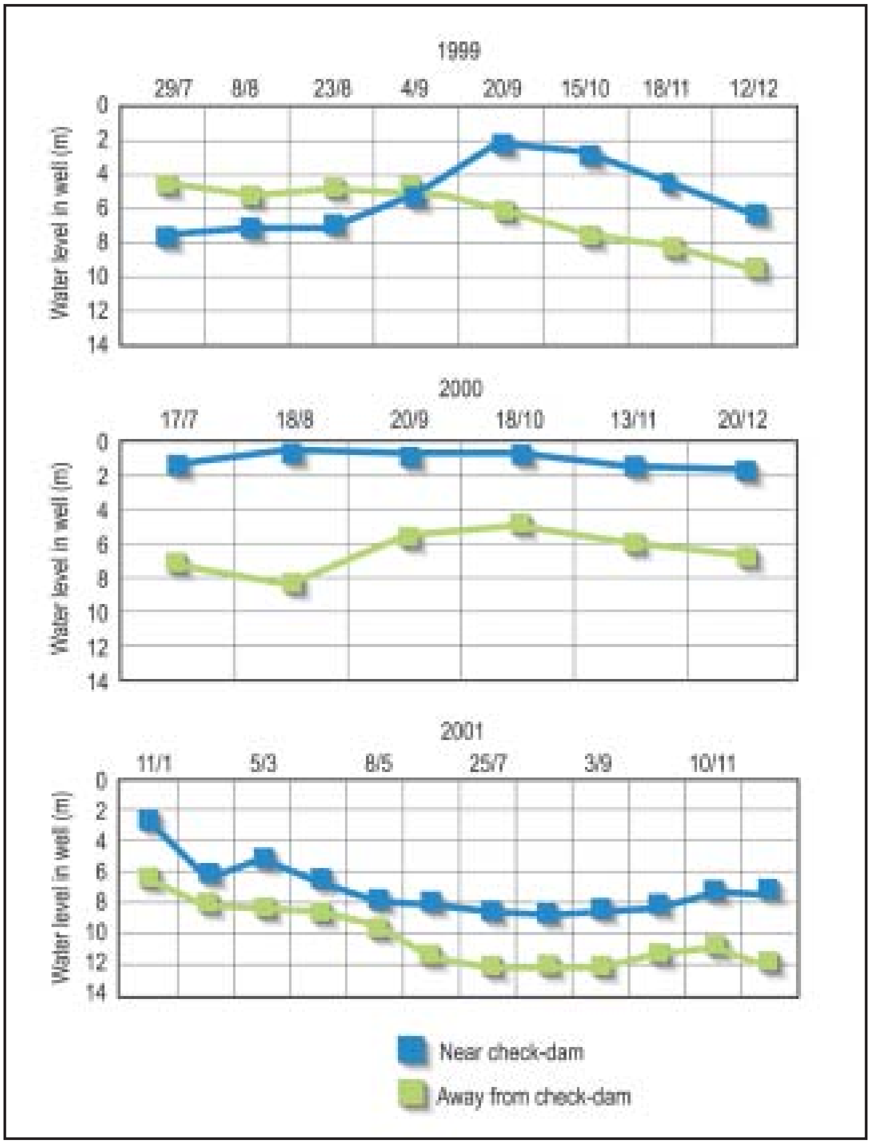

Figure 7. Groundwater levels in open wells at Adarsha watershed, Kothapally, 1999–2001.

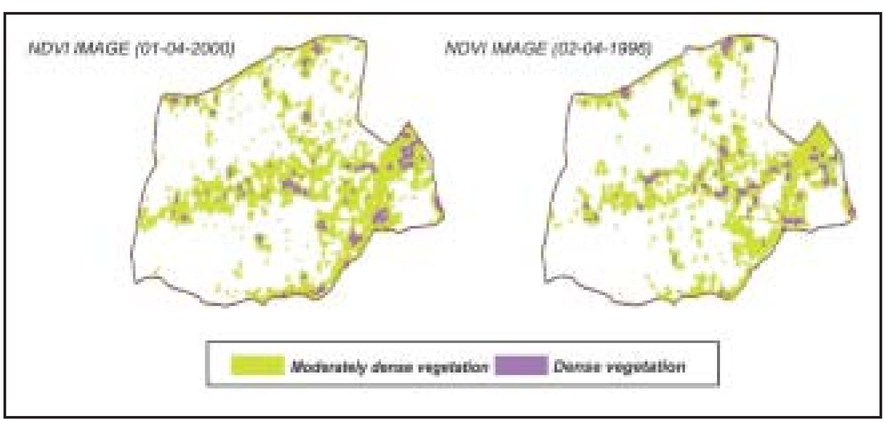

Figure 8. Satellite images of vegetation cover to study the impact of various technological interventions, Adarsha watershed, Kothapally.

