11 Farmer-centric Integrated Water Management for Improving Livelihoods – A Case Study of Rural Electrification Corporation Limited

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Abstract

Rural Electrification Corporation Limited (RECL) supported an ICRISAT-led consortium to establish two watershed learning sites in Penukonda mandal (4 villages, 3150 ha of cultivated land and home to 8700 people) of Anantapur district in Andhra Pradesh and Wanaparthy mandal (4 villages, 3968 ha of cultivated land and home to 11,726 people) in the Mahabubnagar district of Telangana. The community and farm-based rainwater conservation have created a net storage capacity of about 18,000 m^3 with total conservation of about 50,000 m^3/year of surface runoff water in Anantapur watershed, and 27,000 m^3 storage capacity with conservation of about 54,000 m^3/year of surface runoff water in Mahabubnagar watershed. Soil health improvement with soil test-based addition of macro- and micronutrients and carbon building, and varietal replacements are promoted with farmers in the watershed. The science-led management has resulted in increasing and sustaining crop and livestock productivity and diversification leading to increased incomes to farmers. The RECL–ICRISAT watershed sites have provided a proof of concept and a good learning site for holistic solutions to harness the system productivity and strengthening of livelihood.

11.1 Project Background

11.1.1 Why the project?

To achieve food security, minimize the water conflicts and reduce poverty, it has become essential to harness potential of rainfed systems, as globally 80% of agriculture is rainfed and current productivity on farmers' fields is lower by two- to fourfold than achievable potential. A long-term study since 1976 at the International Crops Research Institute for the Semi-Arid Tropics, Patancheru, India demonstrated a virtuous cycle of persistent yield increase with an average annual productivity of 5.1 t/ha through improved watershed management (land, water and crop management, etc.) in rainfed agriculture as compared with 1.1 t/ha

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(Wani *et al.*, 2003a, 2012). In India, the rainfed regions or drylands where water scarcity is a major limiting factor, currently cover majority (54%, 76 million ha) of cultivable land and are projected to still cover 45% (63 million ha) of area by 2050, and thus, need due focus on enhancing rainwater use efficiency (Amarasinghe *et al.*, 2007; Wani *et al.*, 2016). Rainfed regions are also hot spots of poverty and malnutrition with potential opportunities in unexploited two- to fourfold yield gaps (Wani *et al.*, 2009). Further, the projected climate change scenario has increased the chances of water uncertainty and land degradation leading to the vulnerability of food production in tropical countries like India. This necessitates the need for resilience building of production systems through sound water and land management practices. In this scenario, developing rainfed agriculture needs to be a priority for directly benefiting masses to make food and nutrition secure, and enhance economic empowerment.

In rainfed areas, management at watershed scale is one of the most trusted approaches to manage rainwater and other natural resources for increasing food production, improving livelihoods, protecting environment, addressing gender and equity issues along with biodiversity concerns (Wani *et al.*, 2014). Therefore, the Rural Electrification Corporation Limited (RECL), Hyderabad, India has supported the ICRISAT-led consortium to develop 'Model Watershed Sites of Learning' in Mahabubnagar district of Telangana and Anantapur district in Andhra Pradesh with the aim of sustainably increasing agricultural productivity and improving livelihoods of the rural poor in vulnerable rainfed areas. Major focus was on enhancing the water availability and its (green and blue water) use efficiency for intensification and diversification of the livelihood systems and capacity building of stakeholders.

11.1.2 Pilot site description and selection process

The selection of watershed location was the first major activity taken up with the coordination of the District Water Management Agency (DWMA), Department of Agriculture and the local non-governmental organizations (NGOs). The following criteria were considered in the selection of sites for the watershed project.

- Representative in terms of soil, landscape (slope and terrain), rainfall, crops and socioeconomic conditions.
- Farmers who were cooperative and willing to take an active part in the watershed programme.
- Good potential for increasing the agricultural productivity, income and conservation of natural resources.
- Strong need for the watershed programme.
- Major area under rainfed agriculture.
- Good accessibility even during the rainy season.

Considering the above key criteria, two potential sites for the watershed project were identified in Anantapur district in Andhra Pradesh and Mahabubnagar district in Telangana (Fig. 11.1). The ICRISAT team and Watershed Development Department officials visited the proposed sites. At each site, farmers' meetings were conducted, and interactions were held with the local institutions and community members. Based on these discussions and observations followed by a transect walk, the final selection of sites for the watershed project was done.

The RECL–ICRISAT watershed project implemented in Penukonda mandal of Anantapur district in Andhra Pradesh covers four villages, namely Kondampalle, Gonipeta, Settipalle and Cherlopalle with a total geographical area of 6810 ha, including 3150 ha of area under cultivation covering 1480 households with population of 8700. The important crops cultivated are groundnut, maize, paddy, finger millet and sunflower.

