International Journal of Environment and Climate Change

Volume 12, Issue 12, Page 1547-1560, 2022; Article no.IJECC.96167
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Resuscitating Ecological Balance in Palnadu District Watershed Development Programme Using Micro-Watershed Approach

P. Venkataram Muni Reddy [a*], Kona Sasidhar [a], C. P. Reddy [b], R. V. Sagar Kumar Reddy [a], B. Janardhan Reddy [a] and Shilpa Deshpande [c]

[a] Panchayat Raj and Rural Development Department, Tadepalli, Guntur, Andhra Pradesh – 522 501, India.
[b] Department of Land Resources, Govt. of India, New Delhi –110 011, India.
[c] NABARD Consultancy Services Pvt. Ltd., NABARD Building, 1-1-61, RTC 'X' Road, Musheerabad, Hyderabad-500020 (Telangana State), India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2022/v12i121598

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/96167

Original Research Article

Received: 12/12/2022
Accepted: 30/12/2022
Published: 31/12/2022

ABSTRACT

Aim: This study was taken up to understand the impact of Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) Integrated Watershed Management Project (IWMP) interventions on components of Natural Resource Management (NRM) including land productivity, reclamation,land use pattern, water resource replenishment and conservation along with availability and access of drinking waterin Palnadu District of Andhra Pradesh.

**Corresponding author: E-mail: venkat.agri@gmail.com;*

Place and Duration of Study: This study was conducted by Panchayat Raj and Rural Development Department, Andhra Pradesh from 2009 to 2022.
Methodology: The primary data was collected through the field surveys conducted by the MEL&D team of NABCONS during May 2022, covering all 17 Micro Watersheds under four sanctioned PMKSY projects. The secondary data about the projects and watershed interventions was obtained from the DPRs of the projects.
Results: There is a significant reduction in the wasteland area from 198.2 Acres to 126 Acres, which indicates there is an improvement in cultivated area. Irrigated area and fodder area increased by 61.9 Acresand 47 acres respectively. As a result of Natural Resource Management (NRM) works the gross cropped area in the micro watershed increased by 114.5 acres which generate additional employment and income for the farmers.
Conclusion: Implementation of watershed projects had resulted in a significant improvement in natural resource management as evidenced in terms of increases in wasteland reclamation, improving the quantum of green cover, increasing the availability of fodder and fuelwood for local use by the indigenous households, enhancements in crop production and productivity with higher acreage under horticulture crops, which have had positive spin-offs in terms of higher employment opportunities and better wages both for men and women within the project area itself; resulting in a reduction of migration to contiguous areas as well.

Keywords: Integrated watershed management project; Pradhan Mantri Krishi Sinchayee Yojana; natural resource management.

1. INTRODUCTION

Globally around half of the world's population has been 'highly vulnerable' to the impacts of climate change, with those in highly vulnerable regions already 15 times more likely to perish due to floods, droughts, and storms compared to regions with very low vulnerability. This issue has been of topical concern in the context of developing economies viz. India wherein about 'two-thirds' of the cultivated area is rain-fed and the influence of climate has been proven to be a key determinant of crop yields and crop productivity [1] as well. Concerns regarding agricultural productivity [2] engendered by climate change, have not only persisted but have only further compounded in recent times in the wake of frequent incidences of natural calamities as manifested by a rise in global temperature, change in rainfall patterns, weather hazards, rising sea level, melting of glaciers, shifting of crop growing season decline in soil and water quality; shifting dynamics of insects, diseases, extinction of precious soil flora and fauna and frequent occurrences of extreme weather disruptions such as drought and floods across the world at large.

Such vagaries in climatic activity have not only affected food security in the context of a growing human and livestock population; but have also, been threatening the livelihoods of rural communities throughout the developing world. Paradoxically though it may seem that "conventional" agriculture has been both the cause of climate change and also by far has since; suffered from its consequences as well. The adoption of legacy high capital and water-intensive green revolution technologies on a large scale in India; has destroyed land, water, vegetation, environment on the one hand; while precipitating the state of small farmer indebtedness on the other. Moreover, land degradation caused by unsustainable cultivation practices under the aforesaid green revolution technologies had resulted in the ravaging of natural resource endowments in rain-fed regions affecting characteristic climatic activity as manifested by an increase in global temperature, increased intensity of rainfall, rising sea level, melting of glaciers, shifting of crop growing season and frequent occurrences of extreme events such as drought and floods.

