Progress Report

Improving Livelihoods and Agricultural Productivity through Integrated Watershed Management

June 2019 to October 2020

Submitted to
Mahindra & Mahindra
Zaheerabad Mandal, Sanga Reddy District

ICRISAT
INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS

IDC ICRISAT DEVELOPMENT CENTER

Contents

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1. Introduction

Mahindra & Mahindra (M&M) Limited has adopted Bhuchinelli village and its surrounding area to address water scarcity, land degradation and low crop and livestock productivity to improve rural livelihoods with the help of ICRISAT Development Centre (IDC). In April 2017, the project was taken up in a hydrological area of around 813 ha in and around Bhuchinelli village. It was named Mahindra-ICRISAT Watershed. The watershed is located 3 km away from Mahindra Farm Division Plant in Zaheerabad mandal of Sangareddy district in Telangana state (Figure 1). Bhuchinelli village has a population of 4030 in 405 households. The annual rainfall in the project area varies from 650 to 815 mm. The watershed area is characterized by plain topography with less than 2.0% slope. The major soils in the watershed are black (40%), red (40%) and laterite (20%) with medium to high water-holding capacity. Of the total geographical area of the watershed, 70% is under agricultural use and the rest under wastelands and non-agricultural use. Of the total agricultural area, 30% is rainfed and 70% irrigated. Farmers grow soybean, pigeonpea, cotton and black gram in rainfed areas while paddy and sugarcane are grown in irrigated areas of the watershed.

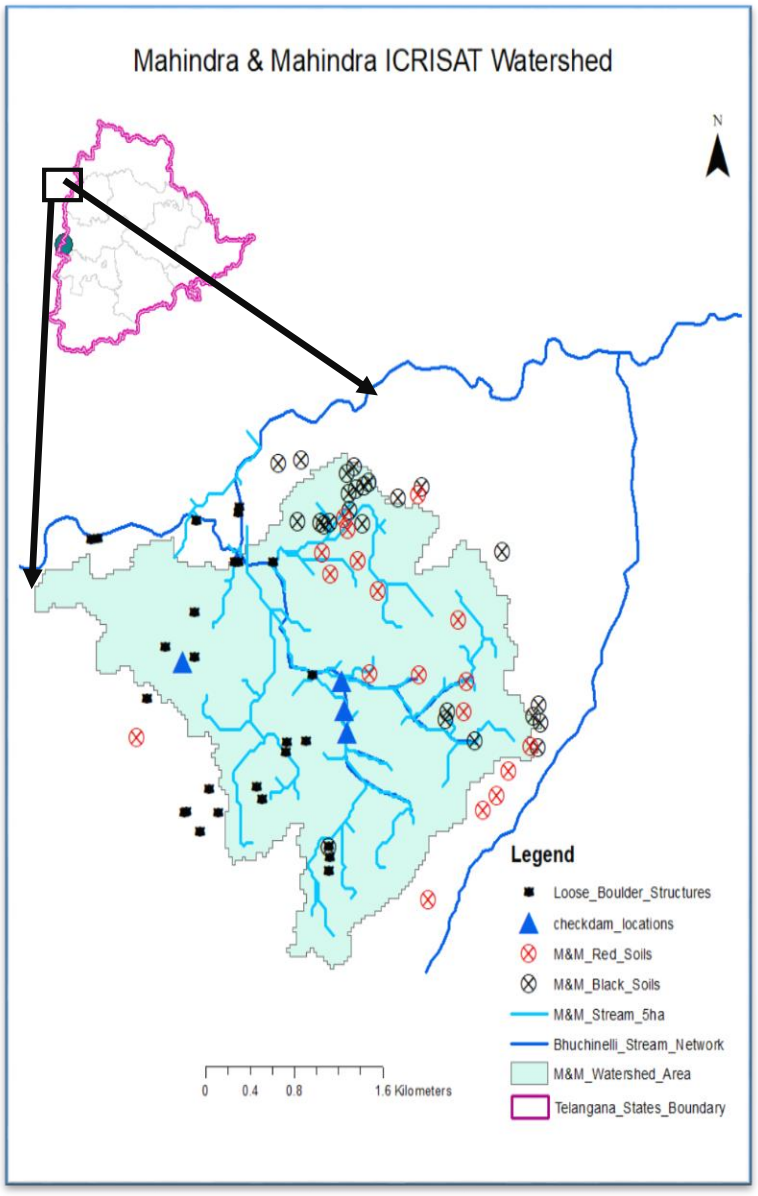


Figure 1. The location map of the Mahindra-ICRISAT Watershed in Telangana State.

2. Goals and objectives

Overall goal of the initiative is to improve agricultural productivity and livelihoods of rural poor in the watershed. The key to sustainability is enhancing impact of interventions through an integrated watershed management approach.