In Wanaparthy mandal in Mahabubnagar district of Telangana, the project was implemented in four villages, namely Rajapet, Kadukuntla, Peddagudem and Mentapalle with a total geographical area of 5400 ha, including 3970 ha of area under cultivation, covering 2285 households with population of 11,726.

The baseline analysis showed lower crop yields, and identified good potential for improvement in productivity and livelihoods. About 315 open wells and 600 bore wells were found in Penukonda watershed. Only 35 open wells were found seasonally functional and depth of bore well for water extraction ranged between 300 feet

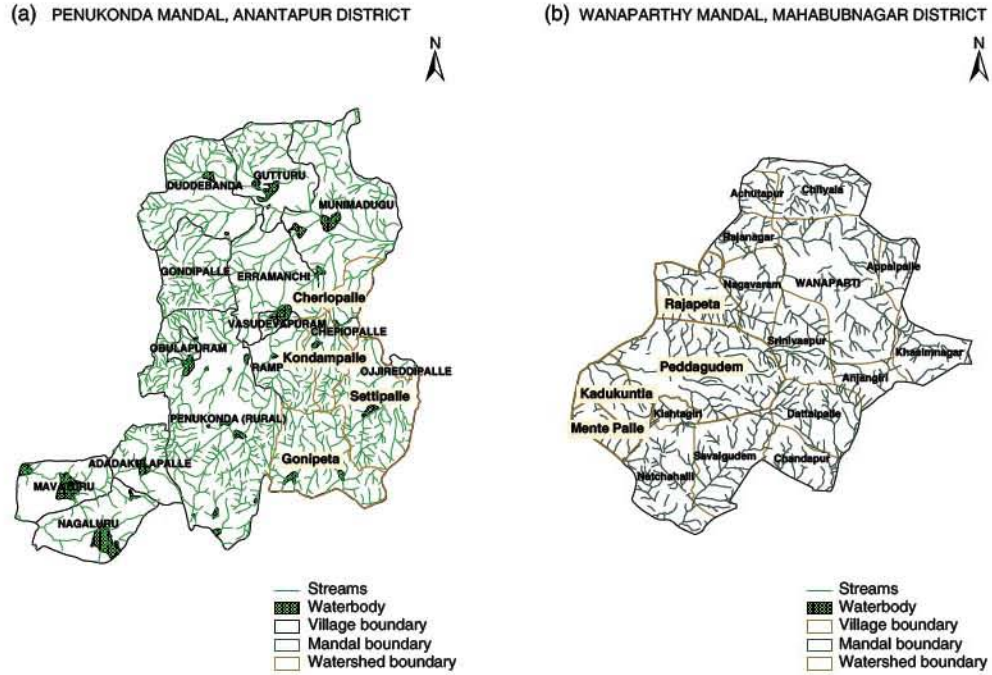

Fig. 11.1. Watershed map with drainage network: (a) Penukonda mandal, Anantapur district; (b) Wanaparthy mandal, Mahabubnagar district.

and 500 feet. Similarly, in Wanaparthy watershed, the survey showed 350 open wells and 950 bore wells and most open wells were defunct and the depth of bore wells ranged between 300 feet and 600 feet.

11.2 Institutional Arrangement

For effective implementation and periodic monitoring, appropriate institutional arrangement is essential. Proper periodical monitoring mechanism is an essential facet for successful implementation of watershed programme. Regular monitoring of the project was carried out at each stage of development by adopting community participatory approach for planning, execution, monitoring and evaluation.

Baseline characterization was undertaken through participatory rapid rural appraisal and detailed household survey by adopting stratified random sampling approach for socioeconomic survey on productivity, land use, inputs use, income source of livelihoods, constraints, etc. For social mobilization and implementation of interventions under the project, ICRISAT entered into agreement with local NGOs like Samatha in Anantapur and BAIF in Mahabubnagar. Work plans were discussed by the watershed committee and NGO partner with the community.

The expert team supported villagers in unanimously nominating and establishing the watershed committee. The watershed committee consisted of 19 members in Anantapur and 13 members in Mahabubnagar and that included the representatives from all the villages. The watershed committee comprised all the sections of the community, including women representatives, proportionately small, medium, large and landless farmers. The watershed committee is responsible to conduct *gram sabha* (village meeting with all farmers) at monthly interval or as and when needed to identify the activities, execution and monitoring of works in the watershed. Community watersheds are implemented purely in a participatory mode, wherein the watershed committee and farmers are involved at every stage of watershed works right from planning and execution, implementation and monitoring of various activities in consultation and supported by the technical expertise from ICRISAT-led consortium for effective implementation of the project.