Climate change and the associated hardships have been of major concern for India, as 85 percent of farmers be vulnerable with low financial resilience. Crop loss leads to farmer distress and inflation, which in turn; have far-

[1] *Source: https://dst.gov.in/sites/default/files/Report_DST_CC_Agriculture.pdf*

[2] *Stagnation of net sown area, plateauing yield levels, deterioration of soil quality, and reduction in per capita land availability caused both by historical agricultural activity and adverse effect of climate change are some of the major challenges threatening the sustainability of contemporary Indian agriculture [1].*

reaching economic consequences. Currently, the annual average crop losses due to extreme weather events alone are resulting in losses estimated at around 0.25 percent of India's GDP [2]. Additionally, Indian farmers are heterogeneous and unorganized in nature. Climate change and its variability are likely to aggravate the problem of extant food security by putting pressure on agriculture and affecting its sustainability[3]. Even the focus of agricultural research and extension programs has long been on only enhancing the livelihoods of rural people by simply improving productivity while giving less emphasis to the conservation of natural resources and sustainable management. Over time these approaches have become redundant in feeding the growing population; in the backdrop of incipient concerns about environmental sustainability. Thus, a focus on the adoption of agricultural practices that shall ensure "livelihood security with a strong commitment to natural resource conservation" had been of late; the foremost challenge of the 21st century, particularly in rain-fed regions across the world.

1.1 Climate Change and Rainfed Agriculture: Some Perspectives

Globally, rainfed agriculture has been the primary source of food production, representing more than 80 percent of land under cultivation and 60 percent of the world's crop production at large [3]. About one-third of the developing world's population lives in less-favored rain-fed regions [4]. Climate is the most important determinant of crop productivity[4], particularly in a country like India, where about 2/3rd of the cultivated area is rainfed. Environmental degradation caused by the chronic presence of acute poverty, and high dependence on human and livestock populations in these rain-fed regions have compounded the concerns about the sustainability of traditional agriculture in most developing countries including India.

1.2 Contextualizing Watershed Development for Natural Resource Management

Good management of natural resources is the key to good agriculture and rural development. This is true everywhere and particularly true for rainfed regions and semi-arid tropics where unbridled exploitation of fragile or inherently vulnerable agroecosystems have degraded land soil and water resources causing a decline in yields and productivity resulting in rampant poverty and hunger across the world [5]. In response to rainfed conditions and their associated food insecurity and poverty globally watershed development (WSD) programs[5] have been implemented in several parts of Asia and Africa to try to provide livelihood support to farmers by augmenting their natural resource base through better management of soil, water (surface runoff and groundwater recharge), and forestry resources.

Management of natural resources at the watershed scale produces multiple benefits[6] in terms of increasing food production, improving livelihoods, protecting the environment and addressing gender and equity issues along with biodiversity concerns [7]. Improvements to this integrative approach over the recent decades are largely accredited to the integration of data obtained using geospatial technology to conduct computer-based simulation models. Access to large databases and information on natural endowments both surface and subterranean using remote-sensing imagery (RSI) along with data obtained using geographic information systems (GIS) and global positioning systems (GPS) and their analysis using meta-analysis approaches have provided explicit interfaces for

[3] *See Gupta & Pathak [4]*

[4] *Currently rain-fed agriculture occupies about 55 percent of country's gross cropped area, accounting for nearly 40 percent of the total food production in India. While it contributes to nearly 60 percent of the agricultural GDP of India; it is also the source of staple food basket for the poor, with a millet-dominant crop pattern. About 61 per cent of India's rural small farm livelihoods predominantly rely on rain-fed agriculture(Source: https://journalsofindia.com/rainfed-agriculture-in-india/)*

[5] *Watershed management is an ever-evolving practice involving the management of land, water, biota, and other resources in a defined area for ecological, social, and economic purposes. In other words; it is the process of organizing and guiding land, water, and other natural resources used in a watershed to provide the appropriate goods and services while mitigating the impact on the soil and watershed resources. It involves management of all available resources along with their inter-relationships i.e. socio-economic, human-institutional, and biophysical among soil, water, and land use and the connection between upland and downstream areas with the watershed as the basic organizing unit.*

[6] *Studies have shown that implementation of watershed development programs in rainfed areas have resulted in a benefit to cost of 2.01, internal rate of return of 27.43 percent, enhanced rural incomes by 58 percent and increased agricultural productivity by 35 percent besides protecting environment. Further, the irrigated area increased by 51.5 percent, cropping intensity increased by 35.5 percent, ground water table improved by 3.2 m, runoff reduced by 13 percent and generated 154 days/ha/year employment [6]*

decision-makers communities, public interest groups, and other stakeholders to interact with each other.

