Original Research Article

Impact of Pradhan Mantri Krishi Sinchayee Yojana Watershed Projects on Cultivable lands in East Godavari District of Andhra Pradesh

ABSTRACT

Aim: This study was taken up to investigate the usefulness of Remote Sensing & GIS tools for evaluation of fourteen watershed projects implemented under Pradhan Mantri Krishi SinchayeeYojana (PMKSY) project in East Godavari District of Andhra Pradesh.

Place and duration of study: This study was conducted by Panchayat Raj and Rural Development Department, Andhra Pradesh2009 to 2022.

Methodology: High resolution data like Resourcesat-2, Linear Imaging and Self Scanning-IV (LISS-IV) of 2011 (pre-treatment) and 2016 (post-treatment) were used in this project to measure the changes in land use/land cover and biomass during project period (2011-16). Due to implementation of the watershed developmental activities, an additional area of 11417 ha has been brought under cultivation.

Results: The fallow land area is decreased by 3686.12 Ha (24.12%) which is attributed to dense and open vegetation categories. The output of Normalized Difference Vegetation Index classification indicates the increase in dense vegetation by 9804.05 ha, which indicates there is an improvement in open vegetation category due to the reclamation of fallow land.

Conclusion: This study reveals that an additional area of 126.88 ha (12.80%) increased under water bodies and 3686.12 ha waste land converted to cultivable land due to construction of farm ponds, percolation tanks and check dams. This area is attributed to cropland and plantations.

Keywords: Watershed, Remote Sensing,Normalized Difference Vegetation Index, Land use land cover

1. INTRODUCTION

India is an agrarian nation where agriculture and related industries, including horticulture, livestock, forestry, and fisheries, combined account for 18.8% of the country's Gross Value Added (GVA) for the year 2021–2022, according to Statista.com, and employ more than 50% of the labour force. Therefore, it is essential that agriculture be taken care of so as to maintain the nation's sustainable economy. The fact that nearly 60% of India's agricultural land depends on rain is also of utmost significance. All efforts must be made to address the issues of areas under rainfed because rainfed crops account for 48% areaunder food crops and 68% of the area falls under non-food crops. Despite having the most areas and production in the world for rainfed agriculture, India's productivity is among the lowest. Rainfed agriculture suffers from a number of biological and socio-economic constraints [1]. These include low and erratic rainfall, land degradation and poor productivity, low level of input use and technology adoption, inadequate fodder availability, low productive livestock, resource poor farmers and inadequate credit availability.

As a critical part of the new watershed policy to handle the rainfed region, the Indian government established the National Rainfed region Authority (NRAA). In the chosen watershed area, a watershed is a system-based strategy that supports the holistic growth of agriculture and related activities. The emphasis is on improving wasteland, reducing runoff, conserving water, and implementing protective irrigation systems. The IWMP, which combines all other existing rainfed area development programmes, was launched on February 26, 2009, as suggested by the Parthasarathy Committee [2]. The time frame for finishing watershed development projects is four to seven years, according to the standard principles for watershed development projects – 2008 (updated version 2011). After approval of Pradhan Mantri Krishi Sinchayee Yojana, the IWMP was subsumed as one of its components and IWMP is now implemented as WDC-PMKSY w.e.f. 01.07.2015.

In Andhra Pradesh the program is being implemented by State Level Nodal Agency (SLNA) under Panchayat Raj & Rural Development Department. Total 373 projects are being taken up bystate in five batches with an exception for Krishna district. In East Godavari, a total of 43 projects in five batches are being implemented. The present assessment of 14 watersheds namely D.Bheemavaram, Ducherthi, Choppakonda, Pamugandi, Lakkonda, Tadepalli, Lagarai, Akuru, Bandapalli, Vadapalli, Vedullapalli, Yerlagadda, Chintalapudi and Pathakota in East Godavari District of Andhra Pradesh provides a fairly positive indication. These Watershed Projects of East Godavari were completed during the year 2021 under Batch-V (2014-15 to 2020-21). The theme of researchstudy was to determine how the implementation of watershed programmes from 2014 to 2021, utilising RS and GIS, had an

impact on bio-physical changes, particularly in Land Use/Land Cover (LULC), Normalised Difference Vegetation Index, and Normalised Difference Water Index (NDWI). Updated Land Use/Land Cover Changes can be conveniently retrieved using remote sensing's by good satellite data source. This is the most efficient technique, and many researchers have used it [3-5].

