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10 Sustainable Development of Fragile Low-rainfall Regions – Power Grid Corporation of India Initiative

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Abstract

Rainfed agriculture in low-rainfall areas of Andhra Pradesh and Karnataka is characterized by high risks from drought, degraded natural resources and pervasive poverty, food insecurity and malnutrition. Under corporate social responsibility, Power Grid Corporation of India Limited, Gurugram, Haryana has been supporting International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Telangana in implementing farmer-centric watershed management in Kurnool district, Andhra Pradesh and Vijayapura district, Karnataka for improving rural livelihoods and reducing degradation of natural resources. This innovative model of watershed management uses holistic approach with science-led development in participatory mode with farmers. The watershed interventions have increased water availability by 25–30%, increased irrigated area by 15–25%, improved cropping intensity by 20–30%, increased crop yields by 15–35%, increased area under high-value crops by 10–15%, increased income, improved livelihoods and reduced runoff, soil loss and environment degradation. Innovative low-cost village-based wastewater treatment units were established at benchmark watersheds to increase the water availability for irrigation and improve the surface and groundwater quality.

10.1 Project Background

10.1.1 Why the project?

In most drylands, increasing population pressure, lack of investment and technological progress are taking a heavy toll on the quality of productive natural resource base. Water scarcity, land degradation and productivity loss are major challenges to the eradication of poverty. Depletion of the resource base diminishes the capacity of the small farmers to earn their livelihood and makes them more vulnerable to drought and other natural disasters (Pathak *et al.*, 2013). In these regions particularly in rural areas, majority of population does not get access to sanitation facilities and safe drinking water services. For such regions, local strategies are needed to tackle the challenges considering locally available resources with people's participation (Wani *et al.*, 2012). Integrated watershed management approach proved to be the suitable strategy for

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achieving holistic development in such regions through collective action (Wani *et al.*, 2003). The very purpose of the watershed development programmes is to reduce water-related risks in rainfed agriculture by improving surface and groundwater availability through implementing both *in-situ* and *ex-situ* soil and water management interventions. Since water and soil are important components of agricultural development, proper management of these resources is crucial to build the resilience of these systems to cope with varying climatic risks and improve livelihoods (Wani *et al.*, 2009; Sahrawat *et al.*, 2010).

As a part of corporate social responsibility, Power Grid Corporation of India Limited (POWERGRID), Gurugram, Haryana has been supporting International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Telanagana to undertake farmer-centric integrated watershed management for improving rural livelihoods and reducing environmental degradation at two sites, one at Bethamcherla mandal, Kurnool district of Andhra Pradesh and another at Ukkali village, Vijayapura district of Karnataka. The overall goal of this initiative is to increase agricultural productivity and improve the livelihoods of rural poor in fragile dryland areas on a sustainable basis by enhancing the impact of integrated watershed management programmes in the selected region through capacity-building initiatives using site of learning in low-rainfall agroecoregions. The specific objectives of the initiative are as follows.

- To establish 'Model Sites of Learning' in Andhra Pradesh and Karnataka for harnessing the potential of rainfed areas by adopting the integrated water resource management approach.
- To enhance water availability and its use efficiency for diversifying the livelihood systems in the target villages.
- To build capacity of the farmers in the region for improving rural livelihoods through knowledge sharing and dissemination.

The two selected benchmark sites for this project have low annual rainfall (<700 mm). Both the project sites are the hot spots of water scarcity, poverty, malnutrition and land degradation, which are critical factors that affect farmers' livelihoods. Agriculture in the two regions where project sites are located needs special attention and requires holistic development for improving rural prosperity. To address these issues, an innovative self-sustaining farmer-centric integrated watershed was initiated at both project sites in 2014. The integrated watershed project is expected to be completed by 2019. This chapter discusses the achievements and impact made during 3 years (2014–17) of the project.

10.1.2 Location details of benchmark watersheds

The Bethamcherla watershed in Kurnool district of Andhra Pradesh comprises ten villages in four revenue villages of Pendekal, Muddavaram, Emboy and Bugganipalli in Bethamcherla mandal. It is located (latitude 15°28′25″ to 15°33′48″ N and longitude 78°03′20″ to 78°10′57″ E) about 45 km from Kurnool town (Fig. 10.1). The second benchmark watershed in Vijayapura district of Karnataka is located in Ukkali village (latitude 16°43′02″ N and longitude 75°53′17″ E) in Basavana Bagewadi taluk (Fig. 10.1). This watershed is about 25 km from Vijayapura district headquarter.

