Innovative Farmer Participatory Integrated Watershed Management Model: Adarsha Watershed, Kothapally, India

A Success Story!

International Crops Research Institute for the Semi-Arid Tropics
Asian Development Bank
Central Research Institute for Dryland Agriculture
Drought Prone Area Programme

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The Problem

Land degradation is becoming a serious threat across the world requiring urgent attention. With increasing pressure of the growing human and cattle population, deforestation, soil erosion, and indiscriminate use of chemical fertilizers, pesticides, and water, a severe threat has been caused to the ecosystem. About 51% of India's geographical area (329 million ha) may be defined as degraded. There has been a rising demand for water as there is acute scarcity. This has resulted in over-extraction of groundwater, with little concern for commensurate improvements in harvesting and use of the increasingly precious water resources available. The impact of nature on agriculture can be felt in rainfed areas as rainfall is variable and it occurs in torrential downpours. In the semi-arid tropics (SAT) of India, rainfall occurs in torrential downpours and most of it is lost as runoff causing severe soil erosion. Rainfall exceeds evaporation only for about 5 months in a year (Jun to Oct) at Patancheru, India. Rainfall use efficiency is low (30–45%) for crop production. Such erratic rainfall results in spells of excess moisture and drought during the crop-growing period.

Efficient and sustainable use of natural resources has become *sine qua non* for economic development, especially in resource-poor countries, and more so in agriculturally dominated economies like India, where two-third of the cropped area is dependent on rainfall without any protective irrigation facilities. The promotion of appropriate technologies and development strategies in rainfed regions could potentially result in multiple benefits such as ensuring food security, enhancing the viability of farming, and improving the ecological balance. Integrated watershed management proved to be an appropriate technology to have all the above said benefits.

Solution to the Problem – Integrated Watershed Management

Integrated watershed management is the process of formulating and implementing a course of action involving natural and human resources in a watershed, considering the social, political, economic, and institutional factors operating within the watershed and its surroundings to achieve certain socioeconomic and ecological objectives. The processes would include:

- Establishing watershed management objectives.
- Formulating and evaluating alternative resource management actions involving various tools and institutional arrangements.
- Choosing and implementing a preferred course of action.
- Evaluating performance through monitoring activities and outcomes in terms of achievement of the specific objectives.

Objectives of Integrated Watershed Management

- To improve rainfed agricultural production through watershed development.
- To reduce poverty of farmers through increased systems' productivity through sustainable use of natural resouces.

ICRISAT's New Integrated Watershed Management Model

A new model for efficient management of natural resources in the SAT has emerged from the lessons learnt from long-term watershed-based research conducted by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and national partners. The important components of the new integrated watershed management model, which are distinctly different from the earlier models, are:

- Farmer participatory approach through cooperation model and not through contractual model: Stakeholders are involved in all the watershed activities from inception.
- Use of new science tools for management and monitoring of watersheds: New science tools such as remote sensing, geographical information system (GIS), digital terrain modeling, and crop simulation modeling are utilized for implementing and executing the watershed activities.
- Knowledge flow: Facilitating the "knowledge flow" of the impressive successes of on-station watersheds at ICRISAT to on-farm watersheds; the on-station watersheds are linked to on-farm watersheds.
- Holistic approach: A holistic system approach to improve livelihoods of people and not merely conservation of soil and water.
- Consortium approach: A consortium of institutions for technical backstopping of the on-farm watersheds. Expertise from different international, national, government and non-governmental organizations (NGOs) is utilized to advise/guide the farmers on the system/approach under operation.
- Islanding approach: A micro-watershed within the watershed where farmers conduct strategic research with technical guidance from the scientists and minimize free supply of inputs for undertaking evaluation of technologies.

- Cost-effective approach: Low-cost soil and water conservation measures are undertaken.
- Traditional knowledge: Amalgamation of traditional knowledge and new knowledge is effected for efficient management of natural resources.
- Soil and water conservation: Emphasis is laid on individual farmer-based conservation measures for increasing productivity of individual farms along with community-based soil and water conservation measures.
- Continuous monitoring and evaluation by the stakeholders: Monitoring is done by the researchers and stakeholders together to know the overall performance of watershed management.
- Empowerment of community: Empowerment of community individuals and strengthening of village institutions are essential for managing natural watersheds.
- Environment protection: The ultimate goal of any program is to protect the environment by conserving the natural resources along with improvement of rural livelihoods.

