Study on Land Use/Land Cover and NDVI Changes in Alliveru Watershed Project of West Godavari District, Andhra Pradesh Using Remote Sensing and Geographical Information System

P.V.R.M. Reddy[1], *Sasidhar Kona*[2], *B. Janardhan Reddy*[3], *Sagar Kumar Reddy RV*[4]
R.V. Ramana[5], *D.V.S.R.L. Rekha*[*6], *N. Sundara Ramaiah*[7]

Abstract

Government of India has taken up Integrated Watershed Development Program (IWMP), now Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) watersheds to restore the ecological balance by harnessing, conserving, and developing degraded natural resources such as soil, vegetation, and water in rainfed areas of the country. In Alliveru Project of Buttaigudem Mandal, West Godavari district of Andhra Pradesh, the watershed programme was started during 2013–2014 and completed in 2020–2021. The present study was taken up to assess the impact of watershed activities on LULC and NDVI using Remote Sensing and GIS techniques.Terrain corrected Resourcesat-2 LISS IV for year 2014–15 and 2020–2,1Erdas Imagine 2015, and ArcGIS 10.8 software have been used in the present study. Onscreen visual interpretation technique has been used while carrying out LULC change analysis and image processing has been used to generate NDVI images. NDVI analysis has shown increase in the vegetative cover in the project area. Significant changes were observed in LULC over the project implementation period due to the soil and water conservation activities by the State Level Nodal Agency (SLNA) under Panchayat Raj & Rural Development (PR&RD) Department. The results showed reduction in wastelands by 21.10% and increase in cropland and plantation by 4.47% and 6.36% respectively. Another positive indicator of watershed development in the project area is the increase in waterbodies by 43.88% due to construction of rain water harvesting structures , that is, 43 check dams, 44 percolation tanks, 6 farm ponds and 2 mini percolation tanks.

Keywords : Geographical Information System (GIS), Land Use/Land Cover (LULC), Normalised Difference Vegetation Index(NDVI), Remote Sensing (RS), Watershed

I. INTRODUCTION

India is an agrarian country where agriculture and allied sectors viz. Horticulture, Livestock, Forestry, and Fisheries together contribute 18.8% of the country's Gross Value Added (GVA) for the year 2021–2022 and provides

Manuscript Received : November 2, 2022 ; Revised : November 12, 2022 ; Accepted : November 15, 2022. Date of Publication : December 5, 2022.

P.V.R.M. Reddy[1], *Director (Watershed)*
S. Kona[2], *Commissioner (Watershed)*
B. J.Reddy[3], *Joint Commissioner (Watershed)*
S. K. Reddy RV[4] , *Assistant Commissioner (Watershed)*
R.V. Ramana[5], *Chief Engineer*
D.V.S.R.L. Rekha[*6], *Chief*
N. S. Ramaiah[7], *Socio-Economic Expert ;* ORCID iD : https://orcid.org/0000-0003-2725-1232

[1,2,3,4]State Level Nodal Agency (SLNA), O/o Commissioner Panchayat Raj & Rural Development (PR&RD), PVS Empire, D. No. 12–47, 3rd Floor, Pathuru Road, Beside Reliance Digitals, Tadepalle Village, Guntur District -522 501, Andhra Pradesh, India. Email : scrdap@gmail.com

[5,*6,7] WAPCOS Limited, Koti's Court, 6-3-1239/2/A/601, Rajbhavan Road, Somajiguda, Hyderabad-500 082, Telangana State. Email : wapcoshydmeld@gmail.com

DOI : https://doi.org/10.17010/ijce/2022/v5i2/172608

employment for more than 50% of the nation's workforce. Therefore, it is imperative that to maintain sustainable economy of the country, agriculture must be taken care of. It also assumes prime importance as about 60% of India's agriculture land is rain dependent. As rainfed crops account for 48% area under food crops and 68% area under non-food crops, all efforts need to be taken to address the concerns of rainfed areas. Despite India ranking first in rainfed agriculture globally in terms of areas and production, productivity is among the lowest in the world. 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, low drought power ability, inadequate fodder availability, low productive livestock, resource poor farmers, and inadequate credit availability. Therefore, Government of India has created the National Rain Fed Area Authority (NRAA) as a crucial component of the new watershed policy to address the rain fed area. The watershed is a system based approach that facilitates the holistic development of agriculture and allied activities in the selected watershed area. The stress is on improvement of waste land, run off reduction, water conservation, and protective irrigation mechanism. As recommended by Parthasarathy Committee (2008) Integrated Watershed Management Programme (IWMP) was started with effect from February 26, 2009 for development of areas, combining all other existing rainfed area development programmes. In [2] the period for completing watershed development projects is four to seven years. Subsequent to approval of PMKSY the IWMP was subsumed as one of its components and IWMP is now implemented as WDC-PMKSY with effect from July 1, 2015.