10.1.3 Benchmark watersheds in Andhra Pradesh and Karnataka

Bethamcherla watershed has 4113 households with total population of 20,213, covering a geographical area of 6402 ha. The analysis of household categories reveal that 71% of households are small farmers, 20% are medium farmers and 9% are large farmers (Table 10.1). The land use information of watershed villages is given in Table 10.2. Out of a total geographical area of 6402 ha only 2962 ha (46%) are under cultivation. The general socioeconomic conditions of farmers in the watershed villages is extremely bad mainly due to low rainfall, recurring droughts and crop failures. In the watershed, red soils are the major soils (85%) with depth ranging from 0.5 m to 1.25 m and black soils (15%) with a depth of 1.0–1.5 m. Average annual rainfall in the watershed area is about 675 mm. Major crops grown in the watershed villages are maize, groundnut, pigeonpea and sorghum. Farmers with bore wells grow cotton, chilli, paddy and onion. Average crop yield (t/ha) of maize under rainfed condition is 2.15,

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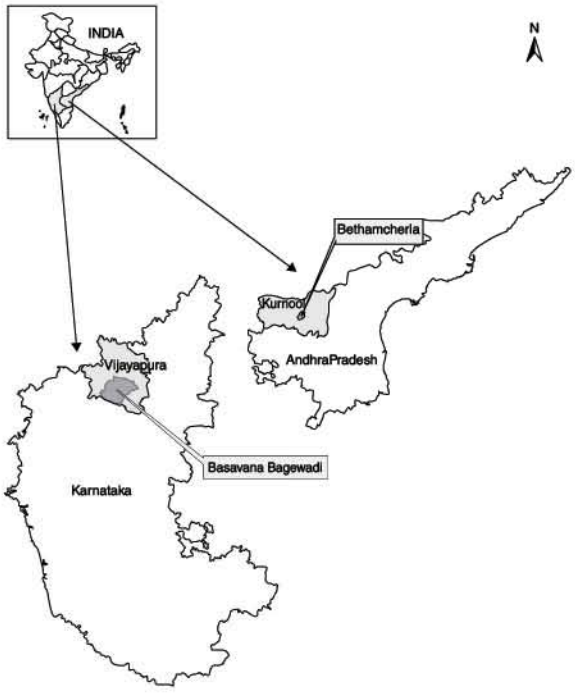

Fig. 10.1. Project sites of POWERGRID–ICRISAT watersheds in Andhra Pradesh and Karnataka.

Table 10.1. Household category of farmers in Bethamcherla watershed, Kurnool, Andhra Pradesh.

Village	Household (no.)	Small farmers (no.)	Medium farmers (no.)	Large farmers (no.)	Landless farmers (no.)
Pendekal	1290	929	232	120	9
Muddavaram	1545	1004	386	143	12
Mandlavanipalli	340	272	48	20	0
Bugganipalli	938	722	150	56	8
Total	4113	2927	816	339	29

Table 10.2. Land use in Bethamcherla watershed, Kurnool.

Village	Geographical area (ha)	Forest (ha)	Uncultivable land (ha)	Land under non-agri uses (ha)	Fallow area (ha)	Current fallow area (ha)	Net cultivated area (ha)
Pendekal	1264	39	207	63	44	475	436
Muddavaram	2599	147	635	74	178	60	1505
Mandlavanipalli	589	0	130	60	0	54	345
Bugganipalli	1950	3259	455	314	516	45	676
Total	6402	3445	1427	511	738	634	2962

pigeonpea 1.1, groundnut 1.15 and paddy 2.7. Water scarcity and drought are the common features of this area and water is the most limiting factor for increasing agricultural productivity. About 90% of the area is rainfed. Most of the irrigation is from bore wells, ponds and open wells. The current rainfall use efficiency is about 45–55% and there is good potential to increase

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the rainwater efficiency and double the agricultural productivity.

The Ukkali watershed in Vijayapura district, Karnataka has 2950 households with total population of 18,000 and covers a geographical area of 8436 ha. The forest area is 383 ha, rainfed area is 7653 ha, irrigated area is 400 ha and net cultivated area is 8053 ha. In this watershed most of the area is under cultivation (96% of total geographical area). The watershed village has 19% small farmers, 41% medium farmers, 24% large farmers and about 16% landless. The soil in the watershed is predominantly medium-to-deep black with a depth ranging from 0.6 m to 1.8 m. The general topography is flat to moderate slope (<1.5%). Average annual rainfall of the district is 625 mm. Major crops grown in the watershed are pearl millet, pigeonpea, chickpea and *rabi* (post-rainy season) sorghum. Now the farmers are showing keen interest in horticultural crops. During *kharif* (rainy season) about 40% of area is cultivated and in *rabi* 60% of total area is cultivated. Average crop yield (t/ha) of pearl millet is 0.85–0.90, pigeonpea 0.68–0.72, chickpea 0.8–1.0 and *rabi* sorghum 0.8–0.9. Most of the crops are grown under rainfed conditions. Due to very low annual rainfall, water scarcity and drought are common features of this area. There is good potential to double the crop yields and improve the rainfall use efficiency by adopting integrated watershed management approach.

10.2 Strategy for Execution and Process

Some of the key features of the project strategy, which has been used in implementing this project at both benchmark watersheds are as follows.