The initiative's specific objectives are:

- To enhance water availability in the watershed through rainwater harvesting and recharging of wells (this is to demonstrate that science-based interventions can increase water availability)
- To enhance agricultural productivity through Good Agricultural Practices (GAP)
- To establish a model village that demonstrates increased productivity and improved livelihoods
- To build capacity of farmers, women and youth in the watershed

3. Major interventions implemented and their impacts in the watershed between 2017-19

S No	Objective	Period	Activity	Impact / Beneficiaries
1	Identifying watershed location.	2017-18	▪ Participatory rural appraisal and baseline survey in surrounding villages: To understand people, their resources, socio-economic conditions, existing cropping pattern, various agricultural practices and fertilizer utilization pattern in surrounding villages.	**M&M employees**: ▪ Visited neighboring villages and interacted with farmers; ▪ Understood farmers' difficulties and issues in farming; ▪ Visited ICRISAT/ Kothapalli watershed, RR dist; ▪ Understand concept of watershed and activities; ▪ Organized *Grama sabha* meetings in the selected villages in collaboration with govt. agencies and village Sarpanch.
2	Understanding Soil nutrient status in the selected village.	2017-18	▪ About 38 soil sample were collected from 38 farmers' fields, 14 soil nutrient status was analyzed for each sample.	▪ Prepared soil health cards with fertilizer recommendations for major crops based on soil health and distributed to the farmers; ▪ Balanced fertilizer application as per soil health card has reduced the cost of cultivation by Rs 1750 – Rs 2000 /ha.

3	Formation of community based organizations.	2017-18	A watershed committee was formed in collaboration with all the farmers in the village (10 members including women, landless farmers and people of Scheduled Caste).	In planning and execution of all the activities, a representative from ICRISAT, Watershed Committee, NGO (READ) and all the farmers in the village were involved.
4	Conserving soil moisture in farmer's fields and increasing rainwater recharge to groundwater storage.	2018-19	▪ In-situ soil moisture conservation measures using Broad Bed and Furrow (BBF) land management was introduced. ▪ BBF land management was demonstrated in 2 ha of farmers' fields.	▪ Nearly 20 farmers were trained in using the Tropicultor. Any farmer can use this machine with prior booking at a minimum cost. ▪ Farmers gained (additional income of Rs 15000/-) about 15-20% higher crop yield (pigeonpea with soybean) under BBF system than the traditional flat system.
5	Understanding the impact of interventions created for improving groundwater storage.	2018-19	▪ Establishing Hydrological gauging stations to monitor the hydrological components.	▪ An auto rain gauge station and a runoff recorder were installed to record daily rainfall and runoff in the watershed. ▪ Monthly groundwater levels in 40 wells of the watershed are monitored.
6	Ex-situ Interventions: Enhancing groundwater availability by harvesting rainwater with check dams, gully plugs, sunken pits, mini pits, farm ponds, recharge units, etc.	2017-18	▪ About 8280 m^3 storage capacity was created with 27 structures and 26,496 m3 rainwater was harvested to groundwater storage.	▪ Every year, around 53-55 farmers in and around these structures are benefitting due to increased groundwater levels in their wells and are able to cultivate additional 30 acres of farm during Rabi season.
		2018-19	▪ About 9550 m^3 storage capacity was created with 18 structures and 30,560 m^3 rainwater was harvested to groundwater storage. ▪ Since 2017, about 58,712 m^3 of rainwater was harvested by 45 structures constructed (storage capacity created-17830 m^3).	▪ Every year, around 50-55 farmers in and around these structures are benefitting due to increased groundwater levels in their wells. ▪ By 2018-19, around 100-110 farmers in and around these structures started benefitting due to increased groundwater levels in their wells.

7	Enhancing crop productivity: Demonstrate and enhance farmers potential on best land and crop management practices to increase crop productivity.	2017-18	▪ Introduction of improved crop varieties such as pigeonpea during kharif and chickpea during rabi seasons along with best management practices enhanced crop yield by 20-25% (1.54 t/ha) and 20-21% (1.15 t/ha), respectively.	▪ Five farmers used micro-nutrients in 28 farm fields along with improved crop varieties.
	Educating farmers on pest management strategies and the use of yellow sticky traps and pheromone traps.	2018-19	▪ Adopting low-cost pest and disease measures has reduced pesticides application and reduced the cost of cultivation by 1500 Rs/ha. ▪ Introduction of improved crop varieties along with best management practices enhanced pigeonpea yield by 15-20%, soybean by 19-21%, maize by 22-23%, green gram by 10-11% and black gram by 9-16%.	▪ Improved crop cultivars of pigeon pea, green gram, maize, soybean and black gram were introduced on 60 acres (75 farmers).
8	▪ Reusing treated wastewater for growing fodder, grain crops and raising nurseries as a business model using hybrid-wastewater treatment unit.	2018-19	▪ A hybrid treatment wetland was set up on a community wastewater drain in the watershed.	▪ About 20,000 liters per day treated household wastewater is made available to grow fodder/sugarcane crops in about 10 ha area.
9	▪ Reducing environmental degradation.	2017-19	▪ Promoted agroforestry on field bunds and community wastelands.	▪ Nearly 1000 teak plant were planted in community waste lands to promote agro-forestry and nearly 4500 road side avenue plants were planted to reduce environmental degradation.

