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Mahatma Gandhi National Rural Employment Guarantee Act Contribution to Sustainable Development: A Case Study of Rangaon Gram Panchayat, Uttarakhand

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ABSTRACT

Natural Resource Management (NRM) activities are vital to watershed management in various Indian government schemes, including Mahatma Gandhi National Rural Employment Act (MGNREGA), PMKSY-WDC, and IWMP. Launched in 2006, India's Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) is a public welfare initiative aimed at poverty alleviation through a multi-faceted approach. Recognized as a fundamental scheme for achieving the Sustainable Development Goals (SDGs), this study evaluates the impact and outcomes of MGNREGA projects in relation to the SDGs in Rangaon Gram Panchayat, Pauri Garhwal, Uttarakhand. A total of 232 geotags belonging to various categories of activities and administrative boundaries pertaining to gram panchayat and state were taken from Bhuvan GeoMGNREGA portal. Remote Sensing data from LISS-IV and Sentinel-2A sensor for the years 2017-18 & 2023-24 were used to calculate vegetation indices like Normalized Difference Vegetation Index (NDVI) and Vegetation Condition Index (VCI). These indices indicate better vegetation health, more productive and sustainable agricultural practices in the study area. Through community interaction, socio-economic survey covering both quantitative and qualitative data collection was carried out on a 5 point Likert scale to measure impacts and beneficiary satisfaction. The survey reflects the positive impacts of the scheme through increased employment, infrastructure development, and enhanced access to education and healthcare and high participation of women, reflecting towards gender equality.

Keywords: MGNREGA, Rangaon, SDG, GIS, RS, NDVI, VCI

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I. INTRODUCTION

Natural Resource Management (NRM) activities play a crucial role in watershed management under various Indian government schemes. Under the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) of 2005, priority is given to Natural Resource Management (NRM) activities such as soil conservation, water harvesting, and afforestation. These initiatives help recharge groundwater, reduce soil erosion, and increase green cover.

MGNREGA and various NRM activities and their significant impact measurement through geospatial technology such as the availability of satellite imagery at high spatial resolutions has enabled the detection of changes in land use and land cover, crop yield, cropping intensity, crop phenology, etc. (Chahat B et al., 2021; WRIG, 2024; Xueet al., 2017; David et al., 2015). So far, there are only a few remote sensing based monitoring methods for impact assessment of NRM interventions in India (Nalgire and Chinnasamy, 2022; B. Sinha et al., 2017). Vegetation indices (NDVI, VCI) computed based on remote sensing data can be used to derive both quantitative and qualitative assessments of vegetation cover (Xueet al., 2017).

The MGNREGA, which began in 2006 in India, is the public welfare scheme that adopts a multi-pronged strategy to poverty alleviation. MGNREGA has been also recognized as 'core of the core' scheme for achieving SDGs (VNR 2017). Though it has been primarily recognized for its contribution to achieving SDG 1: End Poverty (Singh and Chudasama 2020), the scheme is also considered to have direct linkages with SDG 5: Gender Equality (Kelkar 2011), SDG 8: Decent Work and Economic Growth (Ghose 2015) and SDG 10: Reduced Inequalities (Muzafar and Jahangir 2017) that are monitored under Voluntary National Reviews (VNR). The program has also been noted for its indirect connections to several Sustainable Development Goals including Zero Hunger (SDG 2), Good Health and Well-being (SDG 3), Quality Education (SDG 4), Clean Water and Sanitation (SDG 6), Industry, Innovation, and Infrastructure (SDG 9), Climate Action (SDG 13), Life Below Water (SDG 14), SDG 15 (Life on Land), and SDG 16 (Peace, Justice, and Strong Institutions).These SDGs have targets that align closely with MGNREGA's objectives (Faridi et al., 2017).

Applying GIS analysis in acquiring spatial details of MGNREGA implementation has been initiated recently, as evident from the studies on spatial clustering of works (Divya et al., 2019) and their spatial-temporal visualization (Gupta et al., 2020). GIS provides a valuable tool for deriving high-value spatial insights and depicting visual impacts of development obtained from various sources, including satellite data.