User groups are formed for active participation and maintenance of interventions, viz. water harvesting structures, etc. Self-help groups (SHGs) are formed and supported for various activities through revolving fund to benefit small farmers to generate additional family income. All payments to the SHGs are made through the watershed committee bank account cheque withdrawal signed by the NGO representative and the watershed committee members (Chairman/Treasurer).

The monitoring system includes GIS (geographical information system) or remote sensing data with on-the-ground monitoring including a household survey, focus group discussions, participatory observations, thematic studies and case studies. It measures quantitative and qualitative indicators before, during and at the end of the project as well as after project completion. Periodical monitoring is done through weekly, monthly, half-yearly and annual progress reports, utilization certificates, audited statement of accounts, etc. Any further instalment is released only when the unspent balance is less than 30% of the last instalment released to the watershed committee and subject to the satisfactory physical progress as per work plan. Further the watershed project is subjected to mid-term evaluation for any corrections. ICRISAT conducts evaluation study of project and impact assessment studies to assess the overall impact of the programme at village/watershed level.

The staff structure involved in planning, implementation and monitoring of watershed project is as follows.

Project coordinator/director, ICRISAT Development Center: Responsible for overall project management; to provide direction to all the scientists and staff in the project, liaise with donors/stakeholders, guide in planning, and review and monitor the progress (physical, financial and administrative) of the project.

Project implementation committee: Comprises of one member each from RECL and ICRISAT to monitor the planning and implementation of interventions on scientific lines.

Nodal officer: Responsible for all day-to-day affairs for the implementation of works as per the approved action plan and progress report preparation; and overall coordination for on-ground implementation of project and to liaise with stakeholders.

Multidisciplinary scientific team: Inputs of scientists such as the agronomist, soil scientist, entomologist, pathologist, hydrologist and socioeconomist are taken to guide in the specific activity planning, implementation and capacity building of the community in the watershed project.

Scientific officer: Responsible for guiding the research technician to implement the interventions, data collection and tabulation and reporting to site in-charge scientist/manager.

Research technician: Responsible to carry out the activities on the ground, data collection and community mobilization in the watershed; place of posting is in the work site; and weekly progress of work is reported to the coordinator.

Local NGO: A local NGO is involved in community mobilization, construction of water harvesting structures, implementation of action plan on ground and data collection and reporting.

Watershed committee: It is a working committee elected by the community representing all the farmers in the watershed, and is responsible for coordination in planning, implementation and monitoring of watershed interventions at all stages of project development activities.

11.3 Major Interventions

11.3.1 Integrated rainwater management

Rainwater is the main source of water for agriculture, but its current use efficiency for crop production ranges only between 30 and 45%. Annually 300–800 mm of seasonal rainfall is not used productively as it becomes surface runoff or deep drainage. ICRISAT's long experience in partnership with national agricultural research systems in integrated watershed management has clearly demonstrated that areas with good soils in the semi-arid tropics (SAT) in Asia can support double cropping while surplus rainwater could recharge the groundwater. In the integrated watershed approach the emphasis is on *in-situ* conservation of rainwater at farm or community level with the excess water taken out from the fields safely through community drainage channels and stored in suitable low-cost structures. The stored water is used as surface irrigation or for recharging groundwater (Wani *et al.*, 2003b). Rainwater conservation and management has been broadly classified into two types: blue water augmentation (*ex-situ* water management) and green water management (*in-situ* water management).

Blue water augmentation (ex-situ water management)

Currently in most of the watershed programmes in India, community-based soil and water conservation play the key role in improving surface and groundwater availability and controlling soil erosion. Studies conducted by ICRISAT have shown that the cost of water harvesting and groundwater recharging structures varies considerably with type of structures and selection of appropriate location. Large variation is found in the cost of water harvesting in different structures. Selection of appropriate location for structures also can play a very important role in reducing the cost of structures.

In RECL–ICRISAT watershed sites, the rainwater harvesting structures are low-cost and constructed throughout the topo-sequence to achieve equity and access to water. These low-cost structures are proven for sustainability, equity as well as cost-effectiveness. The number of rainwater harvesting structures and storage capacity were determined based on the water availability and through water budgeting approach using simulation modelling with historical weather data sets. In the watershed sites, various rainwater harvesting and groundwater recharge structures such as check-dams, farm ponds, percolation tanks, bore well recharge pits and sunken pits were constructed (Table 11.1; Fig. 11.2). The rainwater harvesting and groundwater recharging structures constructed have created a net storage capacity of 17,800 m^3 resulting in total conservation of about 49,500 m^3 of surface runoff water in 2–3 fillings in Anantapur watershed, while in Mahabubnagar watershed, 26,500 m^3 resulted in total conservation of about 53,600 m^3 of surface runoff water in 2–3 fillings. The rainwater harvested has helped in providing supplemental irrigation in critical crop growth stages during extended dry spell. It also helped in recharging groundwater, while reducing soil loss. The additional availability of water has resulted in increasing and sustaining crop and livestock productivity and diversification to high-value vegetable crops. Water-based works have led to various success stories in RECL–ICRISAT watersheds (see Box 11.1).