10	▪ Build capacity of farmers on good agricultural practices, young women develop computer skills and the land less implement income generation activities.	2017-18	▪ Conducting field days, workshops and exposure visits. Around 150 farmers went on exposure visit to Kothapalli Watershed, Rangareddy District and ICRISAT campus.	▪ Increased knowledge of best agricultural practices (i.e., IPM, INM, crop cultivars, weed management, land form treatment, mechanization, vermicomposting).
11	Income-generating activities for farm less women.	2017-19	▪ Conducted computer training programs, cloth stitching training, millet based kitchen and baking products production.	▪ 30 young women who acquired computer skills saved about Rs 10,000 with this program. ▪ 60 women who received training in tailoring are earning about Rs. 2,500/month. ▪ About 50 landless women were trained in millet based kitchen and baking products, which enhanced the intake of millet-based food products by the children and women in the village.
12	Income-generating activities for non-agricultural workers.		Construction work opportunity: About 15 to 20 non-agricultural workers are benefiting 110 additional working days through maintenance of constructed wetland unit. Work opportunity: Nearly, 20 to 25 non-agricultural workers are benefiting from 80-90 extra working days during construction of rainwater harvesting structures.	▪ Wastewater maintenance workers earn an additional income of Rs 40,000 each year through maintenance of constructed wet land structure. ▪ Construction workers earn an additional income of Rs 32,000 per person each year during construction of rainwater harvesting structures.

4. Major interventions implemented and their impacts in the watershed in 2019-20

I. In-situ water conservation

To ensure equity and tangible economic benefits to small and marginal farmers, Broad Bed and Furrow (BBF), an *in-situ* conservation intervention, was initiated in the watershed (2019). BBF system is one of the best land management practices to conserve rainwater in soils during rainy days. In this system, the land is prepared with 20-cm high broad beds and two furrows on either side of the bed. The raised bed enhances soil moisture by increasing infiltration during rainfall which supports crop water demand during long dry spells. The system was demonstrated on farmers' fields in the watershed using an ICRISAT manufactured tractor-operated Tropicultor that was supplied to the watershed committee (Figure 2). About 20 farmers are trained every year in using the Tropicultor, which can be used by any farmer with prior booking at a minimum cost. Research studies done on BBF system indicate that the crop yield in the BBF system was 15-20% higher than in traditional flat cultivation practice.

In 2020, Ms. Sumitha reddy came forward to practice BBF land management in her five-acre cultivable land. She used the Tropicultor machine to make BBF system and to sow simultaneously improved varieties of pigeonpea (BSMR 736) and soybean (DSB 21), intercropping with fertilizer application (micro-nutrients). This saved the farmer Rs 5000 (Rs 1000 per care) that had to be spent if fertilizer was separately applied. Improved soybean crop variety and micronutrient application with BBF land management system enhanced crop yield by 12% compared to farmers' practice (flat land management, local seed and NPK fertilizers) and yielded an additional 525 kg/5 acres and an additional income of Rs 21,000 per 5 acres (@ Rs 40 per kg of soybean). Overall, the farmer earned Rs 26,000 due to soybean intercropping by following BBF land management, using improved seed and micronutrient application. Generally, after soybean is harvested in the intercropping system, the growth of pigeonpea crop accelerates and is currently in flowering stage in the field. In 2019, farmers who followed BBF system with improved pigeonpea crop gained an additional yield of 160-200 kg/acre (15%), which is expected to be the same this year as well. This is an additional income of Rs 40,000 to Rs 50,000 per 5 acres compared to control farmers (Rs 50 per kg farmers' rate) in the village. Overall, the farmer is expected to earn Rs 66,000 to RS 76,000 due to soybean intercropping with pigeonpea by following the BBF land management, using improved seed and micronutrient application.

Figure 1. 1) Making BBF system using Tropicultor on farmers' fields, 2) BBF system on farmers' fields, 3) and 4) Improved varieties of pigeonpea with Soybean intercropping system on farmers field.

II. Ex-situ water conservation

Excess rainwater from farmers' fields naturally joins the stream network following the slopes. Hydrological structures such as check dams, percolation tanks, etc., were planned for construction to harvest rainwater at suitable sites identified through hydrological studies and at locations identified by the watershed committee. The locations of major hydrological structures constructed (check dams) on the major stream network in the watersheds are shown in Figure 2. In 2019-20, the watershed committee constructed six hydrological structures (one check dam and five loose boulder structures) with a total storage capacity of 8280 m^3, which have harvested 52,164 m^3 of rainwater benefitting 25 farmers in the watershed this year (Figure 3). The details of the structures constructed since project inception, their capacities and number of beneficiaries are given in Table 1. Water levels at major check dams indicate that structures are filled six times over this year due to good rainfall in the watershed as give in Table 2 and shown in Figure 4. It is observed that the rainwater is percolating at a range of 0.12 m/day to 0.26 m/ day in the watershed. Overall, it is estimated that 70% to 85% of the stored rainwater is recharging the

groundwater storage and 15% to 30% of the stored rainwater is evaporating from the structures. Since the project inception, a total storage capacity of 26,110 m^3 has been created with fifty-one water harvesting structures that have harvested 1,37,745 m^3 of surface runoff, benefitting 128 farmers this year (2020) as shown in Figure 5.