Research Gap

While numerous studies have assessed the implementation and effectiveness of MGNREGA in improving rural livelihoods and promoting environmental sustainability, there is limited research on its specific impact at the Gram Panchayat level, particularly in the context of linking geospatial analysis with socio-economic outcomes. Most existing evaluations focus on state- or district-level analyses (Johnson & Hutton, 2018) overlooking micro-level assessments that could provide granular insights into localized impacts. Additionally, the integration of advanced remote sensing techniques with socio-economic data to quantify contributions toward Sustainable Development Goals (SDGs) remains

underexplored. The role of MGNREGA in achieving specific SDG targets, such as poverty alleviation (SDG 1), gender equality (SDG 5), and sustainable agriculture (SDG 2), particularly in ecologically sensitive regions like Uttarakhand, has not been comprehensively analyzed at Gram Panchayat level. Gupta et al., (2020) have focused at district level study on SDG wherein MGNREGA works in various categories were linked to the SDGs for various districts of Uttarakhand.

Background of the Study

Watershed management activities, such as check dam construction, contour bunding, and farm pond creation, align with sustainable rural development by ensuring long-term food and water security. Various schemes of Government of India like PMKSY (Pradhan Mantri Krishi Sinchayee Yojana)- WDC (Watershed Development Component) 1.0 & 2.0, RKVY (Rashtriya Krishi Vikas Yojana), PDMC (Per Drop More Crop), HKKP (Har Khet Ko Pani) etc. focus on the various activities leading to soil and water conservation. By implementing practices such as micro-irrigation and field-level water management, PMKSY helps rejuvenate degraded watersheds and optimize water resources in drought-prone areas; IWMP (Integrated Watershed Management Programme, 2008), presently merged with PMKSY was the cornerstone of watershed management in India and focused on rainwater conservation, soil conservation, and improve vegetation. Through its NRM approach, IWMP promoted sustainable agriculture, improved soil and water consecration and restored ecological balance in rural landscapes by enhancing soil moisture and reducing runoff (MoRD, 2016).

The objectives of the present study are:

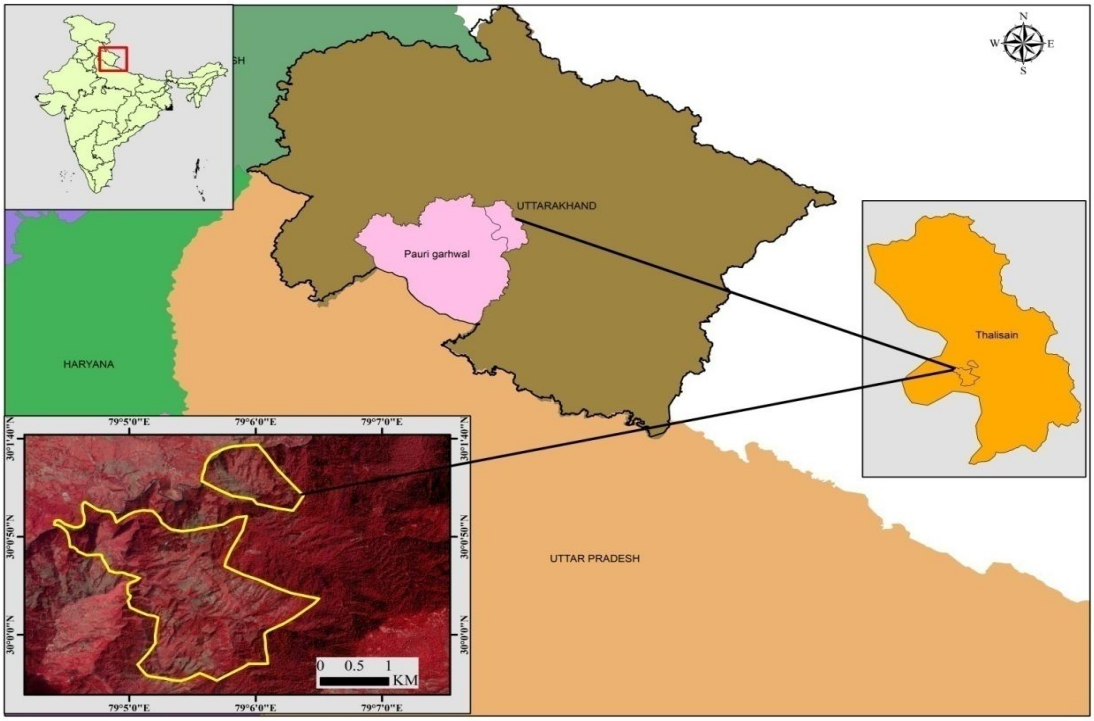
- To evaluate the impact and outcomes of MGNREGA individual works by integrating geospatial analysis with socio-economic surveys, providing a comprehensive assessment of its effectiveness