Table 11.1. Soil and water conservation works done in watershed sites in Anantapur and Mahabubnagar districts during 2015–17.

	No. of structures	
Works	Anantapur	Mahabubnagar
Farm ponds	37	68
Check-dams	6	10
Rock-filled dams	47	62
Sunken pits	11	2
Bore well recharge pits	15	1
Dugwell recharge pits	25	31
Farm pond with plastic lining and drip	2	1

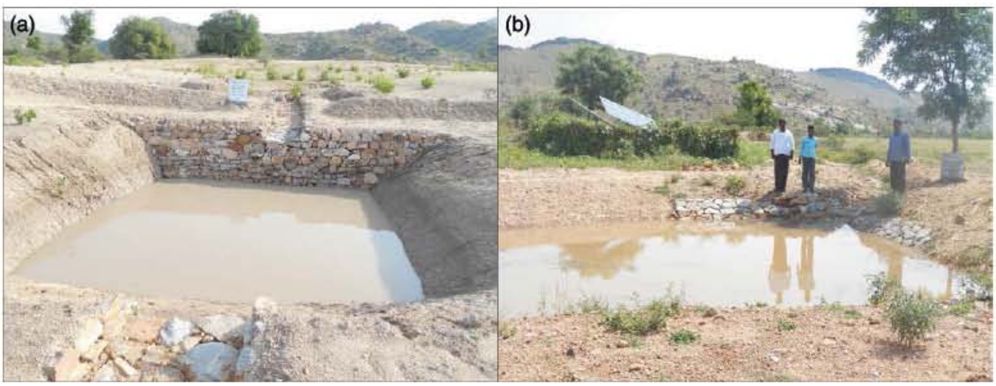

Fig. 11.2. Farm ponds in Penukonda watershed villages: (a) Gonipeta; (b) Kondampalle.

Box 11.1. Farmers in Mahabubnagar reap the benefits of farm ponds.

Mahabubnagar district is a drought-prone area. Huge rainfall variability, in both quantity and distribution, during the growing season is a major challenge and threatens farmers' livelihoods. Due to erratic and undependable rainfall, farmers used to incur huge crop losses especially with groundnut crop where seed cost is a big investment. So, farmers are facing a high risk in cultivating a groundnut crop. In such a situation, a nearby water-harvesting system in a farmers' field such as a farm pond plays a major role through increased access to water for critical irrigation to check yield losses.

Under the RECL–ICRISAT watershed programme, Mr Lokya Naik of Rajapeta village in Mahabubnagar watershed constructed a small low-cost farm pond (10 x 10 x 2 m) to harvest rainwater and used it for irrigation of his groundnut crop. He shared his experience of significant yield advantage (up to 60%) and net additional benefit of about ₹19,000 with farm pond in cultivating groundnut crop during 2016–17 (see table below). He stated that it not only prevented groundnut crop losses during drought spells, but enabled him to cultivate vegetables in a 500 m² area and enhance his income.

Construction of farm ponds, thus, has proved a promising option for rainwater storage that allows for critical and vital irrigation of crops as well as other activities, such as planting of vegetables, fodder and fruit orchards that can supplement diets and incomes. The construction of farm ponds in RECL–ICRISAT pilot sites has enhanced farmers' risk-taking abilities to effectively adopt market-oriented development.

Net additional benefits with farm pond.

Details	Without farm pond	With farm pond
Crop	Groundnut	Groundnut
Area cultivated (acres)	4	4
Cost of cultivation (₹)	51,100	60,000 (plus irrigation and micronutrients)
Yield (q/4 acre)	32.0	52.5
Gross income at 4200 per q (₹)	134,400	220,500
Net benefit for 4 acre (₹)	83,300	160,500
Net additional benefit from groundnut with farm pond (₹/acre)		19,300
Benefit–cost ratio (based on operational cost excluding fixed cost and family labour)	2.63	(40% increase)

Green water management (in-situ water management)

In-situ soil water conservation measures are important for effective conservation of soil and water at the field level. The main aim of these practices is to either reduce or prevent water erosion, while conserving the desired moisture for sustainable production. The suitability of any *in-situ* soil and water management practice depends greatly upon soil, topography, climate, cropping system and farmers' resources. Some of the promising *in-situ* soil and water conservation practices adopted in RECL watershed are broad-bed and furrow, contour cultivation and border strips (Fig. 11.3). Broad-bed and furrow system has resulted in 22% increase in groundnut yields compared with farmers' practice in Mahabubnagar district, while the border strip system in Anantapur has also been found beneficial in terms of moisture conservation and increased yield (28%) over conventional flat cultivation.