Table 6. Economics of production of different crops with improved technology in Adarsha watershed, Kothapally during 1999–2000.

Cropping system	Total productivity (kg ha^{-1})	Cost of production (Rs ha^{-1})	Total income (Rs ha^{-1})	Profit (Rs ha^{-1})	Benefit-cost ratio
Maize/pigeonpea (improved)	3351	6203	22709	16506	2.67
Sorghum/pigeonpea (improved)	2285	5953	17384	11431	1.92
Cotton (traditional)	980	15873	24389	8516	0.54
Sorghum/pigeonpea (traditional)	1139	4608	11137	6529	1.42
Maize-chickpea (improved)	4319	7317	26774	19457	2.66
Chickpea (improved)	840	4886	17292	12406	2.54
Sole maize (improved)	3150	4578	13532	8954	1.96
Sorghum (traditional)	975	3385	6997	3612	1.07
Sole sorghum (improved)	2800	4352	15084	10732	2.47
Maize (traditional)	1600	3599	7281	3682	1.02
Mung bean (traditional)	600	4700	9000	4300	0.91
Chickpea (traditional)	-	4260	11600	7340	1.72
Sole pigeonpea (improved)	1090	4890	17120	12230	1.35

Changes in cropping pattern

Analysis of prevalent cropping systems, their area and previous history before the watershed management intervention provides insight into the way the watershed management approach has benefited farmers. Kothapally was predominantly a cotton-growing area prior to project implementation. The area under cotton was 200 ha in 1998. Maize, chickpea, sorghum, pigeonpea, vegetables and rice were also grown.

After 4 years of activities in Adarsha watershed, the area under cotton cultivation decreased from 200 to 80 ha (60% decline) with simultaneous increases in maize and pigeonpea. The area under maize and pigeonpea increased more than three-fold from 60 to 200 ha and 50 to 180 ha, respectively within four years. The area under chickpea also increased two-fold during the same period (Table 7) (ICRISAT 2002).

Table 7. Area (ha) under various crops in Adarsha watershed, Kothapally.

Crop	1998[1]	1999	2000	2001	2002[2]
Maize	60	80	150	180	200
Sorghum	30	40	55	65	70
Pigeonpea	50	60	120	180	180
Chickpea	45	50	60	60	100
Vegetables	40	45	60	60	100
Cotton	200	190	120	100	80
Rice	40	45	60	60	60

1. Before watershed management activities began.
2. After 4 years of watershed management activities.

Economic Impact of the Project

As discussed above, the basic goal of watershed management in rainfed systems is to reduce rural poverty and improve livelihood security while protecting or enhancing the sustainability of the environment and the agricultural resource base. Watershed development generates various types of benefits – tangible and non-tangible – some captured by individual farmers and some by the entire community or society as a whole. Assessment of the economic and environmental impacts of watersheds is not always easy. Periodic monitoring and evaluation is an essential requirement in this process. Table 8 shows the economic benefits that farmers have started to gain because of the watershed project. The assessment is based on data collected for the 2001 production from a random sample of 120 household farms – 60 households within the watershed and another 60 households from six adjacent villages outside the watershed. Households outside the watershed are from non-watershed villages. Because of the geographical proximity, the adjoining villages just outside the watershed are considered to have comparable socioeconomic and biophysical conditions and the major difference is the absence of a watershed project in these 'control' villages.

Analysis of the data show that average net returns per hectare for dryland cereals and pulses are significantly higher within the watershed (Table 8). For cereals, the returns to family labor and land (net income) is 45% higher even with irrigation, while the net returns on rainfed cereal crops have more than doubled. Similarly for pulse crops, per hectare net returns within the watershed are about twice as large as that outside the watershed. This is mainly because the integrated watershed development approach includes improved cultivars of cereals (eg, sorghum) and pulses (eg, chickpea and pigeonpea) developed by ICRISAT along with improved management of water and soil fertility. Adoption of the improved varieties has not only increased crop yields but also enhanced the economic profitability of other soil and water conservation investments, which may otherwise be economically unattractive to farmers.

Table 8. Net income from crop production activities (Rs ha^{-1}).