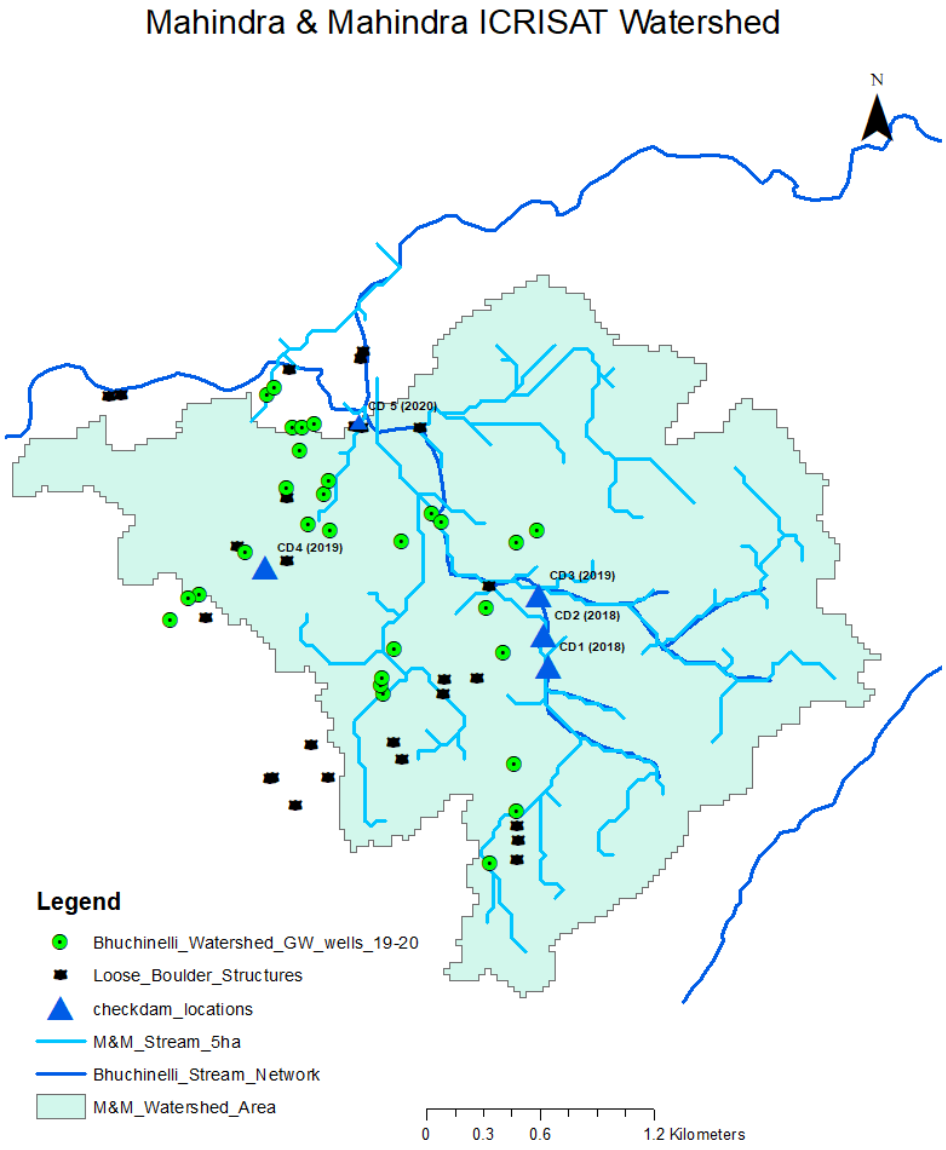


Figure 2. Location map of different water harvesting structures constructed in the watershed.

Figure 3. a) Check dam 5 constructed at catchment outlet, 2020, b) Loose boulder structures constructed in the watershed.

Table 1. Different types of rainwater harvesting structures constructed, their capacity and number of beneficiaries in the watershed.

Year of construction	Type of structures	Number of structures	Storage capacity (m^3)	Total storage capacity (m^3)	Number of beneficiaries
2017-18	Check dams 1 & 2	2	1500	3000	20
	Rock fill dam	4	350	1400	4
	Loose boulder	14	65	910	20
	Mini percolation tank	1	1500	1500	4
	Well recharge pits	4	125	500	4
	Sunken pit	1	35	35	
	Farm pond	1	935	935	1
Total		**27**		**8280**	**53**
2018-19	Check dam 3	1	2100	2100	10
	Check dam 4	1	1200	1200	10
	Rock fill dam	2	350	700	5
	Loose boulder	10	65	650	17
	Farm pond	2	950	1900	4
	Mini percolation tank	2	1500	3000	4
Total		**18**		**9550**	**50**
2018-19	Check dam 5	**1**	7095	7095	20
	Loose boulder	**5**	65	325	5
Total		**6**		**8280**	**25**
				26110	**128**

Table 2. Different types of rainwater harvesting structures constructed in the watershed and their capacity.