2. MATERIAL AND METHODS

Using IRS, Resources Sat-2, and LISS-IV satellite imageries for the years, 2014 and 2021 on cloud-free days. Remote sensing techniques were used to determine the changes in land use, land cover, and NDVI as a result of the watershed implementation programme.

Data used:

The temporal satellite data was used for monitoring the watersheds. The study was carried out using the following data sets;

Pre-2014 – 15 IRS RESOURCESAT 2 LISS IV satellite data

Post-2020 – 21 IRS RESOURCESAT 2 LISS IV satellite data

Topo sheets for reference generated by Survey of India

Ground Truth data

PMKSY monitoring reports from the department

The images and Toposheets used in the study are mentioned in Table.1.

Table 1. Images & Toposheets

S. No	Mandal	Watershed	IRS R2 LISS IV Images	Topo
1	Rajavommangi	Lagari	103060_d_11_apr_2013	65 k/2
			103060_d_29_nov_2020	
2	Addateegala	Ducherthi	103060_d_11_apr_2013	65 k/2
			103060_d_29_nov_2020	
3	Addateegala	D.Bheemavaram	103060_d_11_apr_2013	65 k/2
			103060_d_29_nov_2020	
4	Y. Ramavaram	Yarlagadda	103060_c_03_jun_2012	65 g/14
			103060_c_06_dec_2020	
5	Y. Ramavaram	Pathakota	103060_c_03_jun_2012	65 k/01, 65 g/13
			103060_c_06_dec_2020	
6	Maredumilli	Tadepalli	103060_c_03_jun_2012	65 g/10, 65 g/14
			103060_c_06_dec_2020	

7	Y. Ramavaram	Chintalapudi	103060_c_03_jun_2012	65 g/14
			103060_c_06_dec_2020	
8	Rampachodavaram	Akuru	103060_c_03_jun_2012	65 g/10, 65 g/11
			103060_c_06_dec_2020	
9	Gangavaram	Lakkonda	103060_c_03_jun_2012	65 g/15
			103060_c_06_dec_2020	
10	Y. Ramavaram	Vedullapalli	103060_c_03_jun_2012	65 g/14
			103060_c_06_dec_2020	
11	Y. Ramavaram	Bandapalli	103060_c_03_jun_2012	65 g/14, 65 g/15
			103060_c_06_dec_2020	
12	Devipatnam	Pamugondi	103060_c_03_jun_2012	65 g/11
			103060_c_06_dec_2020	
13	Devipatnam	Chopakonda	103060_c_03_jun_2012	65 g/11
			103060_c_06_dec_2020	
14	Rampachodavaram	Vadapalli	103060_c_03_jun_2012	65 g/14, 65 g/15
			103060_c_06_dec_2020	

The methodology adopted for the study is as per the procedure mentioned in the National Remote Sensing Centre, ISRO, Hyderabad, manual on National Land Use /Land Cover map using Multi-temporal satellite data, i.e., on-screen interpretation using visual interpretation keys like tone (colour), size, texture, pattern, association etc., using ArcGIS software.

Land Use /Land Cover:

The Pre-Land Use /Land Cover map, is first generated using IRS Resources 2 LISS IV images of 2014 – 15. After finalization, the pre-land Use /Land cover map is then overlaid on Resources 2 (IRS), LISS IV images of 2020 – 21 and wherever changes are observed, the Cut Polygon technique in ArcGIS is used to delineate the polygon (changed area) and the new class name is entered in the attribute table along with the class change i.e., 'from – to'. The resultant Pre-& Post Land Use /Land Cover map is then 'Dissolved' in ArcGIS to obtain Pre (2014-15) and Post (2020-21) Land Use /Land Cover maps and Change map. The Pre-& Post Land Use /Land Cover combined map change matrix table is generated in Excel/Pivot table to understand the 'from – to' changes in the land use.

Normalized Difference Vegetation Index (NDVI):

NDVI is a simple indicator of photosynthetically active biomass. It helps to visualize vegetated areas from non-vegetated areas such as built-up and waterbodies. It is calculated with the following expression:

NDVI = (NIR - Red) / (NIR + Red)

NDVI values varied from -1 to +1. Negative values correspond to built-up areas, bare soil and waterbodies or Nil Vegetation. Positive values correspond to vegetated areas. Higher values nearing +1 correspond to Dense Vegetation, Low values correspond to Low vegetation and middle values correspond to Medium Vegetation

In order to determine the changes that took place for each watershed between 2014–15 and 2020–21, the outputs of Land Use/Land Cover, Change Map, and Vegetation vigour from NDVI were compared.