11.3.2 Soil health mapping and need-based recommendations for enhancing productivity

For systematic soil health mapping, stratified geo-referenced soil samples were collected from watershed sites in Anantapur (220 samples) and Mahabubnagar (210 samples) districts. Results of soil analysis showed widespread deficiencies of secondary and micronutrients such as sulfur (S), boron (B) and zinc (Zn) along with macronutrients and low levels of soil carbon (C). In Anantapur watershed, 69% fields were deficient in phosphorus (P), 15% in potassium (K), 77% in S, 94% in Zn, 77% in B, 44% in manganese (Mn),

Fig. 11.3. Broad-bed and furrow (BBF) system of landform for *in-situ* water conservation in RECL–ICRISAT watershed, Mahabubnagar district: (a) preparation of BBF; (b) groundnut cultivated on BBF.

29% in calcium (Ca) and 7% in iron (Fe) along with low soil organic C level in 87% of farmers' fields (Table 11.2). Similarly, in Mahabubnagar watershed, 46% of fields were deficient in P, 14% in K, 83% in S, 81% in Zn, 73% in B, 39% in Mn, 38% in Ca and 10% in Fe, along with low C levels in 81% fields (Table 11.3).

Based on soil analysis results, soil test-based fertilizer recommendations were developed at village level and promoted in RECL–ICRISAT watershed sites. Deficient secondary and micronutrients were also included in recommendations by contrast to general practice of farmers, who are not aware of such deficiencies and do not add these nutrients into their fields. Considering risks of dryland agriculture, fertilizer recommendation included full dose of secondary and micronutrients in case of >50% deficient fields in the village, ½ dose in case of 25–50% deficiency, ¼ dose in case of 10–25% deficiency and nil if only <10% fields were deficient in micro and secondary nutrients. The yearly full dose was 15 kg/ha of S, 5 kg/ha of Zn and 0.25 kg/ha in case of B. Participatory trials/demonstrations with soil test-based fertilizer application showed 25–27% yield benefit in crops like groundnut and paddy in Anantapur watershed (Table 11.4). Similarly, the yield benefit in groundnut crop was 22% in Mahabubnagar watershed. A success story is given in Box 11.2.

11.3.3 Improved crops and varieties for intensification and diversification

As varietal replacement is a big opportunity in watershed sites, farmer participatory field demonstrations were set up to persuade the farmers to adopt climate-smart high-yielding crop cultivars. With the climatic variations observed in the past few years, the farmers are finding it difficult to get a good groundnut crop. In this context, the varieties ICGV 91114, ICGV 350 and ICGV 351 were evaluated in watershed sites and these proved superior over local cultivar with yield advantage of 15–36%. Similarly, in pigeonpea, the hybrid ICPH 2740 showed yield benefit of 96% and the variety ICPL 87119 showed 13% yield increase (Table 11.5).

With augmentation of water resources in the watershed, farmers have started vegetable cultivation by using about 1000–4000 m^2 land for high-value agriculture. Around 250 farmers in Mahabubnagar have started cultivating high-value crops such as tomato, leafy vegetables, brinjal and okra, and selling the vegetables in local market. Thus farmers' incomes have increased and they also earn at regular intervals.

11.3.4 Livelihood improvement through strengthening income-generating activities

Various income-generating activities, such as sheep rearing, improving the local goat breeds through crossbreeding with Sirohi goats, vermicomposting, nursery and home gardening were undertaken by women SHG members with financial support from the revolving fund.

Farm activities

SHEEP AND GOAT REARING. Rearing of small ruminants like sheep and goat supports subsistence

Table 11.2. Soil health status of farmers' fields in Penukonda watershed, Anantapur, Andhra Pradesh.[a]

Villages	pH	EC	% of fields with low organic C	% of fields deficient in available nutrients									
				P	K	Ca	Mg	S	Zn	B	Fe	Cu	Mn
Cherlopalle	7.0	0.12	88 (0.26)	80 (4.3)	43 (65)	68 (975)	0 (151)	90 (7.0)	98 (0.31)	90 (0.26)	3 (9.71)	68 (0.44)	78 (6.99)
Gonipeta	8.1	0.12	95 (0.24)	80 (4.0)	8 (78)	30 (1595)	0 (164)	95 (35)	93 (0.39)	93 (0.27)	10 (5.76)	0 (0.59)	38 (4.97)
Kondampalle	8.0	0.25	92 (0.31)	46 (8.5)	12 (75)	20 (1566)	0 (249)	68 (18.3)	92 (1.0)	76 (0.46)	12 (5.63)	0 (2.06)	58 (5.16)
Settipalle	8.4	0.23	78 (0.34)	73 (4.1)	3 (88)	12 (2225)	0 (322)	63 (9.5)	93 (0.41)	58 (0.48)	3 (8.00)	0 (0.88)	58 (5.67)
Mean	7.9	0.19	87 (0.29)	69 (5.3)	15 (78)	29 (1656)	0 (234)	77 (10.0)	94 (0.54)	77 (0.39)	7 (7.26)	0 (1.04)	44 (5.66)

[a]Figures in parentheses indicate mean of nutrient contents in ppm and percentage values in case of organic C.