- Select target villages in Kurnool in Andhra Pradesh and Vijayapura in Karnataka.
- Establish site of learning of about 5000 ha encompassing holistic community watershed management approach.
- Establish field laboratory for students to undertake strategic research in target agroecoregion in the area of community watershed management.
- Holistic and integrated approach for sustainable development of rainfed areas through conservation, enhancement and efficient use of natural resources by using watershed management as an entry point for improving rural livelihoods.
- Develop innovative and effective mechanisms to share the knowledge with different stakeholders and build community-based institutions for sustainable development.
- Harness public–private partnerships for backward and forward linkages, for improving the incomes of the farming community.
- Establish rain gauges and hydrological monitoring stations at sites of learning watersheds, which will provide strategic data on hydrological parameters for planning watershed interventions in specific agroecoregions with varying soil types.
- Develop natural resource management based income-generating activities for improving livelihoods of vulnerable groups.
- Demonstrate improved management options for enhancing productivity on sustainable basis.
- Train lead farmers to serve as trainers in the district.
- Initiate wastewater treatment and its reuse in agriculture to address the issues of water quality and scarcity.
- Diversify the sources of livelihoods for the families to build their resilience against the impacts of climate change.

10.2.1 Partnerships

The partners were carefully selected based on the need of the project and their expertise. Also organizations which could assist in scaling-up of the technologies in large areas were considered. Key partners in the project are as follows.

- Power Grid Corporation of India Limited, Haryana
- International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Telangana
- Watershed committees at benchmark watersheds in Andhra Pradesh and Karnataka
- Rural Study and Development Society, Dhone, Kurnool, Andhra Pradesh
- Shri Banashankari Mahila Mattu Makkala Abhivruddhi Samsthe, Vijayapura, Karnataka
- Department of Agriculture, Government of Andhra Pradesh and Karnataka

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- Department of Horticulture, Government of Andhra Pradesh and Karnataka
- District Watershed Development Agency, Government of Andhra Pradesh
- Watershed Development Department, Government of Karnataka

10.2.2 Entry point activity

Knowledge-based entry point activity was undertaken based on the need and important constraint of the benchmark watersheds that should benefit the farmers in watershed development-related activities, which will also help to build rapport and confidence with farmers. ICRISAT has used baseline soil characterization as knowledge-based entry point activity successfully in the past. Baseline soil characterization has benefited farmers in implementing balanced fertilization to increase productivity while saving money on wastage of fertilizers and to maintain soil health and environment.

To diagnose soil fertility-related constraints, soil samples were collected from farmers' fields in Bethamcherla, Kurnool and Ukkali, Vijayapura watersheds by adopting participatory stratified soil sampling method (Sahrawat *et al.*, 2008). Under this method, target villages in the watersheds were divided into three topo-sequences. At each topo-sequence location, samples were taken proportionately from small, medium and large farmholding sizes to address the variations that may arise due to different management practices because of different economic status in each farm size class. Within each farm size class in a topo-sequence, the soil samples were chosen carefully to represent all possible soil fertility variations as judged from soil colour, texture, cropping system and agronomic management. The soil samples were processed and analysed in ICRISAT laboratory for organic carbon, phosphorus, potassium, sulfur, boron and zinc following the standard procedures. Soil health assessment of Bethamcherla and Ukkali watershed villages clearly shows moderate to severe deficiencies in critical elements including micronutrients (Table 10.3).

10.2.3 Institutional arrangements

Institutions play a critical role in effective implementation, monitoring, scaling-up and sustaining the impact of watershed programme. In this initiative for social mobilization and implementation of various watershed interventions ICRISAT has entered into agreement with two local non-governmental organizations (NGOs), namely Rural Study and Development Society, Bethamcherla, and Shri Banashankari Mahila Mattu Makkala Abhivruddhi Samsthe, Ukkali. These NGOs supported in implementing the various watershed interventions and day-to-day monitoring. They provided necessary local support in all the watershed activities. At each watershed site one

Table 10.3. Percentage of farmers' fields deficient in soil nutrients in Bethamcherla and Ukkali watersheds.

Village	OC	Av P	Av K	Av S	Av Zn	Av B	Av Fe	Av Cu	Av Mn	Ca	Mg
Bethamcherla watershed											
Emboy	18	0	0	36	73	0	0	0	0	18	0
M. Pendekal	17	6	0	94	78	39	0	0	0	78	0
Mandlavanipalli	85	0	15	100	85	54	0	31	0	100	0
Marrikunta	75	33	33	92	92	75	0	33	0	100	0
Muddavaram	50	23	3	65	58	18	15	0	0	70	0
Musalai Cheruvu	46	8	0	77	77	23	0	15	0	100	0
Pendekal	50	20	5	55	60	30	5	0	0	70	0
Rudravaram	67	0	17	83	100	44	0	17	0	94	0
Veeraiah Pally	45	30	10	95	80	50	0	35	0	100	0
Venkatagiri	50	25	0	75	100	50	0	0	0	50	0
Mean	50	15	8	76	75	35	4	12	0	80	0
Ukkali watershed											
Ukkali	49	89	0	71	94	16	8	0	0	0	0

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watershed committee (WC) was established. The WC comprised of all the sections of the community, including women representatives, proportionately small, medium, large and landless farmers and represented all the communities. The WC was responsible for conducting *gram sabha* (village meeting with all farmers) at monthly intervals or when needed to identify the activities, execution and monitoring of works in the watershed. At each watershed, user groups were formed for active participation and maintenance of various interventions, namely water harvesting structures, etc. Self-help groups (SHGs) were formed and supported for various activities through revolving fund to benefit smallholder women farmers to generate additional family income.