S NO	Structure	Number of fillings (in 2020)	Percolation (m)	Evaporation (m)	Structure Volume (m3)	GW Recharge (m3)	Evaporation (m3)
1	Checkdam 1	6	0.78	0.22	1446	6770	1909
2	Checkdam 2	6	0.78	0.22	1764	8256	2328
3	Checkdam 3	6	0.85	0.15	2218	11310	1996
4	Checkdam 4	4	0.90	0.10	1200	4320	480
5	Checkdam 5	9	0.70	0.30	8280	52164	22356

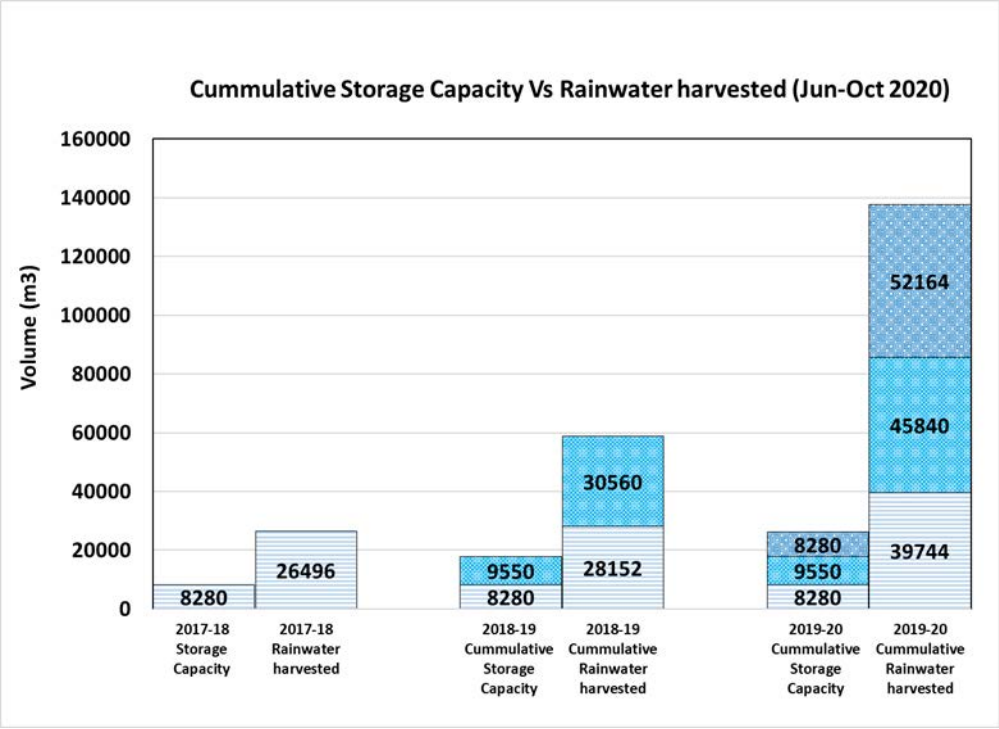
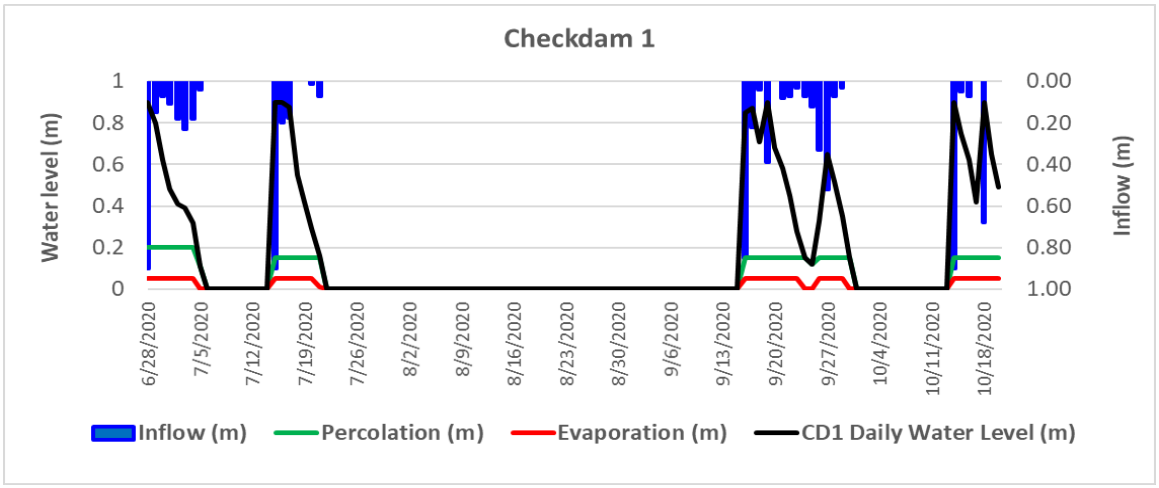
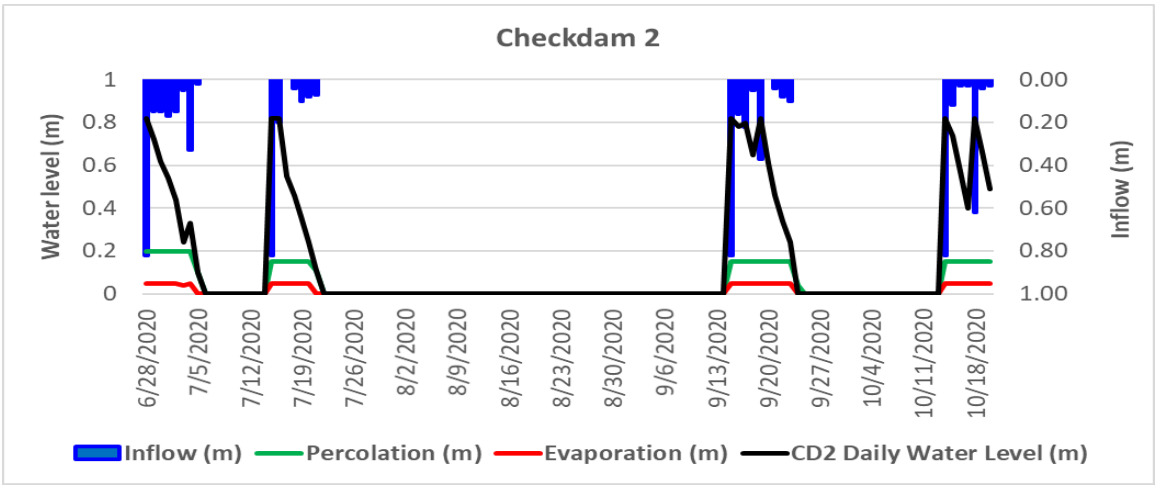