Normalized Difference Water Index (NDWI):

NDWI is used to identify water features from land and vegetation. It is calculated with the following expression:

NDWI = (Green -NIR) / (Green + NIR)

NDWI values ranged from -1 to +1. Negative values correspond to non-water features like land and vegetation and positive values correspond to water features.

The outputs of Land Use /Land Cover, Change Map, Vegetation vigour from NDVI and Water features from NDWI, of the two time periods (from 2014-15 to 2020-21) were compared to derive information on changes that occurred over a period of time for each watershed.

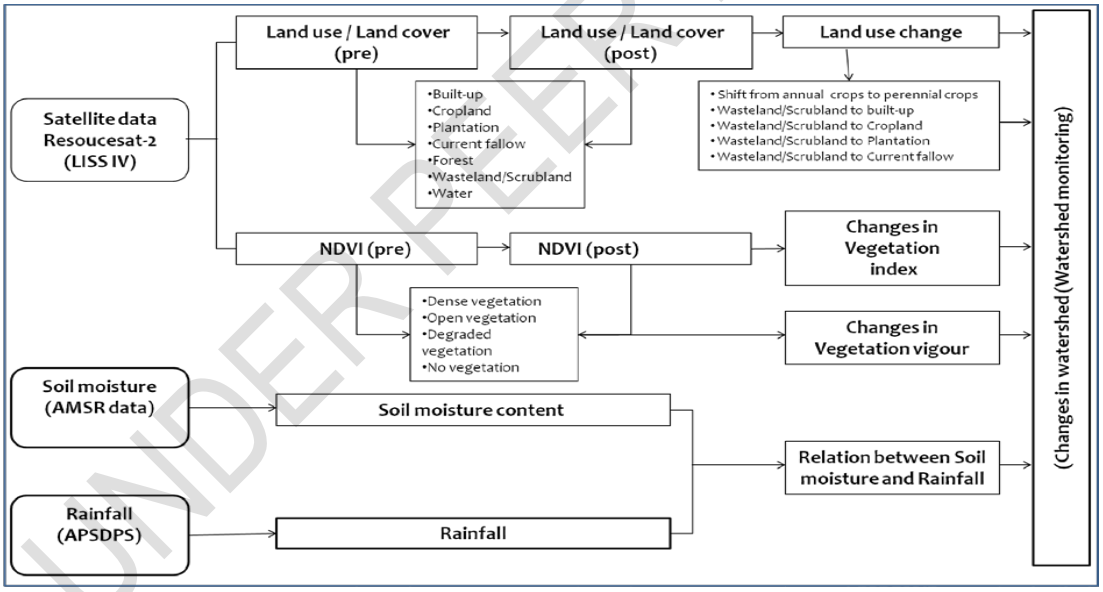


Fig 1: Methodology adapt for the study

3. RESULTS AND DISCUSSION

1. Changes in Land Use /Land Cover from 2014 to 2021:

Spatial distribution statistics for the area under study for pre- and post-project periods are presented under various land use /land cover categories. The results show that agricultural

distribution and land usage have changed significantly during the course of the research. The promotion of horticulture and agriculture has led to significant increases in the area enclosed by plantations and cropland. The area of croplands increased from 19192.93 ha in 2014 to 21562.04 ha in 2021, showing 12.34 % increase (2370.11 ha) over the course of the project, while the area of plantations increased from 5128.23 ha in 2014 to 6305.02 ha in 2021, showing an improvement of 1176.79 ha (22.95%) (Table 2 and fig 2). The scrubland/ fallow which was 15280.05 ha in 2014 decreased to 11593.93 ha during 2021 indicating a decrease of 3686.12 ha (24.12%) in the project implemenation period. The reduction may be due to the conversion of lands which were fallow into cropland/plantation areas due to the implementation of watershed program activities. [6] revealed that the implementation of the Integrated Watershed Management Programme in the Barsi Block of the Jaipur district in Rajasthan resulted in a considerable decrease in wasteland, i.e. land with shrubs and fallows. [7] investigated the effects of the Watershed Programme in eight watersheds run by the government and non-profit organisations and found that the gross cropped area rose in the project's implementation area by between 20 and 78%. In eight watersheds taken up in the Bundelkhand region of Madhya Pradesh State, stated that the area under wasteland or permanent fallow dropped by 50% and increased by a similar amount in pasture land and forest area. They attributed this to the improvement of land quality of wasteland after the implementation of IWMP in the project area which was brought under cultivation.