ICRISAT has its on-station watersheds in operation from 1976 and based on the impressive successes of ICRISAT's on-station watersheds, execution of technologies between ICRISAT and farmers' fields started to take place to enhance the productivity for rainfed systems and also to help the rural poor of the SAT by increased productivities. The whole process is based on "demonstration" of the technology package and possible benefits from the package under farmers' conditions.

On-farm benchmark watersheds in India, Thailand, and Vietnam were in operation with technical backstopping by ICRISAT since 1999. All five on-farm and three on-station watersheds covering varying agroecological, socioeconomic, and technological situations are selected and work is under progress in India, Thailand, and Vietnam. As a case study the on-farm watershed, i.e., Adarsha Watershed at Kothapally, Ranga Reddy district in Andhra Pradesh, India is described.

Adarsha Watershed, Kothapally

Consortium partners

Earlier all the watersheds were managed by government institutes or NGOs, which are the project implementing agencies. Recently, an innovative model with a consortium of institutions for technical backstopping was initiated. The consortium of the Adarsha Watershed included the following institutes/community based in Andhra Pradesh:

- International organizations: ICRISAT
- NGO: M Venkatarangaiya Foundation (MVF)
- Central government institutes: Central Research Institute for Dryland Agriculture (CRIDA) and National Remote Sensing Agency (NRSA)
- State government department: Drought Prone Area Programme (DPAP)
- Farmers

Process of selection

The selection of Adarsha Watershed was done by ICRISAT, DPAP, and MVF along with the involvement of the stakeholders. The process of selection is:

- ICRISAT, DPAP, and MVF together surveyed three watersheds in Andhra Pradesh and selected Adarsha Watershed at Kothapally.
- The total irrigable area was very less. There was more dryland and not a single water harvesting structure for human and animal use was seen at the time of survey in 1998, i.e., at the start of this project. A large area is under rainfed farming in this village. As there were no

interventions made to conserve soil and water in this watershed, it was selected to encompass the convergence.

- Adarsha Watershed was selected after a committee meeting with villagers in a *gram sabha* where villagers came forward to participate in the proposed watershed activities.

Participating groups

Different committees and groups were formed in the village and leaders were selected by the villagers themselves. The leaders were involved from the initiation of any watershed activity such as selection of the site, implementation of the activity, and execution and assessment of all the developmental activities within the watershed. The various committees formed in the watershed are:

- Watershed Committee: This committee consists of a president, secretary, and 270 farmers of the village as members.

- Watershed Association: The working committee consists of a chairman, a secretary, 8 committee members, and 270 farmers in the village as members.
- Women Self-help Groups – Vermicomposting: Ten groups have been formed with 15 members each who took up vermicomposting as an enterprise in the village.
- User Groups: User groups have been formed for water harvesting structures.
- Self-help Groups: Self-help groups have been formed to undertake watershed development activities.

Baseline survey for monitoring and evaluation of the watershed

After the selection process, necessary information on the environment and conditions of the village was collected. Baseline data collection was done by both the researchers and the stakeholders. The following information was collected.

- Socioeconomic status of the farmers and landless people, crop productivities inputs, and livelihood opportunities.
- Soil, water, and nutrient management practices followed by the farmers.
- Soil, climate, cropping systems, and input use. The data was assembled and analyzed.
- Production constraints, yield gaps, and opportunities for crop intensification. GIS maps were prepared for different crops, soils, and cropping systems of the village.

The results of the survey indicated that in Kothapally village dryland area was more than irrigated land; literacy rate was low; and labor was scarce. There was inverse relationship between land size and fertilizer/pesticide use. Crop yields were very low and there was not a single water harvesting structure in the village. No income generating activities were taken up by the villagers.