- To analyze the linkage between MGNREGA's impacts and the Sustainable Development Goals (SDGs), focusing on contributions to poverty reduction, environmental sustainability, and improved livelihoods

II. STUDY AREA

Rangaon Gram Panchayat was selected for this study based on its MGNREGA work performance as well as availability of satellite images. The study area is the part of Thalisain Block which is under Pauri Garhwal district, situated in the North Indian state of Uttarakhand. The geographical location of the study area is extending from 29.59'30" North to 30.1'30' North latitude and 79.4'30" East to 79.6'30" East longitude (Figure-1). The total geographical area is 516.20 ha. Topographically the area is under hilly terrain with high altitude (2,348 m from above MSL). Administratively the Gram Panchayat is consisted of 6 villages, namely Dhuni, Doria, Inddhar, Raj Gaun, Rangaon and Sundar. The major rock types are granite gneiss. The Purvi Nayar, a tributary of the Nayar River, originates from the Ganga River system and flows through the study area. The average annual summer and winter temperature ranges from 150-200Cand -50 – 100C accordingly. The average annual precipitation is 1,690 mm. The total populations are 1031 (2011Census). Groundwater is the main source of drinking water. The main plant species includes Long Pine trees, Oak, walnut, lemon and Kafal.

Figure-1: Location Map of Rangaon GP, Uttarakhand



Source: Generated by authors from mentioned data sources

The socio-economic profile of Rangaon reflects a predominantly agrarian economy, supplemented by small-scale animal husbandry and reliance on forest resources. Traditional terrace farming is practiced, with crops like wheat, paddy, and millets grown during different seasons. However, the challenging terrain and lack of irrigation facilities often result in low agricultural productivity. The spatial distribution of the asset is shown in Figure-2.

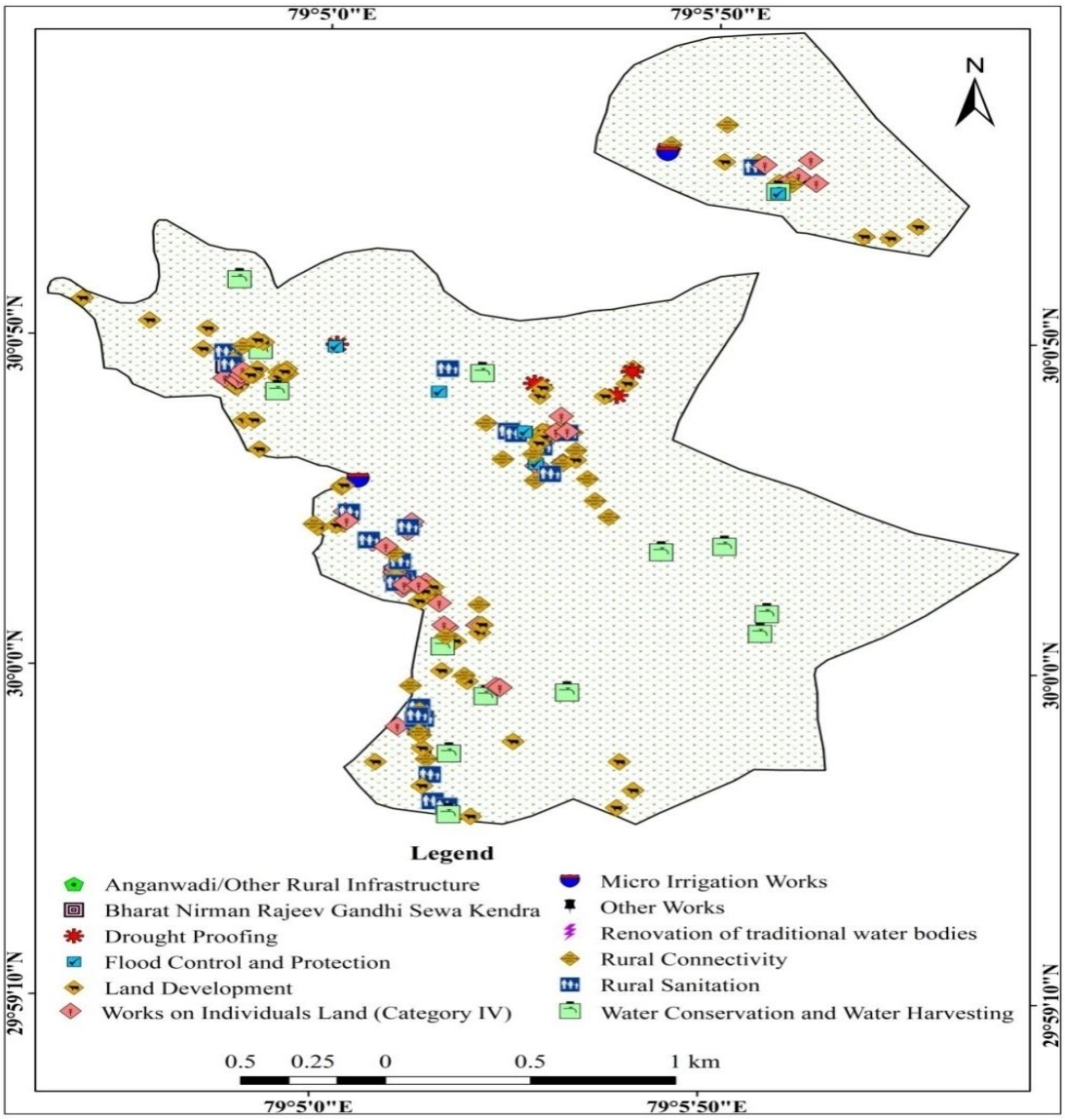
Table-1 shows the gender distribution of MGNREGA workers, with females comprising 51% (390) of the workforce and males accounting for 49% (381). The near-equal participation highlights significant progress towards gender inclusion and equality in employment under MGNREGA.