Table 11.3. Soil health status of farmers' fields in Wanaparthy watershed, Mahabubnagar, Telangana.[a]

			% of fields with low organic C	% of fields deficient in available nutrients									
Village	pH	EC		P	K	Ca	Mg	S	Zn	B	Fe	Cu	Mn
Mentepalle	7.09	0.10	87 (0.36)	32 (8.33)	0 (148)	52 (1189)	0 (299)	84 (7.78)	87 (0.47)	84 (0.38)	6 (7.12)	0 (0.79)	39 (8.52)
Peddagudem	7.74	0.10	80 (0.35)	21 (10.89)	5 (129)	51 (1231)	1 (332)	83 (7.24)	85 (0.56)	64 (0.52)	19 (4.93)	0 (0.63)	60 (5.27)
Rajapeta	7.92	0.10	79 (0.38)	83 (3.34)	29 (84)	20 (1771)	1 (363)	80 (8.81)	75 (0.76)	76 (0.37)	3 (13.47)	0 (0.86)	16 (2.85)
Kadukuntla	7.85	0.09	90 (0.32)	0 (7.25)	0 (129)	40 (1287)	0 (323)	100 (4.48)	70 (0.98)	90 (0.39)	10 (5.53)	0 (0.64)	50 (9.10)
Mean	7.71	0.12	81 (0.36)	46 (7.30)	14 (114)	38 (1441)	1 (338)	83 (7.80)	81 (0.65)	73 (0.43)	10 (8.69)	0 (0.75)	39 (5.04)

[a]Figures in parentheses indicate mean of nutrient contents in ppm and percentage values in case of organic C.

Table 11.4. Crop yields (t/ha) with soil test-based balanced nutrient management (average of 2015–17).

Crop	Improved practice (IP) (t/ha)	Farmers' practice (FP) (t/ha)	% yield increase in IP over FP
Anantapur watershed, Andhra Pradesh			
Groundnut	1.780	1.400	27
Paddy	2.180	1.750	25
Mahabubnagar watershed, Telangana			
Groundnut	1.902	1.556	22

Box 11.2. Groundnut yield increased with soil test-based nutrient management.

Mr Krishna Naik, a small farmer from Settipalle village of RECL–ICRISAT watershed in Anantapur implemented integrated nutrient management practice in groundnut crop (see figure below). After land preparation, he applied 6 tons of farmyard manure to his 2 acres of land. In 1 acre of land, he followed soil test-based fertilizer recommendation including micro- and secondary nutrients like zinc sulphate (10 kg/acre basal), borax (1 kg/acre basal) and gypsum (200 kg/acre, half as basal and half at flowering), while in the other piece of land, he followed his practice without soil test-based micro- and secondary nutrients. These micronutrients were provided through the project on a 50% cost-sharing basis. Other cultivation practices were common in both the plots. The seed rate was 60 kg/acre and seeds were treated with *Trichoderma* and mancozeb. At harvest, Mr Krishna got around 14% yield advantage in the plot where deficient micro- and secondary nutrients were added as compared to the plot where these were not added (5.6 q per acre vs 4.9 q per acre). In economic terms, at full costing, it means an additional return of ₹2800 per acre for a cost of around ₹1200 per acre, i.e. a benefit–cost ratio of 2.33, plus additional benefit of soil health rejuvenation and other ecosystem services.

agriculture and livelihoods in drought-prone areas of Anantapur and Mahabubnagar districts. Hence sheep- and goat-rearing activity was strengthened in RECL–ICRISAT watersheds with financial support from the revolving fund to SHG members. The SHG members who availed themselves of the loan returned the money in ten monthly instalments with reasonable interest decided by the members. Each SHG was provided ₹30,000 to benefit the SHG members on rotational basis. The SHG members as a group decided the priority of beneficiaries to avail themselves of the facility. Around 120 members from watershed villages in Anantapur availed themselves of this benefit and this initiative proved effective for farmers to increase their family income. A success story is described in Box 11.3.

Table 11.5. Crop yields with improved cultivars in Anantapur and Mahabubnagar (average of 2015–17).