Soil and water conservation measures

After having an insight into the situations of the village through the baseline survey, a reconnaissance survey was conducted and sites for water harvesting structures were identified. These sites were technically evaluated before actually starting the watershed activities. Technical backstopping was given by ICRISAT for construction of cost efficient water storage structures and soil conservation structures.

Community-based activities

Community-based activities completed as on 30 Jun 2002 are:

- Checkdams: 21 proposed and 11 completed including one earthen checkdam.
- Gully control structures: 270 proposed and 95 completed.
- Sunken pits: Five pits in the gullies were completed to increase recharging of groundwater.
- Gabion structures: 10 proposed and 1 completed.




- Wasteland development: Custard apple plantations were undertaken involving communities.
- Avenue plantation: Avenue tree plantations with tree-guards and teak plantation on field bunds were undertaken by the villagers.

Farmer-based activities

- Broad-bed and furrow (BBF) landforms to conserve soil and water.
- Contour planting.
- Use of tropicultor for planting, fertilizer application, and intercultivation operations.
- Field bunding: 40 ha proposed and 40 ha completed.
- Planting *Gliricidia* on field bunds to conserve rainwater and also to supply nitrogen (N) rich organic matter for in situ application to the crops to augment N.

Integrated nutrient management

To harness the benefits from conserved soil and water, crops must be provided with appropriate nutrients so as to facilitate good crop growth using the congenial natural resources. The integrated nutrient management approach, which is environment-friendly, has been adopted in this project through on-farm evaluations in farmers' fields by farmers themselves:

- Detailed soil characterization have shown that farmers' fields have less than optimum micronutrients; so boron (B) and sulfur (S) amendments were done. Fields with B and S amendments showed increased yields than control.
- Nutrient budgeting studies were taken up in farmers' fields to study the nutrient budgets with improved and conventional practices. More negative N balances were

seen in cropping systems planted on BBF than on flat landforms. This shows that BBF system is able to extract more N from soil than flat landforms.

- Quantification of biological nitrogen fixation was done by both ^{15}N isotope dilution method and also by N difference method.

In situ generation of organic matter

Gliricidia plantation was taken up by the villagers on their field bunds to conserve soil and moisture. The plants can be used as green manure. *Gliricidia* loppings are applied in the fields; these release nutrients, e.g., N and potassium (K) in 5–10 days of decomposition.

Vermicomposting units

Vermicomposting proved to be a successful enterprise in the village. Training was imparted to 10 self-help groups of women. The raw material required for the process is *Parthenium,* which is an obnoxious weed, earthworms, agricultural wastes, rock phosphate, and cowdung slurry. These organic wastes are converted into compost and can be marketed in the nearby cities.

Integrated pest management

Integrated pest management (IPM) is adopted to harness the benefits from crops which are grown with integrated management options, and to avoid damage by pests. IPM is cost effective and also environment-friendly. The aim of IPM is the coordinate use of environmental information to design and implement pest control measures that are economically, environmentally, and socially sound.

IPM activities implemented by the project

- Crop surveys were carried out to know the plant protection practices adopted within the village.
- *Helicoverpa,* a major pest, was monitored through pheromone traps.
- Shaking of pigeonpea plants was done to control *Helicoverpa.*
- Pest tolerant crop varieties were used.

- Plant-based pesticides like neem cake were used.
- Biological control measures were practiced.
- Precise timing and application of any needed pesticide treatments was ensured.

Village-level HNPV production

The project quickly identified and initiated village-level production to cater to the needs of farmers. Many farmers and extension workers in Kothapally village were given training on *Helicoverpa* nuclear polyhedrosis virus (HNPV) production, storage, and usage on different crops. The villagers quickly adopted the technology. They produced 2000 larval equivalent (LE) of HNPV and used it on cotton, pigeonpea, and chickpea crops. Besides the village-level production, 11650 LE HNPV was supplied to the farmers through ICRISAT to cover cotton, pigeonpea, and chickpea crops. The project has given high priority to train village-level scouts in identifying various pests and their natural enemies in different crops before the cropping season, and assisted them in monitoring throughout the crop period. Farmers were trained on pest control techniques at ICRISAT to control pests on cotton, chickpea, and pigeonpea.