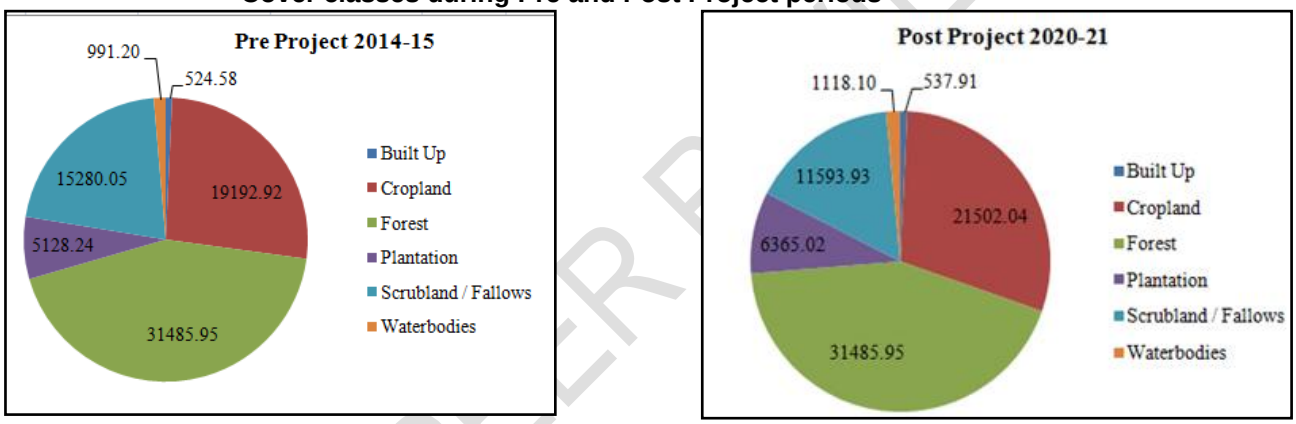
Table 2. Effect of watershed interventions on Land Use Land Cover classes during Pre and Post Project periods

S.No	Classes	Area in Ha					% Change
		Pre-2014-15	% to TWA	Post 2020-21	% to TWA	Change	
1	Built-Up	524.57	0.72	537.91	0.74	13.34	2.54%
2	Cropland	19192.93	26.44	21562.04	29.70	2370.11	12.34 %
3	Forest	31485.94	43.37	31485.94	43.37	0.00	0.00%
4	Plantation	5128.23	7.06	6305.02	8.68	1176.79	22.95 %
5	Scrubland / Fallows	15280.05	21.05	11593.93	15.97	-3686.12	-24.12 %
6	Waterbodies	991.22	1.37	1118.1	1.54	126.88	12.80 %
	Total Watershed Area (TWA)	**72602.94**	**100**	**72602.94**	**100**		

Increase in crop land and plantation in the current study was due to capacity building activities, have taken up by Department of Agriculture through crop technology demonstrations, and training programs etc., there the farmers understood the improved technologies and started cultivating the lands which were left under fallow before the project

had started. Several rainwater conservation activities like percolations tanks, check dams, farm ponds and loose boulder structures etc., were undertaken in the project area which helped in providing irrigation to the crops by using surface and groundwater. [8] made an impact evaluation of 30 micro watersheds in the Jaisalmer District of Rajasthan and reported an average increase in area under agriculture from 882.24 to 917.76 ha due to watershed program. They attributed the increase in cropland area to various rainwater and soil moisture conservation measures taken through watershed activities. As per remote sensing imageries the built-up area increased13,34 ha from 524.57 to 537.91 ha during the project period recording a 2.54% rise [9].