In Andhra Pradesh, the programme is being implemented by State Level Nodal Agency (SLNA) under PR&RD Department. A total of 373 projects are being taken up in the state in five batches in all the districts except Krishna district. In West Godavari district a total of 3projects have been implemented in the 5th batch.

The present study pertains to Alliveru Project which was completed during the year 2020–2021 under Batch-V (2013–2014). The aim of the study was to know the changes in Land Use/Land Cover and NDVI due to implementation of watershed programmes from 2014–2015 to 2020–2021 using Remote Sensing and GIS. Satellite remote sensing provides an excellent source of data from which updated land use/land cover changes can be extracted in an efficient way. This is most effective method which has been adopted by many researchers [3, 4, 5]. This method involves development of spatial and temporal database and analysis techniques. In Alliveru, several natural resources (soil and water conservation) and production system improvement (PSI) activities were taken up during the project period. These programmes were likely to increase the area under cultivation, decrease area in wasteland, conversion of annual cropland to horticulture, change in water body areas, and biomass.

II. STUDY AREA

Alliveru Watershed is a part of ButtayagudemMandal in Drought Prone Area Project (DPAP) block of West Godavari district, Andhra Pradesh. The watershed is located between latitude 81^{0}20'15” and longitude 17^{0}17'47” at ridge point and between latitude 81^{0}19'53” and latitude 17^{0}17'47” at valley point. It is at a distance of 15.40 km from its mandal headquarters and 73.80 km from district headquarters. The watershed is located at an elevation of 86 m above Mean Sea Level (MSL). Highest point in the watershed is 153 m above the MSL. The total geographical area of the watershed is 20,730.20 Hectares (Ha). The average annual rainfall (5 years) in the area is 1,242.20 mm. The temperature in the area is in the range between 31.60^{0}C during summer and 22.22^{0}C in winter. The soilsof the project area are red sandy to red sandy loam with poor water holding capacity and low fertility. There are 20 habitants in the cluster spread over in 5 micro watersheds. The main occupation of the watershed community is rainfed agriculture which is vulnerable to drought, failure of monsoon, and is affected by cyclones as well.

III. MATERIALS AND METHODS

To know the changes in LULCand NDVI due to implementation of watershed programme, Remote Sensing and GIS techniques have been adopted. Based on data availability and cloud free dates for pre and post project period, terrain corrected Resourcesat-2 LISS IV for year 2013–2014 and 2020–2021 have been used in the present study. Survey of India (SOI) topographical sheets on 1:50,000 scale, ground truth data and PMKSY monitoring reports from Panchayat Raj and Rural

Development, Government of Andhra Pradesh have been used for reference.

Onscreen visual interpretation techniques have been used while carrying out LULCchange analysis. In this approach, first the pre-LULC layer has been generated using Pre Resourcesat-2 LISS IV images and ArcGIS 10.8 software. The LULC classes mapped include built up, cropland, forest, plantation, scrubland/fallows and waterbodies. The post-LULC layer has been generated by overlaying the pre-LULC layer onto the Post Resourcesat-2 LISS IV images, identified the changes and edited only the changed polygons (NRSC) [6]. NDVI is calculated using equation (1):

$$NDVI = (NIR - RED)/(NIR + RED) \qquad (1)$$

Where,

NIR Reflection in the near – infrared spectrum.

RED Reflection in the red range of spectrum.

NDVI Measure of the state of plant health based on how the plant reflects light at a certain frequency.