Figure 4. Year-wise storage capacity created and rainwater harvested through the structures in the watershed.

Change in groundwater storage: To understand the impact of rainwater harvested to groundwater storage, monthly groundwater levels were in the watershed. Groundwater levels particularly near major rainwater harvesting structures such as percolation tank, check dam 1, 2, 3 and 5 are being collected since 2019. Figure 6 represents the response of groundwater storage near and far from the structures due to harvested rainwater. It is evident that wells near rainwater harvesting structures respond immediately from June. Whereas, the wells away from the structures responded to the naturally occurring rainfall

recharge in the month of August. The rate of groundwater recharge depends on the quantity of rainwater harvested by the structures.





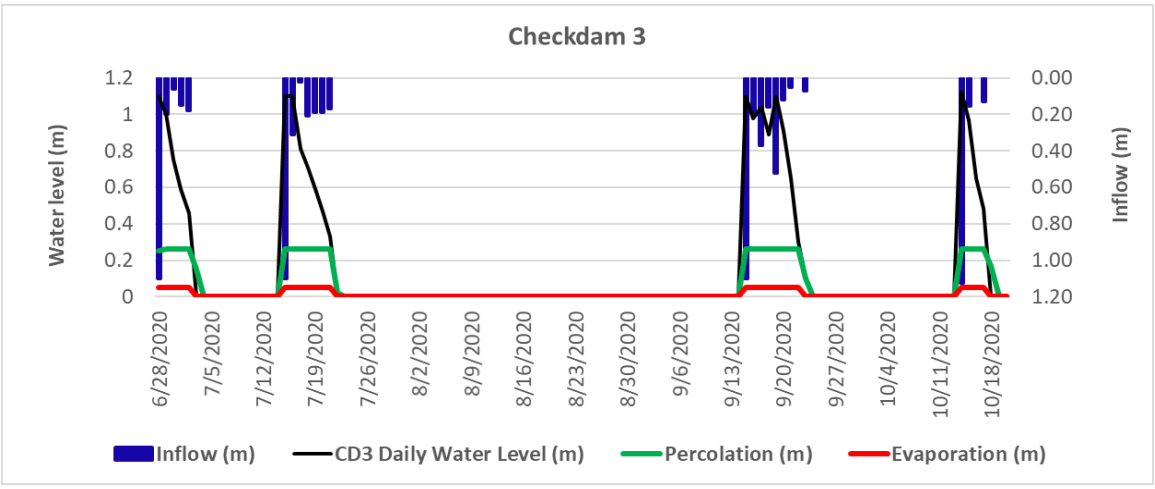


Figure 5. The inflows, fluctuation of water levels, percolation and evaporation depths in major structures.