In India, watershed development (WSD) programs have been ongoing since 1970 [8,9]. The integrated watershed development program[7] with a participatory approach had been advocated since the mid-1980s and in the early 1990s. This approach focused on raising crop productivity and livelihood improvement in watersheds along with soil and water conservation measures. Since the 2000s, the WSD programs in India suggested a shift in focus "away from a purely engineering and structural focus to a deeper concern with livelihood issues". The major objectives of the watershed management program are:

Conservation, up-gradation, and utilization of natural endowments such as land, water, plant, animal, and human resources in a harmonious and integrated manner with low-cost, simple, effective, and replicable technology; Generation of massive employment; Reduction of inequalities between irrigated and rain-fed areas and poverty alleviation [7].

1.3 Motivation for the Study

The Department of Panchayat Raj and Rural Development, Government of Andhra Pradesh had implemented the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) Watershed projects to restore the ecological balance by harnessing, conserving, and developing degraded natural resources such as soil, vegetative cover, and water, and create sustainable livelihoods. Each PMKSY-Watershed is a mega project, with a cluster of micro watersheds covering an average area of 4000ha. The salient features of a mega project envisage a project period of 4-7 years duration and implementation in three different stages viz. 'Preparatory' phase, 'Work' phase, and 'Consolidation' phase. The present study article discusses the findings from an impact assessment (i.e. IA) study regarding watershed projects viz., Remidicherla, Uppalapadu, Mutukuru, and Gurazala as sanctioned in the Guntur region of Andhra Pradesh in Batch-V under the PMKSY scheme during 2013-14.

1.4 Objectives of the Study

The present study focus primarily into undertaking an Impact assessment of Integrated watershed management project (i.e. IWMP) "interventions" on the 'Natural Resource Management (NRM) component under the PMKSY implementation during 2013-2017 in the rainfed regions of Palnadu District (part of erstwhile Guntur region) of Andhra Pradesh, India using the following specific agro-ecological and economic criteria-basedobjectives: -

To study the impact of IWMP project interventions on land productivity; reclamation and land use pattern in the watershed study regions; To study the impact of IWMP project interventions on water resource replenishment; conservation along with availability and access of drinking water in the 'rain-fed' watershed study regions; To study the impact of IWMP project interventions on local employment: agriculture; non-agriculture, household income; wage structure and rural-urban migration in the 'rainfed' watershed study regions.

2. MATERIALS AND METHODS

2.1 Sample Selection and Sample Size

Four IWMP (since renamed as PMKSY) watershed projects viz., Remidicherla, Uppalapadu, Mutukuru, and Gurazala in Palnadu district (part of the erstwhile Guntur district) Andhra Pradesh were sanctioned in Batch-V during 2013-14. The District Water Management Agency (DWMA), Guntur implemented the watershed projects. The total treatment area of the four watershed projects was 18,728 ha encompassing 17 Micro Watersheds with a financial outlay of Rs.2247.36 lakhs. Sample Households were randomly selected from the watershed community representing OC, BC, SC, ST, minorities, women-headed households, landless households, marginal, small, and big farmers in all habitations/villages in each of the Micro Watershed (MWS). To make a fair assessment of the impact of the project under various parameters of the study; out of the total households under each project, a minimum of 5 percent of total households were selected as suggested by State Level Nodal Agency

[7] *Integrated watershed management program (IWMP) have been defined as an adaptive, integrated, and multidisciplinary systems approaches to management that aims to preserve productivity and ecosystem integrity regarding the water, soil, plants, and animals within a watershed, thereby protecting and restoring ecosystem services for environmental, social, and economic benefit.*

(SLNA) for assessment under the field study (Table 1).

2.2 Methodology

The study comprised a collection of both primary and secondary data in respect of the implementation of the project under the PMKSY-IWMP watershed scheme. A select group of key socio-economic parameters and their respective proxy indicators as devised in consultation with the SLNA for assessing the impact of the watershed interventions regardingthe 'Natural Resource Management' (NRM) component under the PMKSY implementation were finalized for the field study (Table 2). The primary data was collected through the field surveys conducted by the MEL&D team of NABCONS during May 2022, covering all 17 Micro Watersheds under four sanctioned PMKSY projects. The secondary data about the projects and watershed interventions was obtained from the DPRs of the projects. Statistical information including the profiles of the villages, rainfall data, cropping pattern, crop production and productivity, sources of irrigation, enrolment in schools, etc., were obtained from the Mandal Revenue Officers of Bollapalle, Durgi, Veldurthi and GurazalaMandals. The Household Survey and Focus Group Discussion (or FGD) questionnaires, were devised with due consultation with the SLNAs respectively.