The NDVI basically represents vegetation. Chlorophyll (a

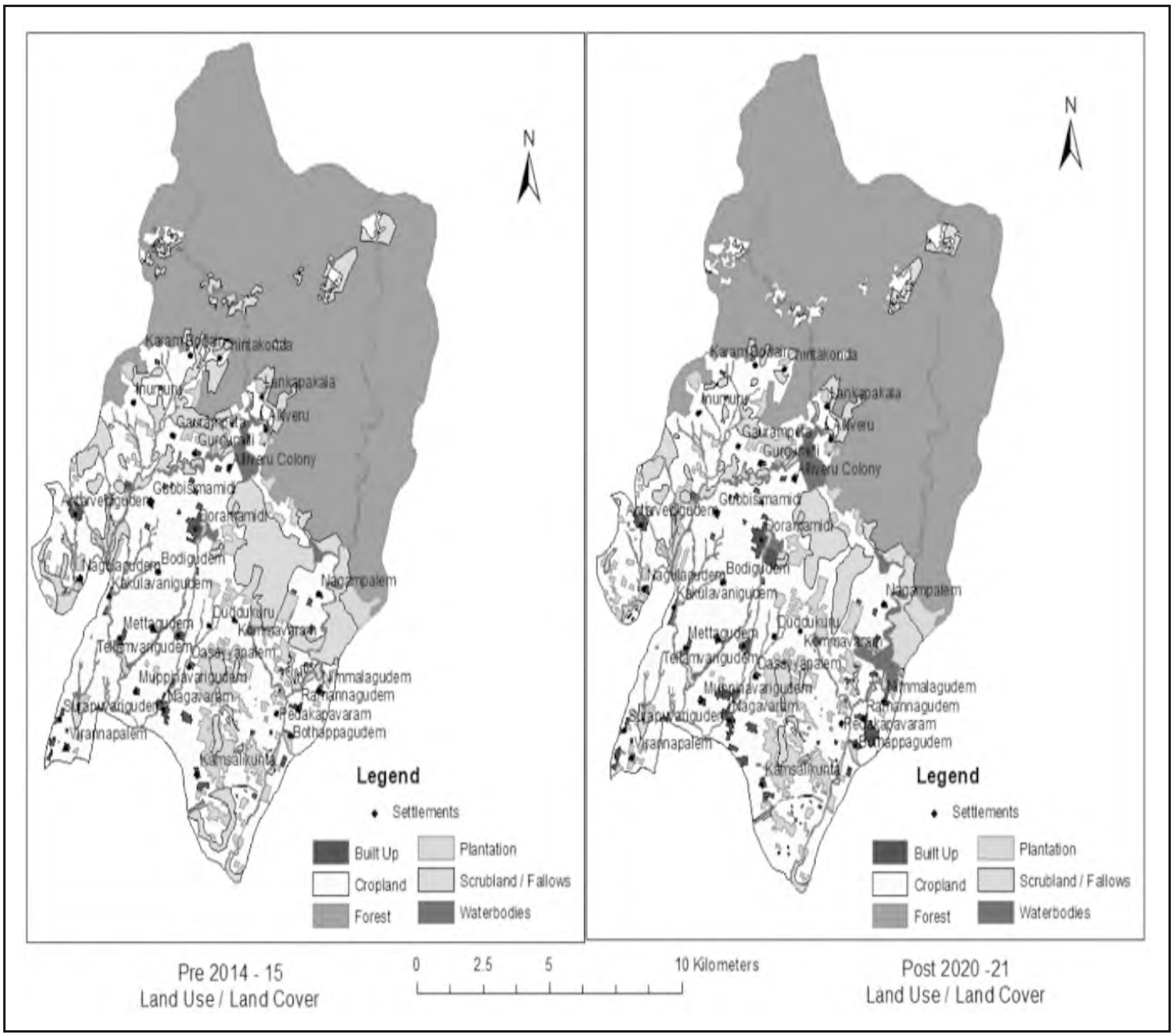

Fig. 1. Pre and Post LULC, Alliveru Watershed

TABLE I.

CHANGE IN LULC IN ALLIVERU PROJECT DURING 2013–2014 TO 2020–2021

S. No.	LULC Category	Pre Project	Post Project	Difference	Difference in %
		Area in Ha			
1	**2**	**3**	**4**	**5 (4–3)**	**6**
1	Built Up	253.25	254.04	0.79	0.32
2	Cropland	6546.65	6839.01	292.36	4.47
3	Forest	9265.60	9265.60	0.00	0.00
4	Plantation	1155.38	1228.84	73.46	6.36
5	Scrubland	2934.12	2315.13	–618.99	–21.10
6	Waterbodies	575.21	827.59	252.38	43.88
7	**Total Watershed Area**	**20730.20**	**20730.20**		

health indicator) strongly absorbs visible light and cellular structure of the leaves strongly reflect near infrared light. The NDVI equation produces values in the range of –1.0 to 1.0, where vegetated areas will typically have values greater than zero and negative values indicate non-vegetated surface. NDVI images for pre and post project have been generated using Erdas Imagine 2015 software. Based on the NDVI values, the watershed area has been classified into four main classes, namely, nil vegetation, low vegetation, medium vegetation and dense vegetation. Besides, analysing the changes in the vegetative cover during the project period, NDVI images have also been used to improve the visual interpretation of LULC mapping.