Several state government departments (Watershed Development, Agriculture, Horticulture and Animal Husbandry) were actively involved in the development of watersheds at both benchmark sites. Several government-funded schemes were effectively converged to strengthen the various watershed activities and impact.

10.2.4 Capacity building

In any integrated watershed management programme, capacity building plays a key role in successful implementation of watershed programme and enhancing the entrepreneurial skills and knowledge of various stakeholders. In this initiative, capacity-building activity has been focused to strengthen the capacity of all stakeholders from partner institutions and farmers. Farmers were oriented on better crop production technology and their capacity was built by organizing various types of training on new technology and better farming practices. Need-based training was conducted on major interventions, namely soil sampling, construction of soil and water management structures, implementation of *in-situ* water management technologies, cultivation of high-value crops, integrated pest management, livestock improvement, construction and management of village-based wastewater treatment unit and farm machinery. Self-help group members were trained on various income-generating activities, namely vermicomposting, tailoring, goat rearing, dal mill and other interventions.

Several capacity-building programmes (76 events benefiting 2375 participants in Bethamcherla and 124 events benefiting 2961 participants in Ukkali) were conducted to create awareness about the watershed programmes and its various activities such as watershed community formation, participatory soil sampling, soil health, action plan preparation, use and application of micronutrients, improved crop productivity technologies, and integrated pest management. Some of the key capacity building programmes conducted include the following.

- Training to the members of WC about their roles and responsibilities, planning on various interventions, budgeting, and monitoring and evaluation.
- Interactive group discussions, field visits, demonstrations, farmers' days where farmers could interact with scientists in exchanging ideas, views and experience.
- Training workshops to enhance awareness about some 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, a core part of the project, where farmers would come together to share details of on-farm research and demonstration and learn from each other in a spirit of openness and curiosity.
- Learning/exposure visits cum study tours to new successful technologies.

10.3 Watershed Interventions

10.3.1 Integrated soil and water management interventions

Soil and water are two most important natural resources for rural livelihoods with agriculture as the key occupation. In rainfed agriculture, the constant risk of drought increases the vulnerability to livelihoods. Both the benchmark watersheds are located in very low annual rainfall region and there is strong demand from the watershed community for interventions which can improve the surface and groundwater availability. Several field-based soil and water management

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interventions such as conservation furrows, contour cultivation, field bunding, loose boulder structures, compartmental bunding and others were undertaken on large numbers of farmers' fields. These interventions increased the rainwater infiltration and improved soil moisture. On average, these interventions increased the crop yields by 13–25%.

To improve the surface and groundwater availability large numbers of water harvesting and groundwater recharging structures have been constructed in participatory mode with the community. Some of these structures which were constructed in benchmark watersheds are check-dams, farm ponds, percolation tanks, bore well and open well recharging pits, rock-fill dams, loose boulder structures, field bunding, gully plugs and sunken pits (Fig. 10.2; Table 10.4).

Due to these structures the surface and groundwater availability increased by 25–30%. Several of the bore wells and open wells which were dead became functional. This activity has significantly increased irrigated area by 15–25% and thereby crop yields. It has also reduced risk to drought and crop failure. A success story about water harvesting and groundwater recharging structures is presented in Box 10.1.

Fig. 10.2. *In-situ* and *ex-situ* soil and water management interventions implemented at POWERGRID–ICRISAT watersheds: (a) check-dam at Bugganipalli, Bethamcherla, Kurnool; (b) broad-bed and furrow system at Ukkali, Vijayapura.

Table 10.4. Soil and water conservation works done at benchmark sites during 2014–17.

Works	Kurnool	Vijayapura
Farm/dugout pond (no.)	22	17
Check-dam (no.)	8	8
Check-wall (no.)	2	–
Rock-fill dam (no.)	16	–
Loose boulder structures (no.)	28	–
Open well and bore well recharge system (no.)	4	4
Mini-percolation tank (no.)	4	4
Land development (stone removal and silt spreading) (ha)	7	–
Stone field bunding (ha)	12	–
Wastewater treatment unit (no.)	1	1
Diversion (feeder) channel (running per metre)	50	–
Gully plugs (no.)	–	2
Sunken pits (no.)	–	5
Field bunding (ha)	–	550
Silt removal from existing tank (no.)	–	1

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Box 10.1. Bore well recharge helps the farmer rejuvenate land and gain increased income.

Kallanagouda A. Patil from Ukkali village has 2.4 ha of land with two bore wells. During the summer, due to a shortage of water, he was forced to remove the lemon trees from his land before the watershed project. During 2014–15 POWERGRID–ICRISAT initiated a watershed project in Ukkali village. Technical team visited his field and analysed the water problem due to drying of the bore well and suggested the farmer to construct a bore well recharge pit beside one of the bore wells.