Fig.2 Pictorial Presentation of Effect of watershed interventions on Land Use Land Cover classes during Pre and Post Project periods



2. LULC Change Matrix:

The LULC change matrix has been developed to understand the 'from – to' changes in LULC over the project implementation period. The Change matrix and Change map are shown in Table.3. The diagonal elements in the change matrix show areas unchanged while off-diagonal elements show areas of change. From the Change matrix table, it is inferred that 94.01 % of total project area remained unchanged and 5.99 % of the area has undergone changes. The decline in scrublands by 24.12%, is mainly because of the conversion of scrublands and fallows into Cropland (2370.11 ha), Plantation (1176.79ha) and Waterbodies (126.88 ha). A decrease in wastelands indicates that watershed development program had a positive impact.The increase in cropland (12.34%), plantation (22.95%) and waterbodies (12.80%) in the present study were due to capacity building activities, have taken up by Department of Agriculture, in the form of crop technology demonstration, training programs etc. there by the farmers understood the improved technologies and started cultivating the lands which were left under fallow before the project

had started. [8] made an impact evaluation of 30 micro watersheds in the Jaisalmer District of Rajasthan and reported an average increase in agricultural area from 882.24 to 917.76 ha as a result the of the watershed program. They attributed the increase in cropland area to various rainwater and soil moisture conservation measures taken through watershed activities.

Table 3. Land Use Land Cover Change Matrix

		Post LULC						
	Classes	**Built-Up**	**Cropland**	**Forest**	**Plantation**	**Scrubland / Fallows**	**Waterbodies**	**Total Watershed Area (Ha)**
Pre-Land Use	Built-Up	524.57						524.57
	Cropland	7.37	18531.07		444.42		110.06	19092.92
	Forest			31485.94				31485.94
	Plantation				5128.23			5128.23
	Scrubland / Fallows	5.97	3030.96		732.34	11593.93	16.6	15379.8
	Waterbodies						991.45	991.45
	Total Watershed Area (Ha)	**537.91**	**21562.03**	**31485.94**	**6304.99**	**11593.93**	**1118.11**	**72602.91**

3. Changes in NDVI:

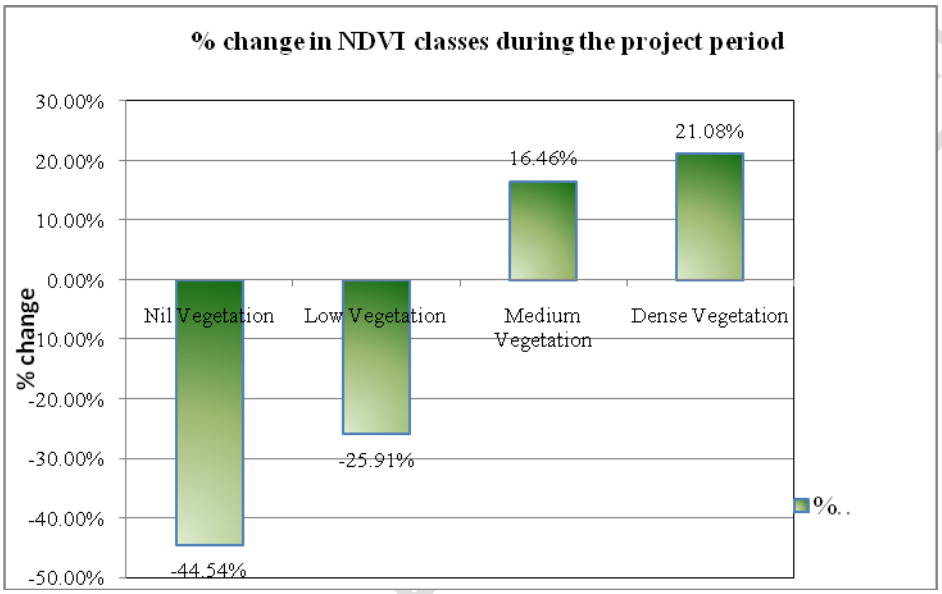
The maps pertaining to Normalized Difference Vegetation Indices in the watershed operational area were generated for both pre-project (2014-15) and post-project (2020-21). These were classified into vegetation vigour classes viz; nil vegetation, low vegetation, medium vegetation and dense vegetation. The results are presented in Fig. 3 and Table 4. From the data, it is clear that an increase in dense vegetation and a decrease in nil, low and medium vegetation. The increase in dense vegetation was from 27072.93 to 36876.98 ha recording an increase of 9804.05 ha resulting in 36.21% during project implementation period from 2014-15 to 2020-21. The increase was due to the conversion of nil, low and medium vegetation areas into dense vegetation. The increase might be the result of greenery created in the area of study due to increased availability of water throughout the year as a result of rainwater conservation techniques like check dams, loose boulder structures, percolation tanks,farm ponds etc [10-16].