IV. CONSEQUENCE OF THE METHODOLOGY

Statistical results of pre and post values generated from the above method are compared with the field investigation data. The results are used to analyse the changes taht have taken place during the project period for studying the impact of the watershed programme.

V. RESULTS AND DISCUSSION

Changes in LULC:Spatial distributionLULC categories and area statistics are shown below in Fig.1 and Table I.

The data (LULC maps and table) indicate significant decrease (21%) in wastelands, and increase in cropland (4.47%), and waterbodies (43.88%). Sharma and Sharma [7] reported significant reduction in the waste land, that is, land with shrubs and fallows decreased due to implementation of Integrated Watershed Management Programme in Barsi Block of Jaipur district in Rajasthan. In [8] the authors studied the impact of Watershed Programme in 8 watersheds operated by the government and NGOs, and reported increased gross cropped area ranging between 20 to 78% in the area of project implemention. They also reported that the area under wasteland/permanent fallow decreased by 50% and similar increase in area under pasture land and forest area in 8 watersheds was taken up in Bundelkhand region of Madhya Pradesh. They attributed this to the improvement of land quality of waste land after implementation of IWMP in the study area which was brought under cultivation.

A. Lulc Change Matrix

The LULC Change matrix has been generated to understand the 'from – to' changes in the LULC over the project implementation period. The Change matrix and Change map are shown in Fig. 2 and Table II.

The diagonal elements in the change matrix show areas unchanged while off diagonal elements show areas of change. From Table II it is inferred that 97% of the total project area remained unchanged and 3% of the area has undergone changes. The reduction in wastelands by 21% is mainly due to conversion of wastelands and fallows into built-up (0.80 Ha), cropland (295.99 Ha), plantation (74.76 Ha), and waterbodies (247.44 Ha). Decrease in wastelands is one of the indicators to show that there is a positive impact of the watershed development programme. The increase in cropland (4.47%) and