After the guidance from project staff, he constructed a bore well recharge pit of 2 x 2 x 2 m filled with gravel and sand (see figure below, left). From the bottom of the recharge pit, a PVC pipe was connected to the bore well so that the filtered and drained rainwater from pit directly flows to the bore well and thus efficiently recharging it. Now the farmer has planted grapes in 0.8 ha of land and has gained an income of ₹250,000 from grapes only (see figure below, right).

10.3.2 Productivity enhancement through improved crop varieties and nutrient management

In 2014, when the watershed project started, most crop yields were extremely low. This was mainly due to lack of water, poor soil health and use of low-yielding crop varieties. Yield gap analysis clearly shows that there is good potential to double the yields of most crops. Large trials/numbers of demonstrations and participatory trials on balanced nutrient management, improved crop varieties and other improved agricultural practices were carried out at both Bethamcherla and Ukkali watersheds.

At Bethamcherla watershed, 267 farmer participatory trials were conducted to evaluate improved crop management practices including soil test-based fertilizer recommendations. The results showed productivity improvement by 22% in maize, 25% in pigeonpea, 10% in groundnut, 35% in foxtail millet and 9% in paddy (Table 10.5). Around 50 farmers every year were encouraged to plant pigeonpea on the periphery of field bunds in the watershed. An average of 1 ha field which was planted with pigeonpea has given an additional yield of 80–100 kg with an economic gain of ₹4000–5000 without any additional expenditure on fertilizer or irrigation.

At Ukkali watershed, Vijayapura district of Karnataka, 376 participatory trials on productivity enhancement were conducted. The yield increase and economic returns from these interventions are shown in Table 10.6. Apart from this under convergence with Department of Agriculture, Karnataka under Bhoochetana initiative soil test-based nutrients management was covered on 2000 ha, wherein average yield increase of 8–10% was recorded in various crops. A success story from this activity is discussed in Box 10.2.

10.3.3 Cultivation of high-value crops for increasing income and water productivity

With improved availability of surface and groundwater in watershed villages the farmers were encouraged to grow high-value crops, namely

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Table 10.5. Increase in crop yields and economic gain due to improved practice (IP) at Bethamcherla watershed, Kurnool district.[a]

Crop	Average % increase in IP over farmers' practice	Additional yield gain (kg/ha)	Additional economic gain (₹/ha)
Maize (65 ha)	22	750	7500
Groundnut (35 ha)	10	150	6800
Pigeonpea (350 ha)	25	220	8800
Paddy (50 ha)	9	250	4500
Foxtail millet (200 ha)	35	400	8800

[a]IP includes *in-situ* moisture conservation and *ex-situ* water conservation, improved crop varieties, balanced fertilization, etc.

Table 10.6. Increase in crop yields and economic gain due to improved practice (IP) at Ukkali watershed, Vijayapura district.

Crop	Yield with IP[a] (t/ha)	Yield with farmers' practice (FP) (t/ha)	% yield increase with IP over FP	Additional economic gain (₹/ha)
Maize (100 ha)	5.88	5.03	17	8,500
Groundnut (40 ha)	1.08	0.91	19	8,500
Pigeonpea (200 ha)	1.55	1.35	15	10,000
Chickpea (70 ha)	1.34	1.10	22	7,200

[a]IP includes *in-situ* moisture conservation and *ex-situ* water conservation, improved crop varieties, balanced fertilization, etc.

vegetables and other horticultural crops (Fig. 10.3). At Bethamcherla watershed, farmers have undertaken mango plantation and cultivation of onion, chilli and tomato. Similarly, at Ukkali watershed farmers have undertaken floriculture and are also growing grapes and pomegranate and brinjal. Necessary training and exposure visits were conducted for watershed farmers to improve their skills. At Bethamcherla watershed, 50 farmers were provided improved vegetable seeds along with micronutrients. These farmers got 18–24% increase in vegetable yields (Table 10.7). A success story from Ukkali watershed is presented in Box 10.3.

10.3.4 Kitchen gardening

Women farmers from Bethamcherla and Ukkali watersheds were encouraged, guided and supported to grow vegetables in a small area as kitchen garden to improve family nutrition and capture market-led opportunities. The demand-driven seeds of vegetables such as brinjal (100 g), tomato (200 g), okra (1500 g), cluster bean (3400 g), bitter gourd (300 g), ridge gourd (100 g), bottle gourd (100 g), common bean (200 g) and leafy vegetables (3900 g) were provided by the project along with required capacity building and other inputs like soil test-based nutrients. Vegetables were grown by around 40 women farmers at both watersheds of Bethamcherla and Ukkali by using improved cultivation practices which resulted in high yields and benefits. At Ukkali watershed, by selling the vegetables, daily income of the women increased from ₹125 to ₹240 per day. A success story from this intervention is presented in Box 10.4.

10.3.5 Livestock improvement

With help from government department, large number of animal health camps were organized for deworming and breed improvement of livestock. In watershed villages, shortage of fodder is the key issue for improving livestock productivity. Therefore, fodder promotion was taken up 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 into their

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Box 10.2. Productivity-enhancement activities increased the income and help the farmer to cope with vagaries of nature.