Table 1. Details of mega watershed wise households and sample size

Project Name	Total Households	Sample size (5 percent of Total Households)	Coverage of Actual Households
Remidicherla	3432	172	213
Uppalapadu	2911	146	156
Mutukuru	6460	68	69
Gurazala	6458	323	165*
Total	19261	709	603

Source: NABCONS Field Study (2022)

Table 2. List of natural resource parameters and indicators

S. No	Parameters	Indicators
1.	Land Productivity; Reclamation	Wasteland under Cultivation Irrigated Area Fodder and Fuelwood Cover
2.	Land Use Pattern	Gross Cropped Area Under Agriculture; Cropping Intensity Operational Land Holding Cropping Pattern Crop Productivity
3.	Water Resource Replenishment; Conservation	Seasonal Stream Water Flow (Duration in Months) Ground Water Recharge (in terms of Avg. Depth Water Table) Number of Ground Water Structures Rejuvenated
4.	Drinking Water Availability and Access	Quantum of Drinking Water (Litres per Day) Drinking Water Facility (No of Piped Water Connections)
5.	Access to Drinking Water-Proximity	Distance Travelled to Fetching Drinking Water (Km) Time Spent in Fetching Drinking Water (Mins)

Source: NABCONS IWMP-Batch V Field Study (2022)

3. RESULTS AND DISCUSSION

3.1 Land Productivity and Reclamation

3.1.1 Wasteland reclamation and increase in irrigated area (across IWMP implementation)

Regardingthe reclamation of wastelands; the study observed that 72.2 acres of the wastelands viz., fallow lands, Banjar lands, uncultivable wastelands, etc., were brought under cultivation. While the Remidicherla project area had the maximum realized area of 31.6 acres; the Mutukuru project had a relatively minimum realized area under cultivation of 7.7 acres under cultivation. With the implementation of the Mega Watershed; the irrigated area increased at the end of the project period in all the watershed projects. The total irrigated area in the four project regions had gone up from 182 acres to 243.9 acres and recorded an increase of 34 percent on account of harvesting of surface run-off water, in addition to enhancement in storage and improvement of water level in bore wells apart from the drilling of new bore wells (Table 3).

3.1.2 Area under production of fodder and fuelwood

The area under fodder cultivation had increased in all watershed projects by 19.13 ha. During the same period, fodder production had increased by 138 quintals [9,7,5,10-12]. With higher production of fodder, the green fodder supplies to milch cattle have resulted in higher yield in milk production and thereby higher incomes from such dairy products. The study peculiarly observed that fuel wood collection had significantly declined in the Remidicherla watershed project area by nearly 45 percent due to a reduction in wasteland areas in the aftermath of IWMP implementation (Table 4).

3.2 Changes in Land Use Pattern (Across IWMP Implementation)

3.2.1 Seasonal variations in gross cropped area (agriculture) and cropping intensity

The study observed that the gross cropped area under cultivation of crops increased in both Kharif and Rabi seasons by 7.52 and 43.2 acres respectively at the end of the project period. The area under double crops has also gone up from 61.6 acres to 94.8 acres during the same period [9,7,5,10-12]. Further, cropping intensity is another key indicator regarding IWMP watershed project interventions relating to soil and water conservation; on average, was observed to have secularly increased in all the watershed projects during the project period (Table 5).

3.2.2 Size of agriculture activity: Operational land holdings

The average operational holdings of the House Holds surveyed in the four IWMP watershed projects was 1.64 acres comprising 1.35 acres of rainfed area and 0.29 acres of irrigated area in the pre-project period. Post-PMKSY implementation of the watershed projects, the average operational holding improved to 1.75 acres comprising 1.17 acres under rainfed area and 0.58 acres under irrigation in the post-project period. In other words; post-implementation of the PMKSY watershed projects, the average operational holding in the project area improved by 6.7 percent. The study found the average operational holding was highest in Remidicherla IWMP and least in Uppalapadu IWMP (Fig. 1).