	Within the watershed		Outside the watershed	
Crops	With irrigation	Without irrigation	With irrigation	Without irrigation
Cereals	11,170	6,040	7,690	2,900
Pulses	8,860	3,810	4, 080	1,920
Cotton	17,830	12,150	17,470	12,030
Vegetables	17,170	7,480	11, 980	6,450
All crops	12,720	5,880	14, 810	3,820

In addition to the impacts on the net productivity of land, we also compared net incomes from crop production activities among the households within and outside the watershed. The results are quite striking. Average household net income (without excluding family labor and owned land costs) from crop production activities within and outside the watershed is Rs 15,400 and Rs 12,700, respectively. The respective per capita income is Rs 3,400 and 1,900. Accounting for the cost of family labor, the average crop income within the watershed was Rs 12,700 compared to Rs 9,500 for the non-watershed villages (Fig. 9). Based on the baseline data from a random sample of 54 households, we also computed the average net crop incomes (accounting for the cost of family labor) within the watershed in 1998, before the project started in the village. The average net crop income (in 2001 prices) in 1998 was about Rs 6,200 despite the high rainfall recorded in the village during that year (1084 mm vs 676 mm in 2001). This shows that the average crop net income has doubled since 1998 (Fig. 9).

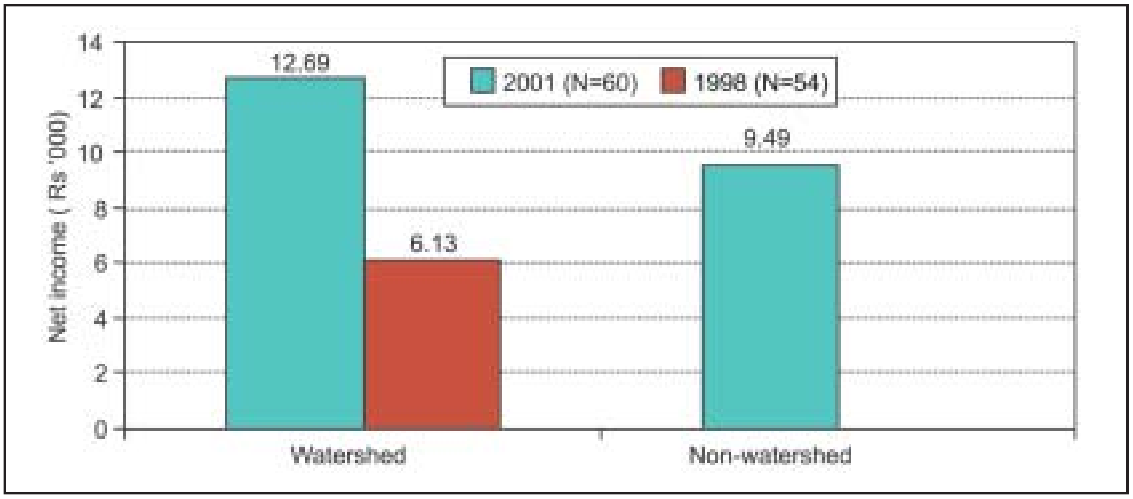

Figure 9. Average household net income from crop production (2001 prices) in Adarsha watershed and surrounding villages. (Note: Total variable cost includes family labor.)

The average income (including livestock and non-farm sources) for households in the watershed before accounting for own labor and land costs was Rs 37,240 in 2001. This compares with Rs 29,140 for households in the six adjacent non-watershed villages just outside the watershed (Fig. 10). Although more analysis needs to be done to confirm these findings and establish the links statistically, this shows a significant impact of watershed intervention activities (initiated in 1999) towards poverty reduction in Adarsha watershed. The technological change brought through availability of improved varieties, soil fertility and pest management practices, and the increased availability of water has made substantial impacts on the livelihoods of the people in the village. Supplementary irrigation and new employment opportunities have also contributed to diversification of income and reduced vulnerability to drought and other stresses.