Before the watershed project, Ayyaswamy from Marrikunta village in Kurnool district cultivated local variety of pigeonpea and foxtail millet as intercrop and received only 1000 kg/ha yield of each crop. He would sell the produce depending on the market rate and gain a net income of ₹25,000–30,000 from the two crops.

After initiation of the watershed project, the farmer decided to try and test the use of micronutrients in his land. With the help of ICRISAT staff and the local NGO staff, he applied 250 kg of gypsum per ha, 25 kg of zinc sulphate per ha and 2.5 kg agribor (boron) per ha. He also used improved varieties such as pigeonpea Asha and foxtail millet Suryanandi (see figure below). With these two crops, the farmer received 1500 kg/ha yield of each crop. He is extremely happy with the yield and has stored the produce and is waiting for the market price to increase so that he can reap a higher net income and earn about ₹90,000-100,000 from the two crops.

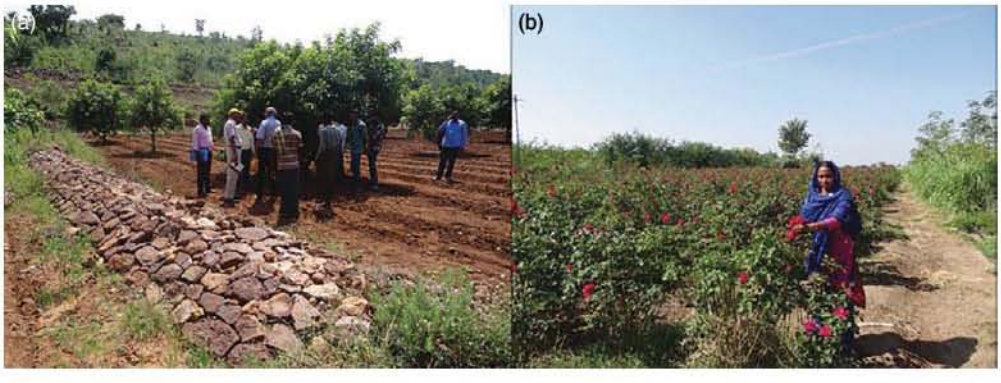

Fig. 10.3. Cultivation of high-value crops for increasing farmers' income: (a) mango at Bethamcherla; (b) rose cultivation at Ukkali.

empowerment. Improved variety of sorghum fodder and agroforestry was implemented in the watershed villages to enhance the availability of green fodder. At Bethamcherla watershed, daily milk production has increased significantly compared to start of the project (Table 10.8). The daily milk production from the local buffalo breed has increased from 1.5 to 2.8 l/day mainly

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Table 10.7. Yield of vegetables with different practices at Bethamcherla watershed, Kurnool.

Vegetable crop	Yield (t/ha) with improved practice (IP)	Yield (t/ha) with farmers' practice (FP)	% yield increase with IP over FP
Onion	26.25	21.25	24
Tomato	16.25	13.75	18

Box 10.3. Vegetable cultivation with watershed project interventions increased the farmer's income.

Ramesh Harake from Ukkali village in Vijayapura district has 3.2 ha of land of which 1.61 ha is irrigated. It was after the initiation of the watershed project by Power Grid Corporation of India Limited with the support of ICRISAT, the farmer was provided information on vegetable cultivation.

The farmer was provided with improved variety of brinjal seeds and was provided guidance about cultivation of vegetables using bed landform sowing technology (see figure below). Earlier he would get an income of ₹1500 per week by growing brinjal but with improved variety, the farmer now gets an income of ₹3000 per week by selling 100 kg of the vegetable.

due to the increased availability of quality green fodder in the watershed villages.

10.3.6 Strengthening livelihood through income-generating activities

In very low-rainfall dryland regions in which benchmark watersheds are located, non-agriculture-based income-generating activities are required to improve and sustain the livelihoods of the community. Several income-generating activities, such as sewing, food processing, dal mill, goat rearing, improving the local goat breeds through crossbreeding with Sirohi goats, vermicomposting, nursery and home gardening, photocopying, small grocery shops and photo studios were taken up by women SHGs (Fig. 10.4). Success stories from two benchmark sites are discussed in Box 10.5 and Box 10.6.

10.3.7 Low-cost decentralized wastewater treatment system

The potential of constructed wetland to improve rural wastewater management was validated through setting-up of decentralized wastewater

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Box 10.4. Kitchen garden helps self-help groups benefit from increased income.

Reshma Abdul Makanadar from Ukkali village has 1.61 ha of land and was not making sufficient income from agriculture due to severe drought and low water availability. After initiation of the watershed project by Power Grid Corporation of India Limited with the support of ICRISAT and the local NGO, Shri Banashankari Mahila Mattu Makkala Abhivruddhi Samsthe, she was given information on self-help groups (SHGs) and their formation. The staff noticed that land beside her residence was barren and suggested growing a kitchen garden in the area. After clearing the land, the staff provided vegetable seeds to her group and trained them in land preparation, methods of sowing and use of household water. After few months, she sold the vegetables in the weekly market and gained an income of ₹500 per week. At present, Reshma manages to sell more and makes an income of ₹800–1000 per week (see figure below).