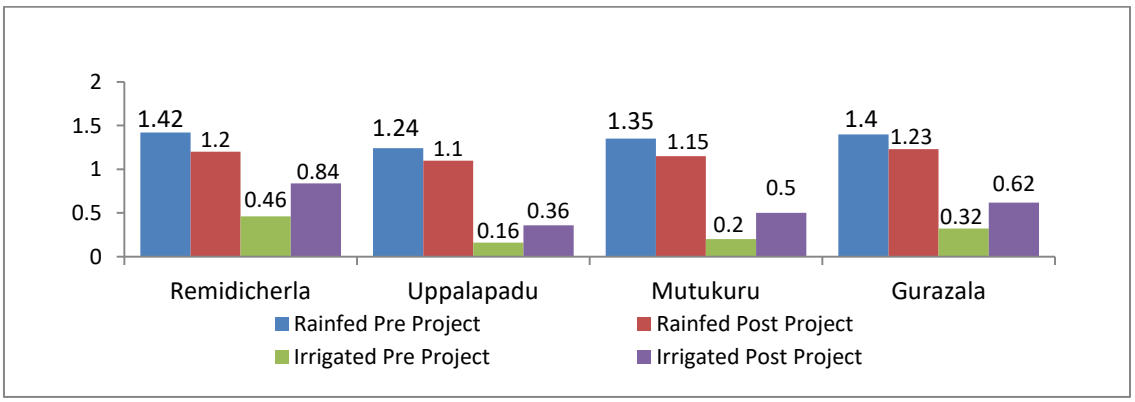

Fig. 1. Average operational holdings (acres)
Source: NABCONS IWMP-Batch V Field Study (2022)

Table 3. Changes in wasteland reclamation; irrigated area

Project Name	On Wasteland Reclamation (Acers)			Project Name	Changes in Irrigated Area (Acers)		
	Pre Project	Post Project	Increase (%)		Pre Project	Post Project	Increase (%)
Remidicherla	94.8	63.2	-31.6	Remidicherla	87.3	117.3	30 (34.4)
Uppalapadu	39.4	25.5	-13.9	Uppalapadu	31.5	43.2	11.7 (37.1)
Mutukuru	16	8.3	-7.7	Mutukuru	13.4	16.8	3.4 (25.4)
Gurazala	48	29	-19	Gurazala	49.8	66.6	16.8 (33.7)
Total	198.2	126	-72.2	Total	182	243.9	61.9 (34.0)

Table 4. Impact of IWMP on fodder production and fuelwood

Project Name	Fodder Area (in Ha)			Fodder Production (Qtl)			Fuelwood (Qtl)		
	Pre-Project	Post-Project	Difference	Pre-Project	Post-Project	Difference	Pre-Project	Post-Project	Difference
Remidicherla	649	658	9	5390	5417	27	70	38	-32
Uppalapadu	155.8	159.9	**4.1**	14790	14828	38	0	0	0
Mutukuru	3.95	6.5	2.5	105	133	28	0	0	0
Gurazala	46.3	49.7	3.48	10620	10665	45	0	0	0
Total	855	874.1	**19.13**	30905	31043	**138**	70	38	**-32**

Table 5. Gross Cropped Area-Agriculture; Cropping Intensity (CI)

Micro-Project Area	Seasonal Changes in Gross Cropped Area-Agriculture (in Acres)									Cropping Intensity (CI)		
	Kharif		Percent	Rabi			Double Crop			Percent		
	Pre-IWMP	Post-IWMP	Difference	Pre-IWMP	Post-IWMP	Difference	Pre-IWMP	Post-IWMP	Difference	Pre-IWMP	Post-IWMP	Difference
Remidicherla	108.2	110	1.8	87.3	96	8.7	36.8	59	22.2	47.9	57.2	9.3
Uppalapadu	88.3	48.2	-40.1	31.5	43.2	11.7	8.3	11.2	2.9	65.3	76.1	10.8
Mutukuru	25.1	41.8	16.7	13.4	19.4	6	4	6	2	41.8	50.95	9.15
Gurazala	82.9	112	29.12	49.8	66.6	16.8	12.5	18.6	6.1	39.7	45.2	5.5
Total	304.5	312	**7.52**	18.2	225.2	**43.2**	61.6	94.8	**33.2**			

3.2.3 Increasein crop productivity

Implementation of watershed projects in the area has facilitated the increase of crop productivity ranging from 9.3% to 35.4% in respect of all the crops in both the Kharif and Rabi seasons. The yield increase of crops in the post-project period was due to effectively conserving and utilizing the soil moisture and this was further facilitated by the growth of high-yielding crop varieties and the adoption of recommended package of practices [9,7,5,10-12].

As a part of the convergence in the watershed program, the farmers were supplied quality seeds by the local agriculture department. The farmers in the watershed project area were also given necessary training on the latest agricultural practices through field demonstrations and exposure visits. The productivity of the red gram crop; one of the major crops grown in the area had increased by 35.4 percent followed by Tobacco (32.6 percent). During the Rabi season, the farmers cultivated only Bengal gram which also had improved by 21.1 percent in the post-project period (Table 6).