Improved cropping systems

Improved varieties and cropping systems were adopted in the watershed. Sorghum and maize crops are intercropped with legumes such as pigeonpea and chickpea. Inclusion of legumes into the cropping systems will increase the yield of the companion crop by fixing more N biologically and improve the fertility of the soil.

The Success

Monitoring

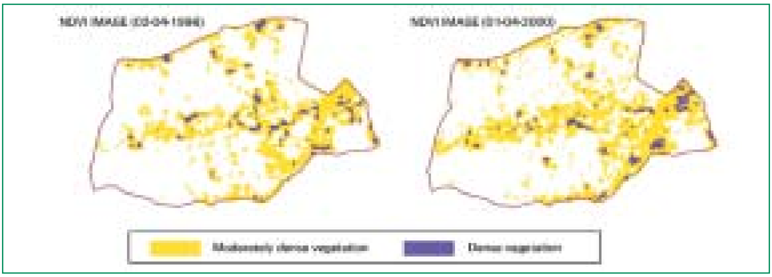
To know the impact of watershed management, continuous monitoring of the parameters described below was done:

- Changes in croping pattern and cropping systems in farmers' fields were monitored.
- An automatic weather station was installed to collect data on rainfall, maximum and minimum temperatures, and solar radiation.
- Sixty-four open wells in the watershed were geo-referenced and regular monitoring of water levels was done.
- Water quality was monitored in all the wells and also in the water storage structures in the village. Sediment samples (silt) were also collected from the tanks to understand the environmental processes in the watershed.
- Nutrient budgeting studies were also undertaken.
- Runoff and soil loss were monitored by using automatic water level recorders and sediment samplers.
- Satellite monitoring was done.
- Pest monitoring was also carried out.

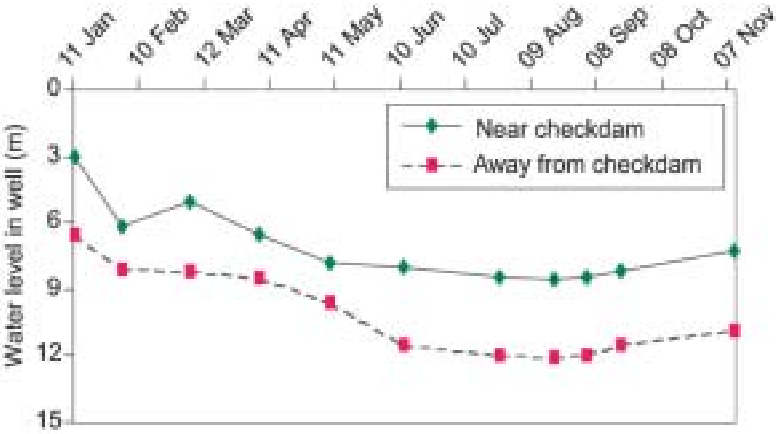
Impact

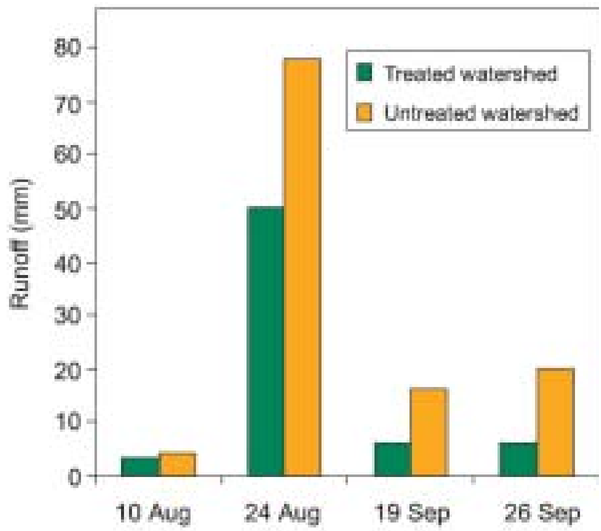
The management of natural resources has become effective and the livelihood of the rural people has improved. Crop productivities and farmers' incomes have improved. The impact is assessed based on the following:

- Improved greenery: An increase in vegetation cover was observed; in 1996 the vegetation cover was 129 ha and in 2000 it was 200 ha.