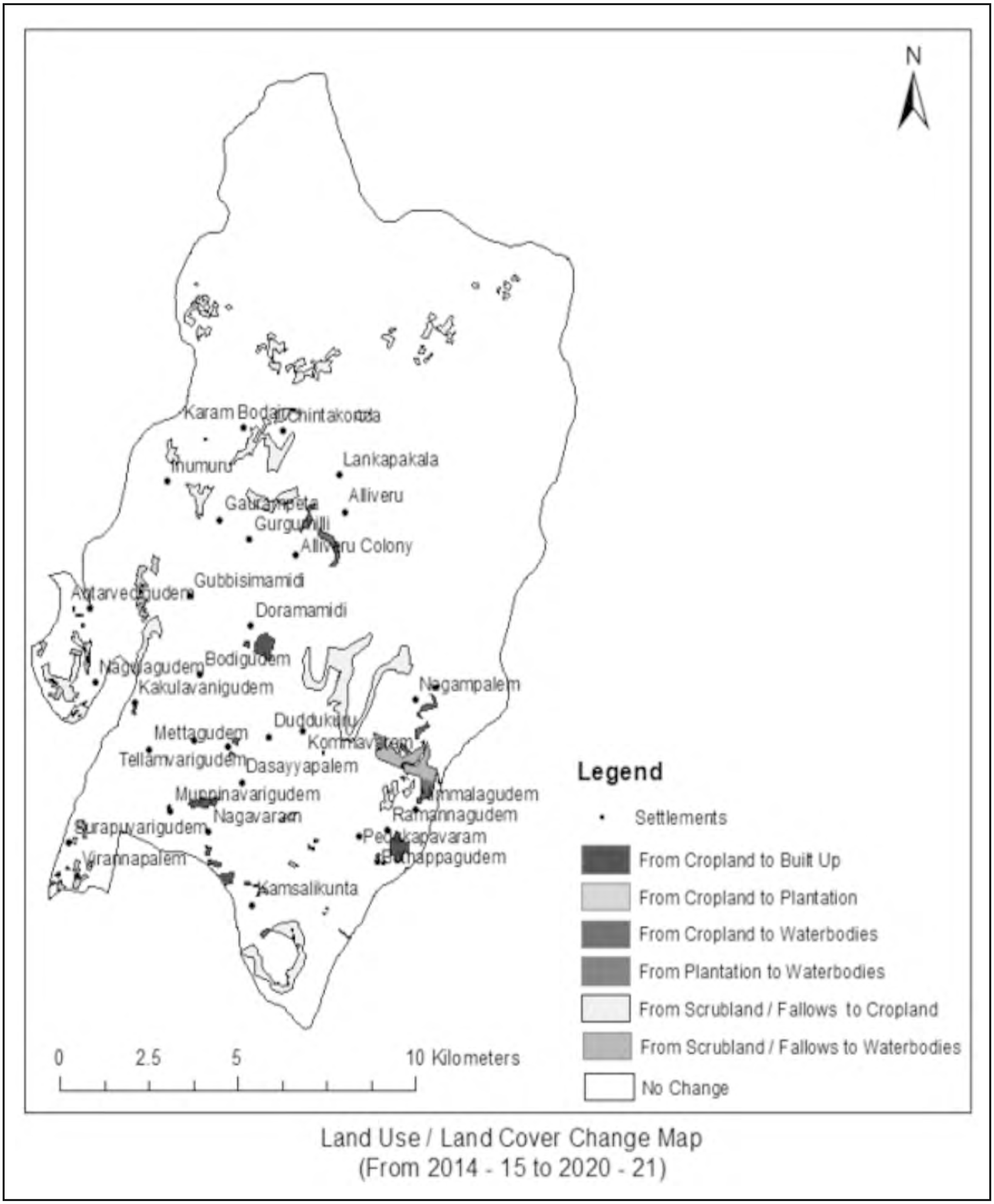

Fig. 2. LULC Change Map, Alliveru Watershed

TABLE II.

CHANGE MATRIX - ALLIVERU WATERSHED, WEST GODAVARI DISTRICT, ANDHRA PRADESH

	Post land Use							
	Classes	**Built-up**	**Cropland**	**Forest**	**Plantation**	**Scrubland / Fallows**	**Water Bodies**	**Total Watershed Area**
Pre-Land Use	Built Up	**253**						253.25
	Cropland		**6543.02**				3.63	6546.65
	Forest			**9265.60**				9265.60
	Plantation				**1154.08**		1.31	1155.38
	Scrubland/Fallows	0.80	295.99		74.76	**2315.13**	247.44	2934.12
	Waterbodies						**575**	575.21
	Total Watershed Area	***254.04***	***6839.01***	***9265.60***	***1228.84***	***2315.13***	***827.59***	***20730.20***