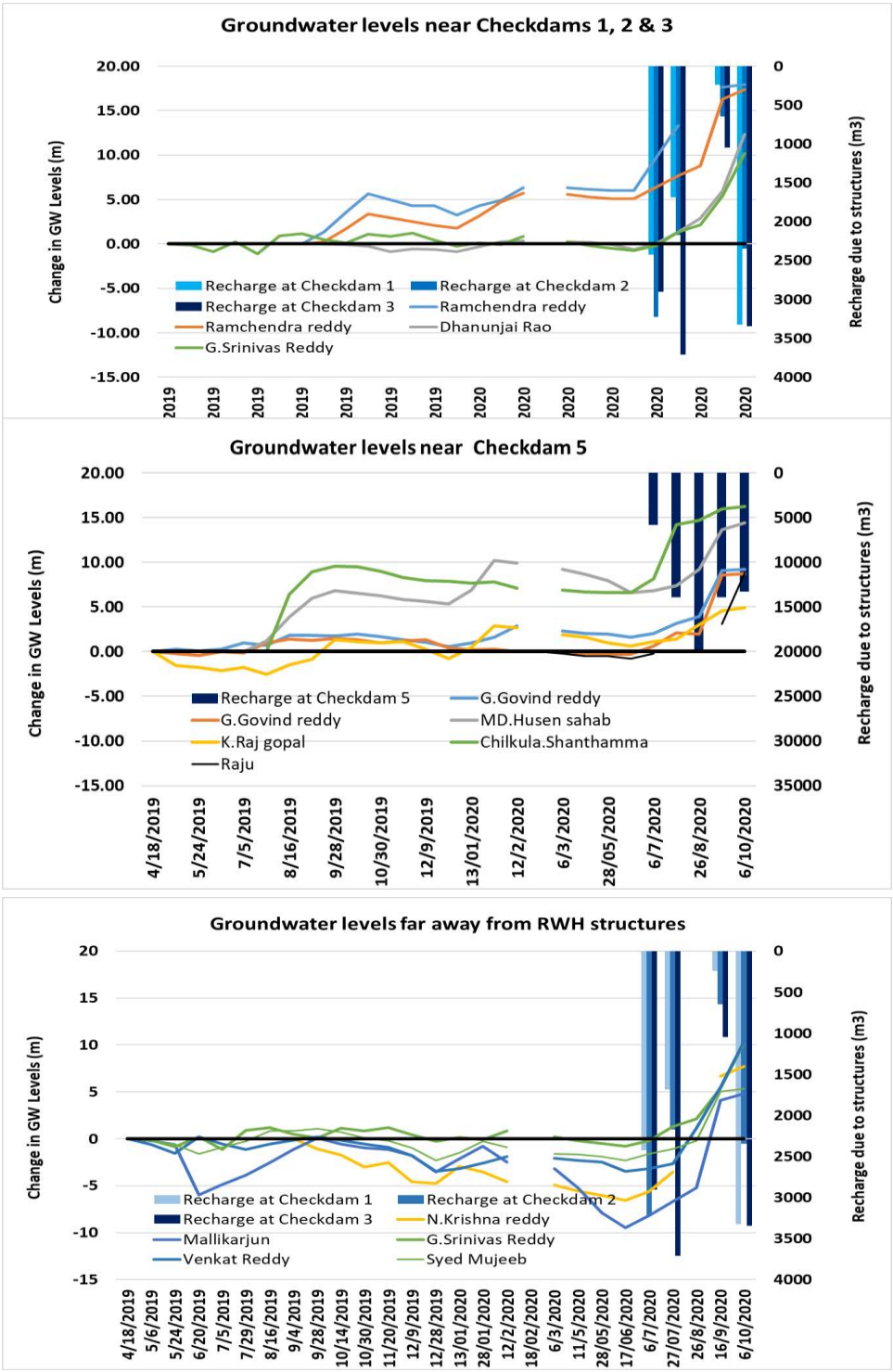


Figure 6. a) Construction of check dam 3 with a runoff gauging station and (b) stream widening and creation of storage capacity at check dam 3, 2019.

III. Participatory Research and Development (PR&D), Integrated Pest Management (IPM) and Integrated Nutrient Management (IPM) trials

Under Participatory Research and Development (PR&D) approach, improved crop cultivars were selected based on agro-ecological region. Crop enhancement demonstrations were conducted in the watershed. In Kharif 2020 season, crop enhancement and balanced fertilizer application activities are planned in nearly 115 farmers' fields. About 40 farmers have come forward to participate in crop enhancement activity in 42 acres of farmers' fields and about 75 farmers have come forward to participate in balanced fertilizers application activity in 75 acres of farmers' fields as shown in Figure 7. In addition to improved seed, farmers were also trained in pest management strategies and the use of yellow sticky traps and pheromone traps. Installation of these traps allows farmers to monitor pest activity regularly and helps avoid indiscriminate use of pesticides while spraying of insecticides needs to be taken up only when pest levels reach a threshold. This is an eco-friendly option and involves species that do not harm beneficial fauna in the ecosystem. Five pheromone traps were installed per acre and 20 yellow sticky traps per acre. These traps last one month after which lures in them need to be replaced.

Conducting crop cutting experiments: Under crop enhancement activity, it is observed that the improved crop varieties of Soybean (DSB 21), black gram (PU 31) and green gram (IPM 2-14) along with micro-nutrient (Boron) demonstrated on farmers' fields performed very well and helped farmers to increase yields by 11-20% in soybean, 6-16% in black gram and 9-15% in green gram (Figure 1&2). Pigeonpea is grown in an intercrop with soybean. Black gram and green gram crops will be harvested by the end of January 2021.

Table 3. Details of crop enhancement demonstrations conducted in the watershed (2020-21).

S No	Crop Name	Variety Name	Farmers participated (numbers)	Number of demonstrations (acres)	Yield Improved Practice (Kg/acre)	Average Yield Farmers Practice (Kg/acre)
1	Black gram	PU 31	7	7	500-550	475
2	Green gram	IPM 2-14	6	7	480-510	440
3	Soybean	DSB 21	17	17	975-1052	877
4	Pigeonpea	BSMR 736	10	11	-	-
		Total	**40**	**42**		

Figure 7. Crop enhancement demonstrations in the watershed.

IV. Wastewater treatment at village community scale

A hybrid wastewater treatment unit was constructed to reduce pollution load, mitigate diseases and to improve hygiene and sanitation of the wastewater generated from households in order to make it reusable for growing fodder for animals, grain crops and raising nurseries as part of a business model shown in Figure 8. The wastewater will be treated using a combination of three sequential treatment systems -- horizontal flow wetland, algae flow way and floating wetland. Through this system, we plan to establish a decentralized wastewater treatment process which harnesses the potential of natural biological agents like macrophytes and microalgae through ecological engineering. Although these treatment systems were used before individually, this is the first time we have used it as a combined system that will enhance the treatment efficiency. Wetland plants are known to remove nitrate and trace metals but they can't remove phosphates and heavy metals; combining plants and algae will aid in the removal of both macro and micronutrients and heavy metals. The resulting treated wastewater from this hybrid treatment wetland will be used for agriculture or to grow nurseries, fodder for animals as a business model. It is estimated that nearly 60% of nutrient load can be removed from the wastewater. About 20,000 liters per day household wastewater is treated and made available to grow fodder/sugarcane crops in about 10 ha area.