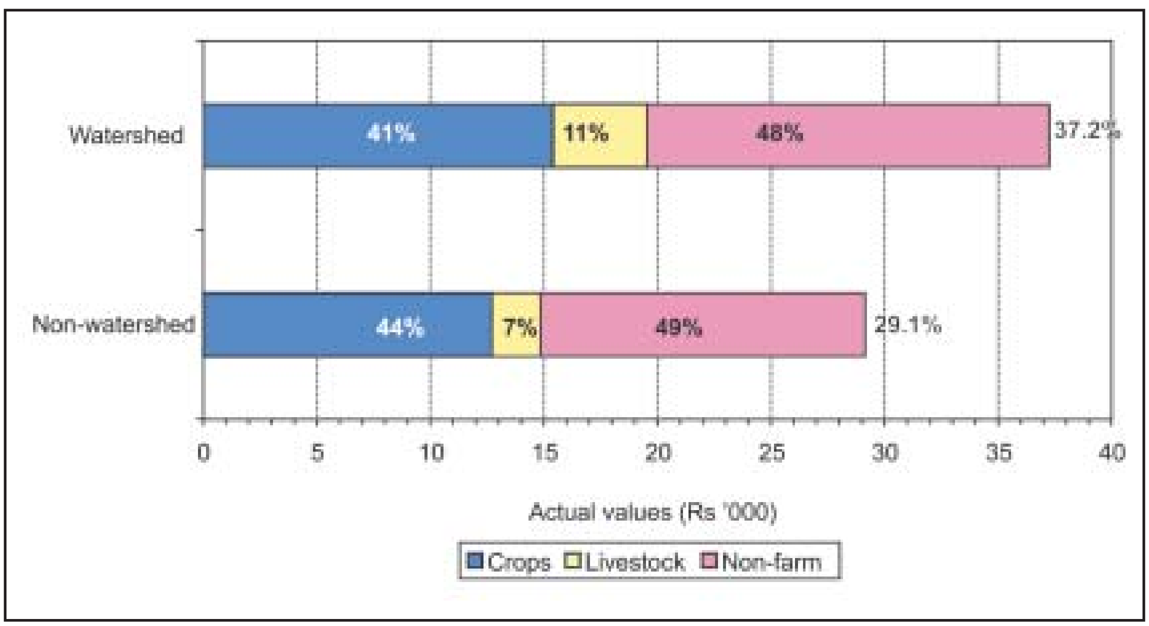

Figure 10. Average household income from various sources at Adarsha watershed and adjoining non-watershed villages, 2001.

Identifying Drivers of Higher Impact

ICRISAT and consortium partners have been trying to understand the factors that contributed to the transformation of people's lives in Adarsha watershed. Along with the continuing dialogue and consultation, several field visits were made to the watershed to listen and learn from the local beneficiaries and community members themselves, to identify the potential drivers of success and also to understand the shortcomings that may affect the sustainability of the benefits. These findings and lessons will be useful not only for Adarsha watershed but also to other dryland watershed communities now grappling with improving livelihoods of the people and protecting the productive resource base.

We used field observations and participatory rural appraisal (PRA) methods informed through focus group discussions, interviews with key informants and consultations with stakeholders (consortium partners) to gain the necessary insights into the factor that contributed to higher impacts in this watershed. The results indicate that the interplay of multiple factors has contributed to efficient utilization of development funds and better management of the resource base, which has already improved agricultural productivity and household incomes substantially.

Why is Adarsha watershed a bright spot?

Acute water stress and high community demand for watershed management

Kothapally receives around 780 mm annual rainfall; the rainy days are mainly between July and August. Before the project started the village had negligible area under irrigation and more than 80% of the cultivated land was totally rainfed. There was not a single water harvesting structure in the village. The crop yields from rainfed fields were low. Farmers were in dire need of increasing water availability and crop yields, and their incomes.

Adarsha watershed was selected by ICRISAT, DWMA and MV Foundation (MVF) in consultation with other stakeholders. The main criteria used in the selection were: existence of a large proportion of cropland under rainfed farming, low crop yields, non-existence of water harvesting structures and the potential for minimum interventions to conserve soil and water. Adarsha watershed was finally selected after a meeting with villagers in *Gram Sabha*, where villagers expressed interest to participate in the proposed watershed activities.

Pre-disposition to work collectively for community development

The villagers have a pro-active attitude towards the watershed program and are willing to cooperate with the consortium partners to gain mutual benefit. They have volunteered to abide by the collectively agreed terms (rules and norms) and work as equal partners for accomplishing the goal of the experiment. The farmers are pro-active but affected repeatedly by adverse seasonal vagaries. Their enthusiasm was triggered and reinforced by frequent droughts and declining productivity of the land. This was expressed during the initial dialogue with the consortium partners and contributed to the selection of the watershed for the participatory experimental trials in dryland agriculture.

Good local leadership

The local Sarpanch (Chief of Panchayat Raj Institution) has been actively involved in the watershed program as an office bearer of watershed association. His good offices enabled initial community mobilization. There are also young 'semi-educated' youth and women groups who are positively disposed towards learning new techniques such as HNPV production and vermicomposting and are willing to train others in the village. The youth groups in the village were receptive to new ideas and came forward to join hands with the consortium partners to try out new methods and innovations.