- Improved groundwater levels: Groundwater level in the village significantly increased.
- Reduced runoff and soil loss: Runoff was 12% of the rainfall in the undeveloped watershed while it was only 6% in the developed watershed where soil and water conservation measures were undertaken. Soil loss was considerably reduced to <1 t ha^{-1}. Also, sediment concentration in runoff water was reduced to <1.2 g L^{-1}.





- **Increased productivities:** The crop productivities significantly increased with improved cropping systems and improved management practices. The yield of maize crop recorded two- to three-fold increase (3.3 to 3.8 t ha^{-1}) when compared with baseline yields (1.5 t ha^{-1}).
- **Increased income:** Farmers' incomes as well as cropping system productivities increased. Maize/pigeonpea cropping system could give 3.5 times benefit (1:3.5) than the traditional cotton system (1:1.5).

Average crop yields with improved technologies in Adarsha Watershed, Kothapally, 1999–2001.

	Yield (kg ha^{-1})			
Crop	1998	1999	2000	2001
Sole maize	1500	3250	3750	3300
Intercropped maize	-	2700	2790	2800
(Traditional)		700	1600	1600
Intercropped pigeonpea	190	640	940	-
(Traditional)		200	180	-
Sole sorghum	1070	3050	3170	2600
Intercropped sorghum	-	1770	1940	2200

Farmers' income with improved crop production practices in Adarsha Watershed, Kothapally, 1999–2000.

Cropping systems	Total productivity (kg ha^{-1})	Cost of cultivation (Rs ha^{-1})	Total income (Rs ha^{-1})	Profit (Rs ha^{-1})	Benefit-cost ratio
Improved					
Maize/pigeonpea	3300	5900	20500	14600	2.47
Sorghum/pigeonpea	1570	6000	15100	9100	1.51
Traditional					
Cotton	900	13250	20000	6750	0.50
Sorghum/pigeonpea	900	4900	10700	5800	1.18
Mung bean	600	4700	9000	4300	0.91

Changes in cropping pattern

A close perusal at the prevalent cropping system, its area and previous history before watershed intervention by ICRISAT gives a precise picture of how watershed approach benefits the final stakeholders, i.e., farmers. Kothapally village was predominantly a cotton growing area before dissemination of watershed technology. The area under cotton in the village was 200 ha in 1998. Maize, chickpea, rice, pigeonpea, sorghum, and vegetable crops were also grown.

After three years of watershed activities in Kothapally, the area under cotton cultivation decreased from 200 ha to 100 ha (50% decline) with a simultaneous increase in maize and pigeonpea cropped area. The area under maize and pigeonpea increased three-fold from 60 ha to 180 ha within three years. The area of other crops remained almost the same. This substantial shift in the cropped area where maize and pigeonpea replaced cotton crop was mainly due to increased net profit per hectare. The cotton-based cropping system had higher cultivation costs (higher inputs) with lesser net profits compared to maize/pigeonpea, sorghum/pigeonpea or maize + chickpea system. Adoption of legume-cereal crop combination or rotation cropping increased the net profit with less cultivation costs in the watershed area.

Area (ha) under various crops in Adarsha Watershed, Kothapally.

	Before watershed	After 3 year of watershed activity		
Crop	(1998)	1999	2000	2001
Maize	60	80	150	180
Sorghum	30	40	55	65
Pigeonpea	50	60	120	180
Chickpea	45	50	60	75
Vegetables	40	45	60	60
Cotton	200	190	120	100
Rice	40	45	60	60

Human resource development

Farmers were empowered with various integrated participatory management options. Farmers themselves acted as trainers for training the next group of farmers. Women and youth groups were trained specifically for income-generating activities such as HNPV production, vermicomposting, and seed production and storage. Along with farmers, NGOs, agricultural officials, and other researchers were also trained on integrated watershed management options.

- About 700 farmers from all over India were trained on integrated watershed management at Kothapally and ICRISAT.