3.3 Water Resource Availability; Conservation (Across IWMP Implementation)

3.3.1 Replenishment of seasonal streams (in watershed project regions)

Generally, as a matter of climatic convention; the southwest monsoon period usually ends by September; while the northeast monsoon begins from November onwards in the Palnadu district. The water in the existing streams beforethe IWMP project implementation project used to be available on an average only for 2 months beyond September in all the micro-watershed project areas. However, the study found that since the IWMP project implementation; the duration of stream water flows on average, had improved by 0.8 months (Table 7).

3.3.2 Recharging of ground water table (within and in watershed contiguity)

Findings from the field study inquiries have revealed that the groundwater table in watershed project regions had risen almost by 5m in bore wells due to water harvesting and storage of rainwater with NRM works like check dams, percolation tanks, mini percolation tanks, and farm ponds despite successive drought-like situation during the project period (Table 7). Interactions with the locals during the study visit revealed that the groundwater table had also been impacted by the horizontal seepage and percolation from adjoining canal areas; along with improvement in surface water flows in local streams, with such recharge being attributed to other soil and moisture conservation measures. Several bore wells in the project area which had dried up earlier and had not been in use beforethe start of the project got rejuvenated due to various interventions under the aforesaid project and are since being used for irrigation and drinking water purposes. The local watershed community during focus group discussions (FGDs) had expressed immense satisfaction regarding the benefits accrued with the implementation of PMKSY Watershed Projects in the project areas.

3.3.3 Availability and access to potable drinking water (post-IWMP implementation)

Under the core guidelines of IWMP, watershed projects are expected to restore the ecological balance and achieve major perceptible impacts related to hydrological status in the context of ground and surface water especially potable drinking water both for human and agricultural purposes. The study findings revealed that the implementation of the PMKSY Watershed scheme had resulted in a rejuvenation of 17 borewells, and the sinking of 2 additional borewells which have enabled the installation of R.O. plants in the project areas (Table 8).

Given the enhancement in groundwater table status on an average; around 236 new piped water supply connections were introduced in the micro-watershed project areas that had significantly increased the availability of water for drinking purposes in the post-project period This development had been a fruitful change in stark contrast to erratic water supply condition in the piped water connections during the pre-PMKSY-IWMP project period. In the post-project period; not only did all the piped water connections have received regular water supply but the quantum of drinking water (in terms of Litres per day) on average; had cumulatively improved by 8677 Litres per day (i.e. an increase of 7.4 percent) in the all the four watershed project regions (Table 8).

Table 6. Impact of IWMP on crop productivity (%)

Crop Season	Crop	Pre IWMP	Post IWMP	Difference (%)
Kharif	Paddy	15	16.3	1.3 (9.3)
	Tobacco	4.4	5.8	1.4 (32.6)
	Red gram	4.4	5.9	1.5 (35.4)
	Green gram	3.4	4.3	0.9 (26.7)
	Cotton	3.5	4.6	1.1 (29.6)
	Groundnut	3.6	4.4	0.8 (23.9)
	Chilli	13.5	14.3	0.8 (6.0)
	Jowar	3.5	4.2	0.7 (17.5)
	Maize	3.5	4.1	0.6 (17.1)
Rabi Crop	Bengal gram	3.4	4.3	0.9 (21.1)

Table 7. Impact of IWMP on water resource availability

S. No	Project Name	Duration of Seasonal Stream Water (Months)			Ground Water Status			
		Pre-IWMP	Post-IWMP	Difference (in Months)	Pre-IWMP	Post IWMP	The difference in Bore-well Depth (in Meters)	No of Ground Water Structures Rejuvenated
1	Remidicherla	1.7	2.8	1.1	87	82.2	-4.7	8
2	Uppalapadu	1.9	3	1.2	142.7	139	-3.7	3
3	Mutukuru	3	3.8	0.8	150.3	145	-5.4	1
4	Gurazala	1.5	1.7	0.2	102	95.6	-6.4	5
	Average	2	2.8	0.8	120.5	115.4	-5.1	17

Table 8. Impact of IWMP on drinking water availability

		Drinking Water Facility (No of Piped Water Connections)			Quantum of Drinking Water(Litres per Day)		
S. No	Project Name	Pre-IWMP	Post IWMP	Increase	Pre-IWMP	Post IWMP	Increase (in Percent)
1	Remidicherla	544	587	43	48687	51375	2688 (5.5)
2	Uppalapadu	653	698	45	42703	46900	4197 (9.8)
3	Mutukuru	184	291	107	10042	10700	658 (6.6)
4	Gurazala	109	150	41	16426	17560	1134 (6.9)
	Total	1490	1726	236	117858	126535	8677 (7.4)

Also, as per field revelations; dependency on hand pumps for drinking water had come down in the post-IWMP project period. Moreover, the average time spent in fetching drinking water from the source of supply by all households in all four project areas had considerably reduced from 19 minutes per day per household beforeIWMP implementation to about 10 minutes per day by the end of the project period. Likewise, IWMP implementation had also significantly impacted better household proximity to drinking water in all four project areas. The average distance traveled by households to access drinking water had on average reduced from 0.2 km to 0.09 km, reducing the distance traveled nearly by 0.11 km (Table 9).