The novel approach

The watershed development program provided tangible economic benefits to individuals through an integrated approach. It focused on natural resource management, improved cultivars and IPM on soil and moisture conservation, water harvesting and afforestation. The benefits from contour bunding, check-dams, percolation tanks, gabion structures and gully plugs are communal and their impact is not immediately visible to the farmers. In integrated watershed development, there is comprehensive scope for natural resources management and multi-disciplinary approach. The interest of the individual farmers and the community is the driving principle for design and development of technologies. In this approach, in situ water conservation, field bunds, soil management, land preparation and vegetative bunds are some of the interventions initiated. The benefits of conserving soil moisture, augmenting soil fertility through soil management, etc show immediate visible gains to farmers in the form of higher yields and reduced input costs (Wani et al. 2002). Integrated watershed management requires a holistic enhancement of biophysical and human resources in the village rather than a mere soil and water conservation program (Wani et al. 2003).

Natural resource management in isolation from livelihood and production activities does not bring optimized benefits, but when coupled with human resource development, improved varieties and water management brings in the desired gains on a more sustainable basis. Hence, a holistic integrated watershed management program was initiated to reduce resource degradation and improve the livelihoods of the poor. In Adarsha watershed the starting point has been to recognize the needs of individual farmers. During an interview with the farmers in Kothapally, farmers attributed the higher impact of the program to the tangible benefits realized by individual farmers. The basic lacunae in the participation of small farmers were addressed through the approach of emphasizing on-farm interventions that improved crop yields and incomes for the individual farmers. The sense of community ownership, individual achievement in tackling the long standing problems of drought and resource degradation and the private economic benefits ensured enhanced individual participation.

In the preparation of the micro-plan, emphasis was given to individual benefits. The problem of general reluctance of the community to engage in watershed management when benefits are delayed and intangible was addressed by providing integrated soil and water management technologies that provide immediate benefit to farmers. This has stimulated their interest and built the foundation for collective action and sustainable community resource management. For example, the BBF system of land preparation conserved soil and retained soil moisture in situ thereby benefiting the farmers, while draining out excess water during heavy rains which was again harnessed in community-based check-dams. Both the individual short-term and long-term community benefits were evenly balanced in the integrated watershed management program.

Equal partnership, trust and shared vision among the consortium partners

The consortium partners have several rounds of free and frank discussions before undertaking any activity. There is a visible mutual trust and a shared vision among partners. Easy access and timely advice to farmers are important drivers for the observed impressive impacts in this watershed. This has led to enhanced awareness of the farmers and facilitated their ability to consult with the right people when they faced problems. This came out clearly from a farmer in an interview; he said he would now reach out to ICRISAT and other partners in case of a problem. The farmers could enhance their ability to take risk owing to the continued trust and timely technical backstopping by ICRISAT and other consortium partners. The farmers were motivated to conduct trials in their own fields based on knowledge and experiences gained from other watersheds in India and other countries.

The attitude of all the consortium partners to provide genuine support to the rural poor is an important factor in the progress of the watershed intervention. Team building within the consortium partners enhanced the team spirit. Farmers were approached with sufficient preparedness. The attitudinal change by researchers to join hands with farmers, the Government agencies, the implementing agency, the NGO and other partners is a step forward in this direction.

The general tendency of a researcher towards transfer of technology from lab to land was re-engineered to working with stakeholders to develop technologies through close partnership with farmers. The methodology adopted in this watershed included learning from the experience, validating expected gains through research and then bringing the benefits back to the farmers. The gap between the researchers and the farmer with indigenous knowledge and experience was reduced to exploit mutual knowledge and synergies for tackling the commonly perceived problem.

Transparency and social vigilance in the financial dealings

Another important factor for the progress of the watershed is the participation and cooperation of both primary stakeholders (farmers) and secondary stakeholders (other partners) to work towards achieving food security in the watershed. The secondary stakeholders have enabled a transparent and vibrant environment wherein the fund utilization is open to community scrutiny and audit. This is to ensure that financial dealings are fair and within the awareness of all concerned. This prevents corruption or underhand dealings within the management committee.

From the beginning of the watershed program the community members were openly invited and participated in the processes of implementation including the preparation of micro-plan, prioritization of works and preparation of budget. Therefore, the need for an external agency to monitor and have vigilance over the program implementation declined with time. This was seen in one of the instances where the chairman of the Watershed Committee tried to embezzle small funds but was immediately tracked and discharged of his responsibilities by the vigilant community. Under strong pressure from the community the ex-chairman was forced to resign. This shows high level of awareness and social vigilance prevalent in the village.