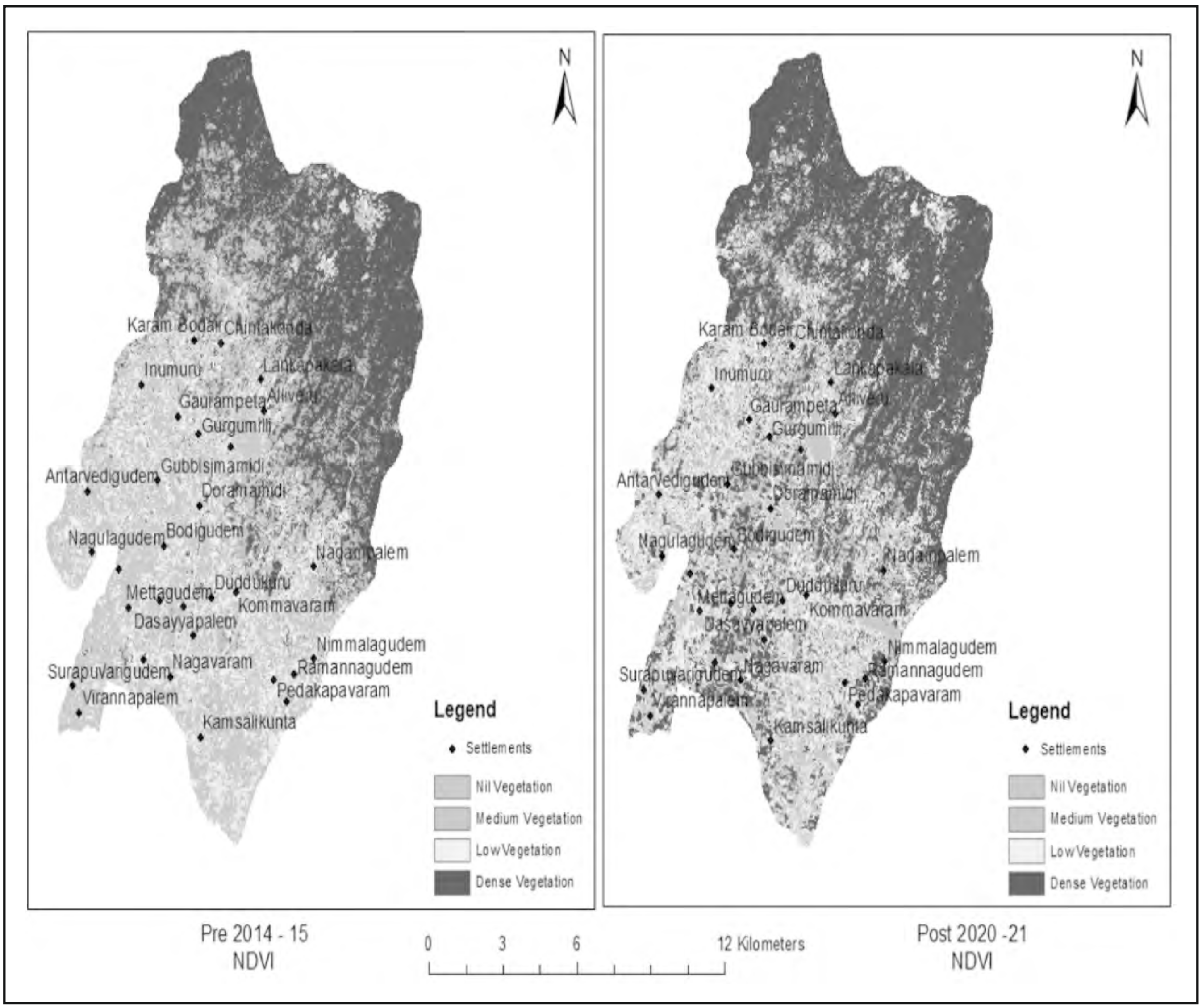

Fig. 3. Pre and Post NDVI, Alliveru Watershed

TABLE III.

CHANGE IN VEGETATION COVER (NDVI) IN ALLIVERU WATERSHED FROM 2014 TO 2020

S. No.	NDVI Classes	Pre Project	Post Project	Difference	Difference in %
		Area in Ha			
1	**2**	**3**	**4**	**5 (4–3)**	**6**
1	Nil Vegetation	5229.85	2411.08	–2818.77	–53.89
2	Low Vegetation	4230.91	4537.23	306.32	7.24
3	Medium Vegetation	4197.69	4564.30	366.61	8.73
4	Dense Vegetation	7071.75	9217.59	2145.84	30.34
5	**Total Watershed Area (TWA)**	**20730.20**	**20730.20**		

plantation (6.36%) in the present study was due to capacity building activities taken up by the Department of Agriculture in the form of crop technology demonstration, training programmes etc. Thereby, the farmers understood the improved technologies and started cultivating the lands which were left fallow prior to the implementation of the project. Painuli, Goyal, Singh, Kalia, and Roy [9] conducted impact evaluation of 30 micro watersheds in Jaisalmer District of Rajasthan and reported an average increase in area under agriculture from 882.24 Ha to 917.76 Ha due to implementation of watershed programme. They attributed the increase in crop land area to various rain water and soil moisture conservation measures taken through watershed activities.

B. Changes in NDVI

The NDVI images were generated for pre-project (2014) and post project (2021) and based on NDVI values. The project area was classified into four vegetation vigour classes, namely, Nil vegetation, low vegetation, medium vegetation, and dense vegetation. The results are presented in Fig. 3. and Table III.

It is clear from the pre and post NDVI data that there is increase in dense vegetation (30.34%), medium vegetation (8.73%), Low Vegetation (7.24%) and nil vegetation (–54.90%).

The increase in these vegetations may be due to lot of greenery created around water bodies like check dams, percolation tanks, loose boulder structures, farm ponds etc. which also reflected in dense vegetation.