Figure 8. a & b) Hybrid wastewater unit constructed in Bhuchinelli village, c & d) Sugarcane crop grown by a farmer using treated wastewater from the unit.

V. Capacity development and field days

To build the capacity, each year farmers are trained on different land, water, soil and crop management practices. Landless villagers and construction workers are trained to construct rainwater harvesting structures and maintaining the wastewater unit in the village.

- Nearly 20-40 farmers are trained on Broad Bed and Furrow land management activity every year (Figure 9a).
- Crop productivity enhancement: Improved varieties that increase crop yields encourage nearly 90-100 farmers to participate in crop demonstrations trials in 30-35 ha of land. They get trained in the use of low cost pest management tools such as yellow sticky traps and pheromone traps (Figure 9b, c & d).
- Nearly 100 - 120 farmers in and around the structures now have the capacity to construct rainwater harvesting structures in the watershed.
- The construction workers, Mr. Ch. Ajay, Ch. Shankar, Ms. Mangamma, Mr. D.Raju, Mr. P. Pradeep, Mr. Ramesh and others used to go to other villages for two to three months in summer to earn, but since the establishment of this project, they never went outside Bhuchinelli village for work during summer.
- *Work opportunity:* About 15 to 20 non-agricultural workers are benefiting from 110 additional working days by way of maintaining the constructed wetland unit. These workers earn an additional income of Rs. 40,000 each year through maintenance of constructed wet land structure (Figure 9f).
- *Work opportunity:* Nearly 20 to 25 non-agricultural workers are benefiting from 80-90 extra days of work during construction of rainwater harvesting structures. These workers earn an additional income of Rs 32,000 per person each year during construction of rainwater harvesting structures (Figure 9e).
- Around 40 farmers went on an exposure visit to ICRISAT campus to learn best agricultural practices (i.e., IPM, INM, Crop cultivars, Weed management, Land form treatment, Mechanization, vermicomposting) (Figure 9g & h).

Figure 9. Various capacity building programs conducted in the watershed.

VI. Income-generating activities

Millet based kitchen and baking program: To address malnutrition in children and women, a training program in making millet-based kitchen and baking products was conducted in the watershed. With a view to providing skills that will aid in generating incomes while supporting agricultural value chains (inputs, outputs and byproducts), a baking class was organized to teach 30 young and married women to bake biscuits, breads, puffs, cakes, etc. (Figure 10).

Figure 10. a) A baking program for self-help groups and (b) biscuits made by them.

Kitchen Gardening: Kitchen garden kits for 100 households that were supplied to address malnutrition in women and children started yielding benefits by producing vegetables for home consumption. It is estimated that every household consumes 6 kg of different vegetables every week, saving at least Rs 400 per week (Figure 11).

Figure 11. a) & b) Kitchen gardens raised by self-help group women in front of their homes and backyards.

Table 4. Activities, milestones and impact, budget details for the period June 2019-October 2020						
SN	**Line items**	**Physical target/ agreed**	**Physical target/ achieved**	**Budget allocated (lakh)**	**Work done**	**Outputs**
1	*In-situ* moisture conservation measures	5 acres	5 acres	1.0	• About 20-40 farmers were trained in Broad Bed and Furrow (BBF) land management using Tropicultor. BBF system was implemented in 5 acres farmers' fields.	• Overall, the farmer earned Rs 26,000 due to soybean intercrop by following BBF land management, using improved seed and micronutrient application.
2	*Ex-situ r*ainwater harvesting through low-cost structures	5	5	14.9	• Constructed 1 check dam, 5 loose boulder structures.	• About 50,000 m^3 of rainwater can be harvested in a normal year by these structures in the watershed.
3	PR&D, INM and IPM trials	40 acres	42 acres (Kharif and Rabi)	2.5	• Introduced improved crop cultivars of pigeonpea, green gram, soybean and black gram over 60 acres.	• Suitable crops and cultivars during Rabi season were evaluated.
4	Wastewater treatment at village community scale	1	1	1.0	• Maintenance of wastewater treatment at village community scale	• About 10,000 m^3 of wastewater per year per unit will be treated.
5	Capacity development & preparing training materials	• 30 women	60 women	1.5	• Imparted basic training to young women in computers and baking	• Saving time and money on computer related activities compared to before. Improved baking skills.
6	Field days	2	2 field visits & 1 field day	1.0	• Rabi season 2019 and Kharif 2020	• Exposure to different best agricultural practices and interactions with best farmers in other watersheds.
7	Technical support			5.0	• 10% time of two scientists;	
8	Income-generating activities Households (HH); W=women; P=plants	• 100 HH	100 HH	2.5	• Promoting kitchen garden (100 HH)	• Improved nutrition and encouragement for increasing their income. Increasing ecological balances in the watershed.
9	Strategic Research			0.5		
	Administrative charges (17%)			5.1		
	GRAND TOTAL			**35.0**		