Improved crop variety	Improved practice (IP) (t/ha)	Local variety	Farmers' practice (FP) (t/ha)	% yield increase in IP over FP
Groundnut in Anantapur watershed				
ICGV 9114	1.975	K6	1.750	29
ICGV 351	2.250	K6	2.075	15
ICGV 350	1.725	K6	1.525	36
Pigeonpea in Mahabubnagar watershed				
ICPH 2740	1.91		0.97	96
ICPL 87119	1.03		0.97	13

FORAGE PRODUCTION ACTIVITY AND LIVESTOCK IMPROVEMENT. Considering the fodder scarcity, fodder promotion is a targeted activity in the watershed villages. Fodder promotion translates into improving livestock-based productivity, including milk, which is generally in the domain of women and thus leads to their empowerment. Moreover, the benefits of soil health-based management are realized not only in increased grain yield but also in straw which is major fodder for cattle. Soil health management has also brought improvement in fodder quality in terms of micro- and macronutrients along with quantity as such. Specifically, *Stylosanthes hamata* fodder, which is rich in protein, was promoted in the watersheds along the sides/bunds of water-harvesting structures. Sorghum CSH 24 MF, a high-yielding multi-cut fodder variety has been introduced in the watersheds. A success story is described in Box 11.4.

KITCHEN GARDENING. With an objective to improve family nutrition and mainstreaming of women farmers, nutri-kitchen gardens were promoted as a women-centred activity in the backyards or a small piece of land. The farmers were trained in good management practices and about 1000 women farmers were provided with inputs, mainly seeds of vegetable crops such as tomato, brinjal, cluster bean, okra, bitter gourd and leafy vegetables to cultivate in the backyard in an area of 5–20 m^2 in both the watersheds (Anantapur and Mahabubnagar) that support for home consumption and the excess was sold in the market. In addition to this, around 1000 households were provided with 4–5 fruit plants for planting in the backyard as a perennial source to improve nutrition.

COMPOSTING AND BIOMASS GENERATION. Vermicomposting and aerobic composting are income-generating activities as well as produce manure for farmer's use in the field.

Nonfarm activities

Watershed villages have considerable population belonging to Schedule Tribe community who have very little farmland or are landless. To improve livelihoods of such households, several activities like tailoring and petty shops were supported. This initiative has benefited about 173 households with an average income of ₹2000–3000 per month. A success story is given in Box 11.5.

11.3.5 Capacity building

Capacity building plays a key role in any project for successful implementation and ensuring sustainability. This activity has been focused in RECL–ICRISAT watersheds to strengthen the capacity of all stakeholders. Need-based capacity-building activities were identified and assessed considering the current level of capacity/knowledge, gaps and priorities targeting the right topics at right time with right participants. These activities were also converged with Agricultural Technology Management Agency/department training programmes, wherein Krishi Vigyan Kendra scientists and department officials were also involved as resource persons.

Several capacity building programmes (90 events benefiting around 3000 participants in Anantapur district and 55 events benefiting around 1500 participants in Mahabubnagar district) were conducted to create awareness about

Box 11.3. Additional income through promoting livestock rearing for the SHGs.

In RECL–ICRISAT Watershed in Anantapur district, 120 farmers who were living below the poverty line collectivized in 20 SHGs across 4 watershed villages. They were supported with ₹3000 per member for ram lamb rearing as an income-generating activity to enhance their livelihoods through revolving fund. The SHG members bought ram lambs at the rate of ₹3000 each and reared them for 4–5 months (see figure below). After 4–5 months they sold the lambs at a profit of ₹2400–3200 (see table below).

Participating farmers have expressed satisfaction with this activity of the project as it supplemented their family income. Such developmental assistance enables farmers to earn more, and improve livelihoods and also reinvest for further gains. Such initial small investments slowly increase the resilience of smallholders to manage risks and harness markets.

Benefits of lamb rearing.

Name of SHG	Name of farmer	Date purchased and amount	Date sold and amount	Benefit (₹)
Shiridi Sai SHG	Ms P. Kavitha	02.01.2015; ₹3000	27.05.2015; ₹5800	₹2800
Janshi Mahila SHG	Ms Lakshmi Bai	02.01.2015; ₹3000	27.04.2015; ₹6200	₹3200
Ganesh SHG	Ms Santhi Bai	06.01.2015; ₹3000	01.05.2015; ₹5400	₹2400

Box 11.4. Promoting green fodder increased milk yield and farmer's income.

Mr Adikeshava Naidu from RECL–ICRISAT watershed in Anantapur district has achieved reasonably good success by cultivating fodder sorghum (CSH 24 MF) for his dairy animals. He has 2 milch buffaloes that yield only 4 litres milk/buffalo/day with fat content of 7%.