C. Changes in Water Body Area

Changes in water body area is a good indicator of rain water harvesting activities taken up in the project area. The increase in waterbodies by 43.88% may be due to construction of rain water conservation structures like percolations tanks, check dams, farm pond, and loose boulder structures etc. during the project implementation period (Table IV). Thakkar, Desai, Patel, and Potdar [10] while studying the impact of Integrated Watershed Management Programme and land use/land cover dynamics in Khan-Kali watershed and Anas River from Gujarat reported 20% to 50% increase in water body area due to implementation of watershed programmes and it can be concluded that watershed management programmes resulted in overall positive impact in the study area.

TABLE IV.

RAIN WATER CONSERVATION WORKS TAKEN UP IN ALLIVERU PROJECT AREA DURING 2014–15 TO 2020–21

S. No.	Rainwater conservation works	No. of works
1	Check Dams	43
2	Percolation Tanks	44
3	Farm Ponds	6
4	Mini Percolation Tanks	2
5	Loose Boulder Structures	45
6	Gabion SMC	8
7	Gabion WHS	3

VI. CONCLUSION

The evaluation watershed project implementation programme using Geospatial Technology (Remote Sensing and GIS) has shown positive impact which is reflected by the fact that wastelands have decreased by 21.10% and cropland and plantations have increase by 4.47%, and 6.36% respectively due to the watershed developmental activities. Another positive indicator of watershed development is the increased availability of water due to construction of rain water harvesting structures like check dams, percolation tanks, and farm ponds. Kumar, Sena, Kurothe, Pande, Rao, Vishwakarma, Bagdi, and Misra [11] mentioned that all the changes in the vegetative cover and waterbodies may not be due to watershed programme. Biophysical indicators of watershed impact evaluation in rainfed areas are highly sensitive to weather condition, mainly rainfall. Even one rainfall event makes a huge difference in the analysis of vegetative cover and water spread area in water bodies.

AUTHORS' CONTRIBUTION

P.V.R.M. Reddy provided the concept for the preparation of the paper and selected the micro-watershed for impact study analysis. Sasidhar Kona reviewed overall ideas of the team while preparing the paper. B. Janardhan Reddy encouraged collection of data related to remote sensing maps and discussed with the team about the changes that took place due to the intervention of Watershed Management Programme. Sagar Kumar Reddy RV was involved in procuring and finalizing the remote sensing maps. R.V. Ramana was involved in the preparation of manuscript and gave valuable guidance in finalizing the data from onscreen visual interpretation techniques while carrying out LULC change analysis. D.V.S.R.L. Rekha was actively involved in processing, tabulation and finalization of the remote sensing and GIS data and interpretation of the data in a meaningful way.N. Sundara Ramaiah collected relevant literature for review write-up.

CONFLICT OF INTEREST

The authors do not have any conflict of interest (financial or non-financial) in the subject matter or materials discussed in the manuscript.

FUNDING ACKNOWLEDGEMENT

The authors are grateful for the financial support rendered by Government of India through Stale Level Nodal Agency (SLNA) of Andhra Pradesh.

REFERENCES

[1]V. R. Reddy and G. J. Syme, *Integrated assessment of scale impacts of watershed intervention assessing hydrogeological and biophysical influences on livelihoods*,2014. Elsevier.

[2] Government of India, “Common guidelines for planning and implementation of watershed development program in India–2008,” [Online]. Available: http://www.jnkvv.org/PDF/29042020124914294201036.pdf

[3]A. K. Thakkar, V. R. Desai, A. Patel, and M. B. Potdar, “Impact assessment of watershed management program on land use/land cover dynamics using Remote Sensing and GIS,”*Remote Sens. Appl.:Society Environ.*,”vol. 5, pp.1–15, 2017.

[4] A. K. Bhandari and A. Kumar, “Feature extraction using normalized difference vegetation index (NDVI): A case study of Jabalpur city,”*Procedia Technol.*,vol.6, pp.612–621, 2012, doi: 10.1016/j.protcy.2012.10.074.

[5] N. Chokkavarapu and V. R. Mandla, “Impact assessment of watershed management on land use/land cover change using RS and GIS: Acase study,”*Int. J. Civil Eng. Technol.*, vol.8, no. 4, pp.394–400, 2017.

[6] *NRSC User manual National Land Use Land Cover Mapping using Multi-temporal Satellite Data*, NRSC, ISRO, Hyderabad,2012, p.4.