High confidence of the farmers

Farmers who successfully conducted the trials with the technical support from the consortium partners shared their experiences and motivated other farmers. The results from farmers' fields have shown that traditional crops through improved practices can bring substantial incremental income. Under improved management some of the cash crops such as cotton were proved to be less attractive when compared to the traditional crops in terms of risk reduction and input costs. These successful trials have built up the confidence of other dryland farmers. They now consider dryland agriculture as a sustainable livelihood option in the semi-arid tropics. In fact, the farmers participated in these experiments and assimilated the best practices into their own system and have begun sharing this knowledge with farmers of other villages.

Low-cost structures and equitable sharing of benefits

Adoption of low-cost water storage and harvesting structures ensured that more check-dams were built. This has helped to distribute water conservation benefits more equitably for farmers in different parts of the watershed landscape. The cost implication of each water harvesting structure is well understood by farmers. During the initial phase of implementation, the farmers have undertaken a detailed transect study and identified sites for various structures. But owing to the budgetary constraints they have prioritized for optimizing the benefits and maximizing the number of beneficiaries. Those farmers who could afford were asked to contribute higher than the prevalent norm and their lands were also treated.

Knowledge-based entry point activity

In Adarsha watershed there is no conventional entry point activity. Mutual trust was developed through knowledge-based entry points. Soil testing of samples from farmers' fields have brought the farmers close to the service providers. As stated above, priority was also given to interventions that provide immediate resource conservation and livelihood (economic) benefits to the individual farmers. The farmers could understand the intention of the consortium partners to work with them and cooperated as equal partners in the whole program.

Capacity building

As mentioned above, integrated watershed development requires multiple interventions that jointly enhance the resource base and livelihoods of the rural poor. This required capacity building at the local level across diverse areas of livelihood strategies. Landless households and women groups were trained in the production of biopesticides and biofertilizers with high demand within the local economy. These kinds of linked livelihood activities benefit the poor and provide necessary inputs for the watershed program thereby creating forward and backward linkages. Thus even the poor and landless SHGs have developed a stake in the watershed program.

This has contributed to equitable sharing of benefits from integrated watershed development. Farmers were also trained in the use of tropicultors for land preparation, in the construction of low-cost soil and water conservation methods and in the use of micronutrients for soil fertility management. The enhanced accessibility of new technologies and the sharing of knowledge had significant effects in the development of the local capacity for resource management.

Sustainability of the watershed project

With regard to post-project sustainability the farmers have started developing strategies. The user groups (UGs) which were formed for each water storage structure and gained benefits through these structures will form interest groups and will take up desiltation and maintenance in the future. They may transform into common interest groups or SHGs in place of UGs. They also look towards using the watershed development fund (WDF) as the revolving fund so that the fund is not depleted at any time. The women SHGs who have started local enterprises in the production of vermicompost, preparation of HNPV, etc will continue to expand and diversify these activities.

The remarkable progress made in the implementation of a new science-based farmer participatory consortium model led by ICRISAT is making Adarsha watershed a promising model in watershed management. The example of Adarsha watershed is reaching different states in India as well as other countries like Vietnam and Thailand in Asia. International donors are now asking to replicate and scale-up this model in new areas. An effort is already underway to scale-up this approach in selected watersheds of Kurnool, Nalgonda and Mahbubnagar districts of Andhra Pradesh with the support of the Department for International Department (DFID), UK and through the Andhra Pradesh Rural Livelihoods Programme (APRLP). Similarly, the Sir Dorabji Tata Trust, Mumbai and the Asian Development Bank (ADB) have provided funds to replicate this approach in selected watersheds in India (Madhya Pradesh and Gujarat), Thailand and Vietnam.

Summary

Drought-prone areas are categorized by land degradation, low and erratic rainfall, low rainwater use efficiency, high soil erosion, inherently less fertile soils and subsistence agriculture. The farmers in these areas are very poor and their ability to take risk and invest in necessary inputs for optimizing production is low. There is a general tendency to exploit groundwater for food crops by the few resourceful farmers. Dryland areas are repeatedly prone to drought because of their geographical location. Also these areas are prone to waterlogging situations during the cropping season due to torrential downpours interspersed with long dry spells.

Watershed programs implemented in India for improving the productivity in drought-prone areas have mainly focused on natural resource conservation and interventions such as soil and water conservation and to some extent afforestation in the government forestlands. Sufficient emphasis and efforts were not targeted to build the capacity of the community for enhanced management of the resource base while improving the livelihoods of the poor. Similarly issues like gender equity and benefits for the landless have not been addressed adequately thereby resulting in a mere water storage structure-driven investment giving only wage labor benefits to some deprived sections of the society.