Table 10.8. Increase in milk production due to watershed intervention (WI) with improved multi-cut variety of sorghum fodder at Bethamcherla, Kurnool district.

		Milk production (l/day)			
		Local breed buffalo		Crossbreed buffalo	
Name of the farmer	Village	Before WI	After WI	Before WI	After WI
Giddaiah	Veeraipalli	1.5	2.5	6	10
Lyyaswamy	Marrikunta	1.5	3.0	6	11
Balaiah	Muddavaram	1.5	3.0	6	10.5
Suneetha	Veeraipalli	1.5	2.5	6	10
Giddaiah	Repalle	1.5	3.0	6	11
Average		1.5	2.8	6	10.5

treatment (DWAT) unit comprising a field scale subsurface flow constructed wetland at the Pendekal village in Kurnool district of Andhra Pradesh and at the Ukkali village in Vijayapura district of Karnataka. Pendekal village, Bethamcherla mandal has 400 households with a population of 1800 individuals. An initial survey of possible site locations was carried out and an area where wastewater flows under natural gradient and collects near a piece of panchayat land at the village periphery was selected for the construction of the DWAT unit. Wastewater analysis was conducted using the standard methods and consistently high concentrations of inorganic nitrogen (ammoniacal as well as nitrate) and phosphate were observed. Further village-level meetings were conducted to disseminate the

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Fig. 10.4. Income-generating activities for women SHG members at benchmark watershed sites: (a) dal mill at Bethamcherla; (b) sewing at Ukkali.

Box 10.5. Increased benefits for self-help groups after watershed activities.

Ms Padmavathamma, a self-help group (SHG) beneficiary and watershed committee member from Muddavaram village, has been handling 21 SHGs in her village. After observing her dedicated efforts, the watershed committee decided to enrol her as a member and provided ₹30,000 as a revolving fund to the Madhuri group, a group that is run by Padmavathamma. Under the revolving fund, the group was supported to buy ram lambs to improve the livelihoods in addition to agricultural income (see figure below). Each member purchased a ram lamb at ₹2500–3000 and sold them at a rate of ₹7000 per lamb.

concept of DWAT to end users. The DWAT unit was designed based on the average wastewater flow (51 m^3/day) and average inlet wastewater characteristics. The wastewater flow was estimated from the population data and guided by the supplied water data for the village. The designed hydraulic retention time of the unit was three days. The DWAT unit comprised an upstream inlet and flow equalization tank (length: 2 m, width: 3 m and depth: 2.25 m) followed by a subsurface constructed wetland (length: 56 m, width: 3 m and depth: 0.8 m) divided in three equal and hydraulically connected cells. An outlet tank (length: 1 m, width: 3 m and depth: 0.8 m) was provided downstream of the constructed

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Box 10.6. Business flourishes after formation of self-help group.

Ms Kaveri Prakash Bashetti has been running a photo studio in Ukkali village and was earning an income of ₹200–300 per day. It was not sufficient to maintain her household expenses and she was finding it difficult to meet the needs of the family. After initiation of the watershed project, she was given information on self-help groups (SHGs) and their formation.

After training, ten members together formed a group named Shri Annapoorneshwari Mahila Swa Sahaya Sangha, in Ukkali and were given an amount of ₹30,000 as a revolving fund from watershed project. From the revolving fund, Kaveri requested other SHG members and borrowed an amount of ₹10,000 from the SHG. With the money, she purchased a colour printer and scanner. She has started developing photos, scanning, designing and printing and is now getting an income of ₹600 per day (see figure below). She also manages to save ₹200 per day and is sending her children to an English-speaking school.

wetland to maintain the subsurface flow regimen. The treated wastewater was stored in a storage pond located further downstream of the outlet tank (Fig. 10.5). The DWAT unit was vegetated with *Canna indica*. The period during which plants get established in the constructed wetland is known as stabilization period. During this phase the plant roots get established and the microbial biofilm in the rhizosphere of these plants undertakes biodegradation of pollutants from the wastewater. *Canna indica* plants got established within a period of 35 days at this location. The DWAT unit at present is exhibiting an average removal efficiency of 54% for chemical oxygen demand, 47% for sulphate, 67% for inorganic nitrogen and 86% for suspended solids concentration. Treated water can be used for agriculture during water scarcity and it can also help in increasing the efficiency of domestic wastewater treatment leading to improved health and hygiene of the village. A similar decentralized wastewater treatment unit has been established in Ukkali village in the Vijayapura district of Karnataka, which is at same stage of implementation. In coming years, these two DWAT units are expected to provide extra water for irrigation as well as significantly contribute to improving quality of drinking water in the villages.