3.4 Some Allied Externalities due to IWMP Implementation (under PMKSY)

3.4.1 Impact of IWMP on local employment: agriculture; non-agriculture

Agricultural and horticultural crops are conventionally cultivated both in rain-fed and irrigated conditions. In the aforesaid context; the study found that the quantum of household employment in agriculture-related activities witnessed an improvement in all four project regions of the Palnadu district (under the Guntur region) during the period of IWMP implementation due to enhancement in both areas of cultivation and area brought under irrigation. This also resulted in an increment in the area under double crops during the same period. As a result of this, the average agriculture man-days increased from 123.3 to 162.7 in the post-project period. The study observed that the growth of agricultural-related employment was highest in the Remidicherla project at 39.9 percent followed by the Uppalapadu project at 39.8 percent and the least being Gurazala at 15.1 percent. Notably, the IWMP watershed program implementation also generated increased employment among the respondents even in the non-agricultural sector as well. Moreover, labor works under natural resource management (NRM) in convergence with MGNREGS implementation have also aided in augmenting employment in non-agricultural-related activities during the project period. The increase in non-agricultural employment for the sampled households surveyed was by far the highest at 48.6 percent in the Mutukuru project, followed by 41.9 percent in the Uppalapadu project. As a matter of serendipity; the average number of man-days of non-agriculture work in the pre-project period to that in the post-project period increased by 32.2-man days per year per household in the post-project period i.e., at 35.5 percent (Table 10).

3.4.2 Impact of IWMP on household income; wage structure

The study observed that the average annual income of households increased in all IWMP-watershed project regions of Palnadu District (of Guntur region) relative to those during the pre-project period. The total annual income per household was observed to be highest in the Mutukuru project region and lowest in the Uppalapadu project region by the end of the project period (2013-2017). The average income of the surveyed households had improved by 40.9 percent during the project period. In the foregoing context; the study findings illustrate that the wages earned by male and female members in all the watershed project areas had improved by an average of Rs.139.3 per day per male member and Rs.116 per day per female member. Also, farmers during summer and off-season were found to be engaged in both MGNREGS works and watershed interventions (Table 11).

3.4.3 Impact of IWMP on rural-urban migration

The study observed that the implementation of IWMP had resulted in a perceptible and significant reduction in migration by 35.5 percent from rural to urban areas in all four project study regions of the Palnadu district of Andhra Pradesh. This was mainly due to increased employment in agricultural and non-agricultural activities (Table 12).

Table 9. Impact of IWMP on access to drinking water (proximity)

S. No	Distance Travelled to Fetching Drinking Water (Km)				Time Spent in Fetching Drinking Water (Mins)		
	Project Name	Pre-IWMP	Post IWMP	Difference (in Km)	Pre-IWMP	Post IWMP	Difference (Mins)
1	Remidicherla	0.21	0.05	-0.17	20	11	9
2	Uppalapadu	0.14	0.09	-0.05	18	14	4
3	Mutukuru	0.25	0.1	-0.15	20	6	14
4	Gurazala	0.21	0.12	-0.09	18	9	9
	Average	**0.20**	**0.09**	**-0.11**	**19**	**10**	**9**

Table 10. Impact of IWMP on local employment

Micro-Project Area	Employment							
	Agriculture (Number of Man-days per year per household)			Non-Agriculture (Number of Man-days per year per household)			Ancillary Activity Number of HHs	
	Pre-IWMP	Post IWMP	Increase (Percent)	Pre-IWMP	Post IWMP	Increase (Percent)	Pre-IWMP	Post IWMP
Remidicherla	117.4	164.2	46.8 (39.9)	95.6	134	38.4 (40.2)	6	2
Uppalapadu	101	141.2	40.2 (39.8)	79.2	112.4	33.2 (41.9)	5	0
Mutukuru	125.5	173.5	48.0 (38.2)	87.5	130	42.5 (48.6)	24	0
Gurazala	149.3	171.8	22.5 (15.1)	100.5	115	14.5 (14.4)	1	0
Total	123.3	162.7	39.4 (32.0)	90.7	122.9	32.2 (35.5)	36	2