Table 4. Effect of watershed interventions on NDVI classes Pre and Post Project periods

S.No.	NDVI Classes	Pre_2014_15		Post_2020_21		Change (Ha)	% Change
		Area (Ha)	% Total Watershed Area	Area (Ha)	% Total Watershed Area		
1	Nil Vegetation	10821.9	14.91	6015.17	8.29	-4806.73	-44.42 %

2	Low Vegetation	15019.14	20.69	11662.03	16.06	-3357.11	-22.35 %
3	Medium Vegetation	19688.97	27.12	18047.8	24.86	-1641.17	-8.34%
4	Dense Vegetation	27072.93	37.29	36876.98	50.79	9804.05	36.21 %
	Total Watershed Area (TWA)	**72602.94**	**100**	**72601.98**	**100**		

Fig. 3. Percent change in NDVI classes During the Project Period



4. Changes in NDWI:

Under NDWI class which gives actual water present on the surface of the project area recorded 111.65 ha in the pre-project and 184.92 ha in the post-project period leading to an increase of 73.27 ha (65.62%). This increase in water area was due to natural resource management plans especially the construction of soil and rain water conservative structures given in table.5. Soil water conservation works has been taken up in the project area would facilitate the recharging of ground water and retention of rainwater on the soil surface which resulted in the increase of water area in the project.

Table 5. Change in Water Features Detected by IRS -2 LISS-IV Imageries

		Water area (ha) in NDWI Classes			
S.No	**Project name**	**Pre-Project (2014-15)**	**Post-Project (2020-2021)**	**Change**	**% change**
1	**Lagari**	43.22	86.00	42.78	98.98
2	**Ducherthi**	10.37	20.29	9.92	95.66
3	**D.Bheemavaram**	13.53	16.10	2.57	18.99

4	**Yarlagadda**	1.24	2.1	0.86	69.35
5	**Pathakota**	0.21	0.63	0.42	200.00
6	**Tadepalli**	1.52	2.37	0.86	56.95
7	**Chintalapudi**	20.02	23.96	3.94	19.68
8	**Akuru**	0.92	1..27	0.35	38.04
9	**Lakkonda**	5.92	10.95	5.03	84.97
10	**Vedullapalli**	4.78	5.64	0.86	17.99
11	**Bandapalli**	0.53	0.82	0.29	54.72
12	**Pamugondi**	3.52	5.44	1.92	54.55
13	**Chopakonda**	1.96	2..39	0.43	21.94
14	**Vadapalli**	3.92	6.96	3.04	77.55
Total		111.65	184.92	73.27	

Table 6. Natural Resources (Soil and Water) Management Works taken up in Watersheds of East Godavari District.

S.No	Category of work	Physical No.
1	Percolation Tanks	769
2	Mini-Percolation Tanks	100
3	Check Dams	53
4	Rockfill Dams	31
5	Farm Ponds	4
6	Loose Boulder Structures	721
7	Gabion Soil moisture Conservation Structures	56

Soil and water conservation harvesting activities are given in table.6 support the project area to enable to supply of irrigation water whenever necessary for saving crops and reaping a good harvest. Water harvesting and conservation structures might enable the rainwater to rest on soil surface and leads to recharge ground water in watershed area of stduy [10-16].

4. CONCLUSION

Significant changes were noticed in LU/LC over the seven years due to PMKSY Watershed project implementation and interventions. The cropland and plantation area was increased by 2370.11 ha (12.34%) and 1176.79 ha (22.95%), respectively, during the project period. The area under scrubland/fallow decreased by 3686.12 ha (24.12%). However, as per remote sensing imageries, the built-up area increased from 524.57 Ha to 537.91 ha during the project period resulting in a 13.34 ha (2.54%) improvement. A substantial increased area under dense vegetation 9804.05 ha (36.21 %) was observed. In NDWI classes the water area increased from111.65 ha to 184.92 ha showing a 65.62% improvement. The increase of water body area in NDWI is a good sign of success in soil and rainwater conservation activities of PMKSY Watershed management in the project area.

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