- Eighty agricultural officials were trained on various aspects of watershed management.
- Sixty government officials were also trained on integrated watershed management.
- Fourteen research scholars and several apprentices from different countries were trained on different aspects of watershed management.
- About 800 visitors visited the watersheds at Kothapally and ICRISAT.

Flow of technology from Adarsha Watershed to neighboring villages

Spill over of technology was clearly observed in farmers from nearby watersheds of Nawabpet and Adilabad districts as they adopted the improved practices that were successful in Adarsha Watershed. The farmers purchased a tropicultor for their field operations. They have undertaken BBF landforms in their fields. Farmers in the neighboring villages are keenly interested in various aspects of Adarsha Watershed such as improved cropping systems, improved varietes, vermicomposting, HNPV production units, *Gliricidia* plantations, and wasteland development in their watersheds.

Why Adarsha is a Model Watershed?

- Private contractors were not involved in the watershed activities.

- Community participation was ensured in all the watershed activities through facilitation. Tangible economic benefits to individuals through on-farm interventions facilitated their participation.
- Supply of inputs for technology evaluation was not free.
- Farmers conducted on-farm trials with technical support from ICRISAT and other collaborative research institutes.
- Farmers were empowered through training programs and workshops.
- Availability of inputs and necessary machinery was ensured.
- The NGO was only a social mobilizing agency and project implementation was by the watershed committee and association.
- Monetary disbursement was by watershed committees under the supervision of DPAP staff.
- Social auditing was done by villagers.
- A consortium approach was followed for technical backstopping from research institutes.
- There was a convergence of various activities in the watershed.
- Scientific tools were used for development and management of watershed.
- Farmers adopted improved cropping systems including legumes, weaning away from traditional crops such as rice and cotton.
- Farmers have been learning by themselves.
- Farmers have become trainers.

Conclusion

Adarsha Watershed as the name (*Adarsha* means model) implies has become a model watershed for other farmers from nearby villages to come, see, believe, and implement the activities of the watersheds. Along with the off-site impacts like spill over of the technology, the on-site impacts such as improved groundwater levels, improved crop productivities, and increased incomes are observed which improved the rural livelihoods. As farmers are the ultimate stewards of natural resources, farmers' participation is involved in the watershed activities from the inception of any event. This was one of the reasons for success of the watershed. Women and youth are given special emphasis by successfully implementing income-generating activities such as vermicomposting and village-level HNPV production. Continuous training and capacity building was given to make the community effectively manage the natural resources. This facilitated to sensitize the policy makers, NGOs, project managers, and project staff about the need of the environment-friendly, efficient natural resource management options through the holistic watershed management approach. Farmers became the spokespersons for this approach and as a result of which this watershed is unique and effective as a "Model Watershed".

Important Events

Visit of Mr Kamaluddin Ahmed, Member, Planning Commission, Government of India

Visit of Dr Ian Johnson, Chair, CGIAR

Visit of Director General, ICRISAT

Visit of Ms Pratima Dayal, Asian Development Bank

About ICRISAT

The semi-arid tropics (SAT) encompasses parts of 48 developing countries including most of India, parts of southeast Asia, a swathe across sub-Saharan Africa, much of southern and eastern Africa, and parts of Latin America. Many of these countries are among the poorest in the world. Approximately one-sixth of the world's population lives in the SAT, which is typified by unpredictable weather, limited and erratic rainfall, and nutrient-poor soils.

ICRISAT's mandate crops are sorghum, pearl millet, chickpea, pigeonpea, and groundnut – five crops vital to life for the ever-increasing populations of the SAT. ICRISAT's mission is to conduct research that can lead to enhanced sustainable production of these crops and to improved management of the limited natural resources of the SAT. ICRISAT communicates information on technologies as they are developed through workshops, networks, training, library services, and publishing.

ICRISAT was established in 1972. It is supported by the Consultative Group on International Agricultural Research (CGIAR), an informal association of approximately 50 public and private sector donors. It is co-sponsored by the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP), and the World Bank. ICRISAT is one of 16 nonprofit CGIAR-supported Future Harvest Centers.

Science with a Human Face

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