Table 11. Impact of IWMP on household income; wage structure

S. No	Project Name	Annual HH Income (Rs)			Wage Structure (Rs./Day)					
					Male			Female		
		Pre-IWMP	Post- IWMP	Increase (%)	Pre-IWMP	Post IWMP	Increase	Pre IWMP	Post IWMP	Increase
1	Remidicherla	103993	145503	41510.0 (39.7)	272	450	178	220	390	170
2	Uppalapadu	85505.9	117579.7	32073.9 (37.5)	356	480	124	266	380	114
3	Mutukuru	106252	155740	49488.0 (46.6)	325	450	125	275	375	100
4	Gurazala	94749.4	131541.4	36791.9 (38.8)	270	400	130	210	290	80
	Average	97625.1	137591.0	39965.9 (40.9)	305.75	445	139.3	242.75	358.8	116

Table 12. Impact of IWMP on rural-urban migration

S. No	Project Name	Rural-Urban Migration		
		Pre IWMP	Post IWMP	Increase (%)
1	Remidicherla	240	169	-71 (-29.6)
2	Uppalapadu	290	175	-115 (-39.7)
3	Mutukuru	27	15	-12 (-44.4)
4	Gurazala	150	97	-53 (-35.3)
	Total	707	456	-251 (-35.5)

4. CONCLUSIONS

From the foregoing field survey findings; the study observed that the implementation of watershed projects had resulted in a significant improvement in the state of natural resource management as evidenced in terms of increases in wasteland reclamation followed by irrigated area apart from improving the quantum of green cover as indicated by the availability of fodder and fuelwood for local use by the indigenous households in the watershed regions. These IWMP interventions have additionally fostered enhancements in crop production and productivity with higher acreage under horticulture crops, which have had positive spin-offs in terms of higher employment opportunities and better wages both for men and women within the project area itself; resulting in a reduction of migration to contiguous areas as well.

Moreover, the implementation of the watershed projects also resulted in enhanced availability and access to drinking water supply with a drastic reduction in drudgery to fetch water in the watershed project areas under IWMP implementation. The study concludes that the implementation of IWMP watershed projects under the PMKSY had by far aided in rejuvenating the indigenous ecological balance on the one hand while also holistically improving the well-being of livelihoods in the watershed regions of Palnadu district of Andhra Pradesh as well.

COMPETING INTERESTS

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

1. Gupta N. Decline of cultivators and growth of agricultural labourers in India from 2001 to 2011. International Journal of Rural Management. 2016;12 (2):179–198.
2. Datta, Behera. Climate Change and Indian Agriculture: A systematic review of Farmers Perception, Adaptation & Transformation 2022.
3. FAO. The State of Food & Agriculture FAO Report: Overcoming Water Challenges in Agriculture. Rome; 2020.
4. Gupta and Pathak. Climate change and agriculture in India, A Thematic Report of National Mission on Strategic Knowledge for Climatic Change (NMSKCC) under National Action Plan on Climatic Change (NAPCC); 2016.

   Available:https://dst.gov.in/sites/default/files/Report_DST_CC_Agriculture.pdf
5. Walker, et al. The Nexus Between INRM and IWRM; 2014.

   Available:https://www.researchgate.net/publication/238685252
6. Palsaniya, et al. Integrated watershed management for natural resource conservation in semi-arid regions of India. Indian Journal of Agricultural Sciences; March Issue 2012.
7. Wani, et al. Best-Bet Options for Integrated Watershed Management-Proceedings of the Comprehensive Assessment of Watershed Programs in India, 25-27 July 2007 ICRISAT, Patancheru, Andhra Pradesh, India-Conference Papers; 2009.
8. Gray E, Srinidhi A. Watershed Development in India: Economic Valuation & Adaptation Considerations. Case Study 1 Out of 3, SUGAP Project, December; 2013.
9. Reddy R, et al. Assessment of Scale Impacts of Watershed Intervention on Livelihoods. Elsevier Publication; 2015.
10. Reddy PVRM, et al. Impact analysis of kurichedu pmksy watershed project on land use, water resources, crop and livestock productivity in Prakasam District, Andhra Pradesh, India. Int. J. Curr. Microbiol. App. Sci. 2021;10(10):501-513. DOI:https://doi.org/10.20546/ijcmas.2021.1010.060.
11. Siwach M, Singh A. Impact of watershed development programs on livelihood conditions of farmers in Haryana. J. Rural. Dev. 2019;38(1):144-170.

12. Thakkar AK, Desai VR, Patel A, Potdar MB. Impact assessment of watershed management programs on land use/land cover dynamics using remote sensing and GIS. Remote Sens. Appl. Soc. Environ. 2017;5:1-15.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/96167