[7] G. Sharma and R. N. Sharma, “Application of GIS and remote sensing for impact assessment of integrated watershed management program: A case study of Bassiblock, Jaipur district,”*Int. J. Scientific Technol. Res.,* vol. 9, no. 1, pp. 983–989, 2020.[Online]. Available: http://www.ijstr.org/final-print/jan2020/Application-Of-Gis-And-Remote-Sensing-For-The-Impact-Assessment-Of-Integrated-Watershed-Management-Program-A-Case-Study-Of-Bassi-Block-Jaipur-District.pdf

[8] B. Mondal, A. Singh, S. D. Singh, B. S. Kalra,

P. Samal, M. K. Sinha, D. Ramajayam, and Suresh Kumar, “Augmentation of water resources potential and cropping intensification through watershed programs,” *Water Environ.Res.*, vol. 90, no. 2, pp. 101–109, 2018, doi: 10.2175/106143017x14902968254700.

[9] D. K. Painuli, R. R. Goyal, B. Singh, R. K. Kalia, and M. M. Roy, “Impact evaluation of watershed programs in Jaisalmer District of Rajasthan,” Central Arid Zone Research Institute, Jodhpur, India (Report), 2014.

[10] A. K. Thakkar, V. R. Desai, A. Patel, and M. B. Potdar, “Application of remote sensing in analysis of impact assessment using biomass vigour changes of watersheds,”*J. Environmental Biol.*,vol.38, no. 4, pp.543–551, 2017, doi: 10.22438/jeb/38/4/MS-210.

[11] G. Kumar, D. R. Sena, R. S. Kurothe, V .C. Pande, B. K. Rao, A. K. Vishwakarma, G. L. Bagdi, and P. K. Misra, “Watershed impact evaluation using remotesensing,” *Current Sci.*, vol.106, no.10, 2014, pp.1369–1378, 2014. [Online]. Available: https://www.currentscience.ac.in/Volumes/106/10/1369.pdf

About the Authors

P.V.R.M. Reddy is Soil Scientist with Ph.D degree. His parent institute is Acharya N.G. Ranga Agricultural University, Guntur, Andhra Pradesh. He specialized in soil fertility and plant nutrition. He is presently working with Panchayat Raj and Rural Development and looking after the Watershed Development activities sponsored by Government of India.

Sasidhar Kona is Commissioner, Watersheds, Government of Andhra Pradesh. He is the overall authority for financial sanctions and is the administrative head of watershed. He is responsible for overall activities of the State Level Nodal Agency (SLNA), Government of Andhra Pradesh.

B. Janardhan Reddy is Joint Commissioner, Watershed, Government of Andhra Pradesh. He is responsible for implementation of the approved work plan in various sections of the Watershed Commissionerate and is partly responsible for financial sanctions and auditing.

Sagar Kumar Reddy RV is Assistant Commissioner, Watershed, Government of Andhra Pradesh. He specialized in soil science and he is a product of Acharya N.G. Ranga Agricultural University, Guntur, Andhra Pradesh. He is responsible for grass root level planning and execution of different programmes related to watersheds.

R.V. Ramana is Chief Engineer and Head of Department of WAPCOS, Hyderabad office. He has more than 30 years of experience in the field of Civil Engineering. He is involved in Third Party Quality Control Assurance (TPQCA), Project Management Consultancy (PMC), preparing Detailed Project Report (DPR) of various infrastructure and water resource projects, agriculture projects in Andhra Pradesh and Telangana State as a part of Accelerated Irrigation Benefit Program (AIBP) Project under Pradhan Mantri Krishi Sinchayee Yojana (PMKSY). He has vast experience in Environmental Impact Assessment (EIA) study of water resources, irrigation, infrastructure, hydro and thermal plants, ports and harbours, water treatment plants, ecological studies etc.

D.V.S.R.L. Rekha is a Civil Engineer working as Chief at WAPCOS Hyderabad office. She has 25 years of experience in the field of Water Resources Projects viz. irrigation, water supply, watershed development in addition to Hydro power projects. She has expertise in preparation of project reports, feasibility report, DPR, Project Management supervision, quality control, monitoring of watersheds projects, and report preparation for projects under AIBP (PMKSY) programme.

N. Sundara Ramaiah is a social and economic expert with (Ph.D) and has worked with several government and non-government organizations e.g. NABARD, NABCONS and is presently working with WAPCOS. He has vast experience in monitoring, evaluation, and impact assessment studies, baseline study etc. in various sectors viz. agriculture, water resources, nutrition etc.