10.4 Impact and Outcome from the Integrated Watershed Project

During the three years of the project, Bethamcherla, Kurnool and Ukkali, Vijayapaura watersheds have made significant impacts on economic gain,

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Fig. 10.5. Different phases in construction of decentralized wastewater treatment DWAT unit in Pendekal village: (a) construction of tanks; (b) planting of *Canna indica*; (c) fully constructed DWAT unit during stabilization phase.

social and environmental parameters (Fig. 10.6). Watershed interventions have increased surface and groundwater availability, irrigated area, cropping intensity and crop yield and reduced runoff and soil loss and improved water quality. These two watershed programmes will continue for another two years (up to 2019) and are expected to make much greater impact and outcome.

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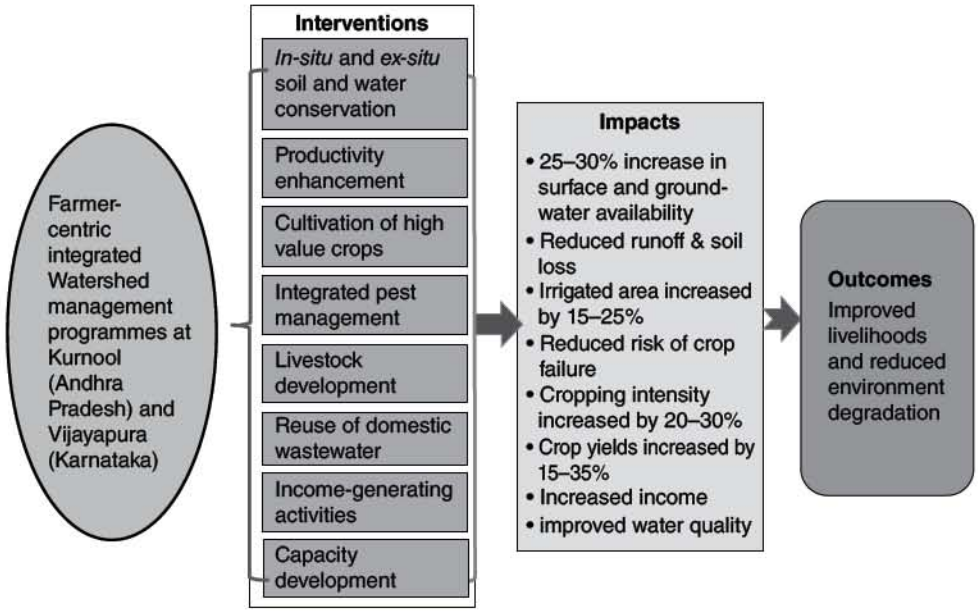

Fig. 10.6. Flow chart of interventions, impact and outcome from farmer-centric integrated watershed management programmes at benchmark sites in Bethamcherla, Andhra Pradesh and Ukkali, Karnataka.

10.5 Sustainability

Success of any watershed programme depends on sustainability of the various watershed interventions. From the beginning emphasis has been laid on capacity building and empowerment of various stakeholders. Community-based organizations (CBOs) have been established, trained and strengthened to continue development and management. Economic activities will be sustained through community participation. Participatory research and development approach along with demand-driven interventions will reduce dependency on subsidies. Through community contributions for all the activities, watershed development fund is being built and the CBOs are trained to run watershed as business model. The economic activities and tangible economic benefits along with empowerment and hand-holding from the consortium partners is empowering the CBOs to develop and sustain the watershed activities after project phase. Also with active involvement of various state government departments, various long-term funded schemes are being effectively converged in the watershed programmes to further strengthen and sustain the watershed activities after the project phase.

10.6 Scaling-up Process

To scale-up the benefits from the innovative farmer-participatory consortium model, necessary strategies are being identified. In the process of scaling-up, the watershed implementing NGO becomes the pilot trainer for other NGOs in the districts as well as in the region. In addition, the pilot NGOs transfer the lessons learnt from these model watersheds to other watershed projects implemented by their staff in the area and thus promote knowledge dissemination. New science tools such as remote sensing, geographical information system (GIS) and digital terrain modelling are being used. These tools provide the capabilities for extrapolating and implementing technologies to other potential areas.

This project has already been running for three years and in the next two years the scaling-up process will start. It is also envisaged that the district watershed departments who are closely involved in this watershed project will assist in scaling-up this farmer-centric integrated

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watershed management model in the districts as well as in the region. It is expected that this watershed model will potentially benefit large numbers of the watershed programmes which are being implemented in the low-rainfall areas of Andhra Pradesh and Karnataka.

10.7 Summary and the Way Forward

The farmer-centric integrated watershed management model implemented by ICRISAT along with its partners could be effectively used for improving rural livelihoods and reducing environment degradation in low-rainfall regions of Karnataka and Rayalaseema region of Andhra Pradesh. This initiative of POWERGRID and ICRISAT could go a long way in addressing the key issue of rural poverty in low-rainfall dryland areas on sustained basis. The project should now focus more on organizing field exposure visits of officials from private companies, watershed departments and other development agencies to sensitize and bring more awareness about the impact of this approach. In the next two years of the project, the focus should gradually shift from development phase to consolidation phase, considering the sustainability of these watersheds after project phase. All efforts should be made to make these two watersheds as learning sites to benefit large numbers of watersheds implemented by other agencies.

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