The watershed projects should move from purely soil and moisture conservation and water harvesting interventions to a wholesome community-based integrated watershed management approach which creates a voice and stake for the landless, and poor women and men. Also, it is necessary to involve the primary stakeholders right from the beginning and build up their capacities to take the program towards a sustainable initiative. The project design and proposed intervention should also aim at building local capacity for sustainable management of the resource base especially in the post-project phase.

A new science-based farmer participatory consortium model for efficient management of natural resources emerged from the lessons learned from long-term watershed management research by ICRISAT along with the national partners like CRIDA, NRSA and DWMA. This new approach was implemented in Adarsha watershed, Kothapally. The important components of the new model, which are distinctly different from earlier models are: a consortium of institutions which provides technical backstopping and essential advisory services for community watershed development facilitated through experienced NGOs; greater role for farmers and local communities in project design, implementation, monitoring and evaluation; no subsidy (users pay principal for interventions on private lands; low-cost soil and water conservation structures; in situ conservation measures on farmers' fields to ensure tangible economic benefits to individuals; interventions that enhance the productivity of traditional crops and provide livelihood benefits to the poor and landless farmers;

emphasis on capacity building of the stakeholders to become trainers and continuous monitoring and refinement jointly by farmers and other partners.

For conservation of soil and water, the following community-based interventions were implemented using watershed development funds: water storage structures, gully control structures, mini percolation pits and gabion structures. Similarly, farmer-based soil and water conservation measures like BBF, and contour planting to conserve in situ soil and water; use of tropicultor for planting, fertilizer application and weeding operation; and field bunding and planting of *Gliricidia* on field bunds for strengthening, conserving rainwater and supply of N-rich organic matter were implemented in individual farmers' fields.

To enable good crop growth from conserved soil and water, INM practices such as use of inorganic and organic nutrients, application of deficient micronutrients like S and B and balanced application of all the essential nutrients were advocated. For effective control of pests and diseases, the consortium initiated training on production, storage and usage of HNPV. The village common lands and wastelands were planted with custard apple saplings, *Gliricidia* saplings and avenue plantations as a part of the village afforestation program. The women SHGs were motivated to take up vermicomposting as a micro-enterprise to provide biofertilizers on local demand and generate income.

The implementation of soil and water conservation interventions resulted in about 30–45% reduction in runoff and rise in the groundwater level. Due to additional groundwater recharge, a total of about 200 ha in post-*kharif* season and about 100 ha in post-*rabi* season are cultivated with different crops and cropping sequences. Adoption of improved practices like high-yielding cultivars, and integrated nutrient and pest management practices by farmers in the Adarsha watershed resulted in increased productivity and profitability of crops and cropping sequences. For instance the productivity of maize increased 2 to 2.5 times under sole maize and four-fold under maize/pigeonpea intercropping system. Maize/pigeonpea intercropping system and maize-chickpea sequential system were identified as the most profitable ones. The area under maize, pigeonpea and maize-chickpea has increased more than three-fold and two-fold, respectively.

Assessment of the economic benefits that have accrued due to the implementation of the watershed approach have revealed that the average net returns per hectare for dryland and irrigated cereals and pulses are higher within the watershed as compared to that of adjacent villages outside the watershed. Similarly for pulse crops, per hectare net returns within the watershed are about twice as large as that outside the watershed. Implementation of holistic integrated watershed management has also resulted in increases in average household net income (Rs 15,400 within watershed as compared to Rs 12,700 outside watershed area). Compared to the 1998 levels, the evidence shows that farmer incomes in 2001 from crop production have doubled.

Several factors have contributed to the impressive progress made in Adarsha watershed. We can conclude that the vital drivers of higher impact were:

- Acute water stress and high community demand for watershed management
- Pre-disposition to work collectively for community development
- Good local leadership
- The novel approach to watershed management
- Equal partnership, trust and shared vision among the consortium partners
- Transparency and social vigilance in the financial dealings
- High confidence of the farmers

- Low-cost structures and equitable sharing of benefits
- Knowledge-based entry point activities
- Capacity building and skill development

This case study has shown that with appropriate interventions and pro-active participation of the beneficiary communities, watershed management can substantially improve the livelihoods of the poor in dryland areas while also enhancing the sustainability of resource use. Water conservation and access to improved germplasm has increased the profitability of otherwise unattractive conservation practices. Without access to improved varieties and markets, the conservation structures are unlikely to be attractive to individual farmers. The consortium approach to integrated watershed management has shown how the potential of marginal lands in predominantly rainfed systems can be enhanced. We hope that these results and lessons from Adarsha watershed will help enhance the effectiveness of other watershed development programs being undertaken by the Government of India and in other countries.