As a part of the watershed project, he was guided and provided with the multi-cut fodder sorghum CSH 24 MF. He sowed fodder crop in 0.1 acre of land and has been reaping rewards ever since. With the required quantity and quality of fodder, the average milk yield of buffalo increased to 6 litres milk/buffalo/day (see figure below). The fat content has also increased to 7.5% and that is fetching a higher price. With this simple intervention, Mr Adikeshava's net additional income increased by ₹2400/month/buffalo, and a total of ₹4800/month from 2 milch animals. Moreover, with increased fat content, he sells milk at a better price of ₹40/litre.

the watershed project on various aspects such as community formation, participatory soil sampling, soil health, action plan preparation, improved crop productivity initiatives and integrated pest management. Various capacity-building programmes were included as below.

- Training workshops to enhance awareness or technical skills.
- For specific technical skills, combining indoor training and practical application in the field through interactive sessions as formal and informal events.
- Field demonstrations through participatory mode.
- Field days have been a core part of the project, where farmers came together to share details of on-farm research and demonstrations and learn from each other in a spirit of openness and curiosity.
- Learning/exposure visits cum study tours to new successful technologies.

11.4 Impact of Watershed Interventions

11.4.1 Productivity and economic benefits

Farmer participatory trials to evaluate improved crop management practices, including soil test-based fertilizer recommendations, improved

Box 11.5. Nonfarm-based activities enhanced income for landless in the watersheds.

Ms Ansuya belongs to Settipalle village in Anantapur watershed. She has her family of two children and elderly parents to take care of, but does not own any land. She was looking for a livelihood opportunity. Her parents suggested that she learn tailoring and supported her training. She took out a loan from the local moneylender to buy a sewing machine and tailoring materials with a high interest rate. Later, she approached the watershed committee for financial help to repay the loan through a revolving fund. The watershed committee decided to give a loan of ₹5000 from the revolving fund with repayment through ten instalments.

Ansuya is now working in tailoring and embroidery in the village and earning an income of ₹5000 to ₹6000 per month. She has repaid her entire loan. She is now selling stitched garments to shops and she has been able to send her children to school. She is very happy that her family income has improved and she is able to take care of her children and give them a good education, and take care of other family needs (see figure below). Thus she expresses gratitude to the watershed project for the needed timely support.

cultivars and rainwater management have shown significant productivity benefits with improved incomes for the farmers. Other livelihood programmes have resulted in significant improvement in income of the people with profit of ₹1000–6000 per month under different interventions (Table 11.6).

11.4.2 Social benefits

Formerly, women farmers' participation in watershed meeting and development works was very low, but now they are participating in development activities with increased awareness. Now women are actively participating in watershed activities and attending meetings and events in large numbers. Empowerment of women SHGs has enabled landless women to have additional income to support the family as well as improve social status. Vegetable cultivation in backyards or a small area of the field has helped in improving family nutrition as well as income with surplus.

11.4.3 Environment benefits

Soil and water conservation interventions have reduced runoff by 50% and soil loss significantly. This initiative has strengthened climate resilience. Avenue and bund plantation has increased greenery and improved soil C sequestration. Forest tree species, namely teak, red sandal and

Table 11.6. Income generation through various livelihood activities in Anantapur and Mahabubnagar watersheds.

Intervention	Net gain (₹)
Ram lamb rearing (120 persons)	2400–2800 per lamb[a]
Sewing machine (2 persons)	4000–5000 per month
Petty shops (173 persons; tea shop and cloth shop)	2000–3000 per month
Carpentry (one power saw)	5000–6000 per month
Vermicomposting (20 persons)	1000–1200 per month

[a]During 4–5 months.

Gliricidia (20,000 plants) were also planted by farmers in project villages on field bunds and wasteland. Organic manure (vermicompost and aerobic compost) is available for farm use and thus reduces the use of chemical fertilizers while improving soil health.

11.4.4 Technological benefits

Soil and water conservation interventions created a storage capacity of about 50,000 m³ of rainwater in Anantapur watershed and 54,000 m³ in Mahabubnagar watershed, otherwise this would have been lost as runoff leading to soil erosion. The additional availability of water has served as climate resilient production system under prevailing climate change scenario to stabilize the production system on the farm.

Groundwater level has increased by 1.5–2.0 m. Along with groundwater yield, the period of water availability has also improved. Capacity of farmers and stakeholders in improved crop production technologies has increased.

11.5 Summary and Key Findings

The RECL–ICRISAT watershed sites in Penukonda mandal of Anantapur district in Andhra Pradesh and Wanaparthy mandal in Mahabubnagar district of Telangana are exemplary sites of learning for harnessing potential of rainfed agriculture. This has provided a proof of concept that farmers' incomes can be doubled through integrated resource management and end-to-end holistic solutions. Within these watersheds, the benefits need to be scaled-up to a large number of farmers in the watershed, and backed with policy, these simple technical solutions need to be scaled-up to farmers in the large tracts of drylands in the country. This has provided the way forward not only for uplifting drylands, but also to corporates to leverage social responsibility in mainstreaming the underprivileged, while contributing to food security and ecosystem services as such.

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