References

Dwivedi RS, Ramana KV, Wani SP and Pathak P. 2003. Use of satellite data for watershed management and impact assessment. Pages 149–157 *in* Integrated watershed management for land and water conservation and sustainable agricultural production in Asia: proceedings of the ADB-ICRISAT-IWMI Project Review and Planning Meeting, 10–14 December 2001, Hanoi, Vietnam (Wani SP, Maglinao AR, Ramakrishna A and Rego, TJ, eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

ICRISAT. 2002. Improving management of natural resources for sustainable rainfed agriculture. TA RETA 5812 Completion Report submitted to Asian Development Bank, Philippines, September 2002. Patancheru 502 324, Andhra Pradesh, India: ICRISAT. 94 pp. (Limited distribution.)

Pathak P, Wani SP, Singh P, Sudi R and Srinivas Rao Ch. 2002. Hydrological characterization of benchmark agricultural watersheds in India, Thailand, and Vietnam. Global Theme 3: Water, Soil and Agrobiodiversity Management for Ecosystem Health. Report no. 2. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 52 pp.

Shiferaw B, Anupama GV, Nageswara Rao GD and Wani SP. 2002. Socioeconomic characterization and analysis of resource-use patterns in community watersheds in semi-arid India. Working Paper Series no. 12. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 44 pp.

Wani SP, Pathak P, Tan HM, Ramakrishna A, Singh P and Sreedevi TK. 2002. Integrated watershed management for minimizing land degradation and sustaining productivity in Asia. Pages 207–230 *in* Integrated land management in dry areas: Proceedings of a Joint UNU-CAS International Workshop, 8–13 September 2001, Beijing, China (Zafar Adeel, ed.). Tokyo, Japan: United Nations University.

Wani SP, Singh HP, Sreedevi TK, Pathak P, Rego TJ, Shiferaw B and Shailaja Rama Iyer. 2003. Farmer-participatory integrated watershed management: Adarsha watershed, Kothapally, India, An innovative and upscalable approach. *A case study.* Pages 123–147 *in* Research towards integrated natural resources management: Examples of research problems, approaches and partnerships in action in the CGIAR (Harwood, RR and Kassam AH, eds.). Washington, DC, USA: Interim Science Council, Consultative Group on International Agricultural Research; and Rome, Italy: Food and Agriculture Organization of the United Nations.

Wani SP, Sreedevi TK Pathak P, Singh P and Singh HP. 2001. Integrated watershed management through a consortium approach for sustaining productivity of rainfed areas: Adarsha watershed, Kothapally, India, Andhra Pradesh – A case study. Presented at the Brainstorming Workshop on Policy and Institutional Options for Sustainable Management of Watersheds, 1–2 November 2001, ICRISAT, Patancheru, India.

About ICRISAT

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a non-profit, non-political, international organization for science-based agricultural development. ICRISAT conducts research on sorghum, pearl millet, chickpea, pigeonpea and groundnut – crops that support the livelihoods of the poorest of the poor in the semi-arid tropics encompassing 48 countries. ICRISAT also shares information and knowledge through capacity building, publications and ICTs. Established in 1972, it is one of 15 Centers supported by the Consultative Group on International Agricultural Research (CGIAR).

Contact information:

ICRISAT-Patancheru
(Headquarters)
Patancheru 502 324
Andhra Pradesh, India
Tel +91 40 23296161
Fax +91 40 23241239
icrisat@cgiar.org

ICRISAT-Nairobi
(Regional hub ESA)
PO Box 39063, Nairobi, Kenya
Tel +254 20 524555
Fax +254 20 524001
icrisat-nairobi@cgiar.org

ICRISAT-Niamey
(Regional hub WCA)
BP 12404
Niamey, Niger (Via Paris)
Tel +227 722529, 722725
Fax +227 734329
icrisatsc@cgiar.org

ICRISAT-Bamako
BP 320
Bamako, Mali
Tel +223 2223375
Fax +223 2228683
icrisat-w-mali@cgiar.org

ICRISAT-Bulawayo
Matopos Research Station
PO Box 776,
Bulawayo, Zimbabwe
Tel +263 83 8311-15
Fax +263 83 8253/8307
icrisatzw@cgiar.org

ICRISAT-Lilongwe
Chitedze Agricultural Research Station
PO Box 1096
Lilongwe, Malawi
Tel +265-1-707297/071/067/057
Fax +265-1-707298
icrisat-malawi@cgiar.org

ICRISAT-Maputo
c/o INIA, Av. das FPLM No 2698
Caixa Postal 1906
Maputo, Mozambique
Tel +258-1-461657
Fax +258-1-461581
icrisatmoz@panintra.com

Visit us at **www.icrisat.org**

434–2004