Table-1: MGNREGA Registered Job Holders

Villages	No. of Registered		Male	Female
	Household	Persons		
Dhuni	44	139	71	68
Doria	31	94	40	54
Idhdhar	33	117	60	57
Rajgaun	0	0	0	0
Rangaon	78	250	125	125
Sunder	54	171	85	86
Total	240	771	381	390

Source: https://nregastrep.nic.in/netnrega/

Figure-2: Major Category of MGNREGA Works and their Geotags



Source: Generated by authors from mentioned data sources

III. DATA

The data used in this study encompasses both geospatial and field survey components to ensure a comprehensive analysis. It includes remote sensing datasets, socio-economic survey findings, and geotagged records of MGNREGA works within the Gram Panchayat.

Remote Sensing Data

This study utilized satellite imagery and derived products to analyze spatial and temporal patterns. In this study, satellite data and products used are given in Table-2.

Table-2: Satellite Data/products used in the Study

Satellite data/ Product	Year	Generated Outcomes
SIS-DP	2018-23	Land-use/Land-cover (base layer)
LISS-IV	2017 & 2024	Land-use/Land-cover
Sentinel 2A	2017 & 2024	NDVI & VCI

Source: Modelled by authors

Socio-Economic Field Survey

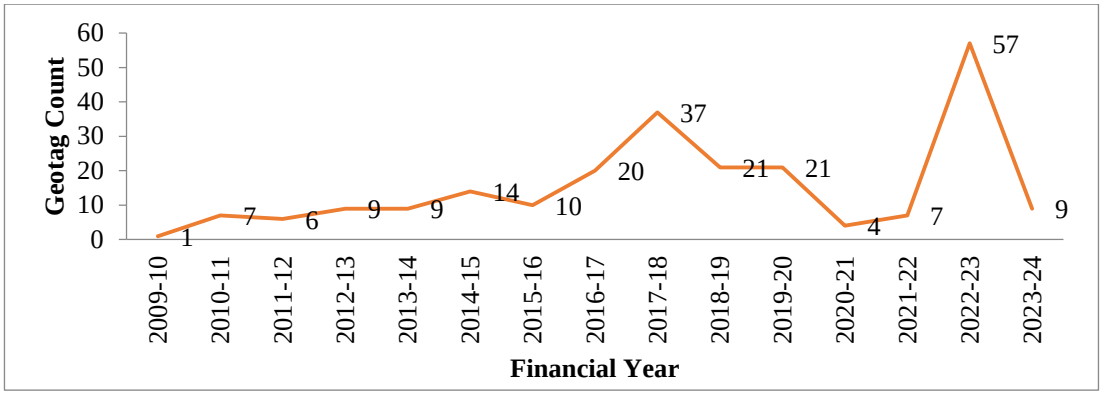
Field data collection was carried out at the Gram Panchayat level with the primary objective of conducting ground truthing for MGNREGA Asset impact evaluation, land-use classification and employing a comprehensive mixed-methods both qualitative and quantitative surveys among MGNREGA beneficiaries. During the field 35 geo-tagged locations were visited in the study area. The Gram Panchayat has done most of their work on land development, water conservation and water harvesting and most of them have been done in individual's land/property. Majority of the individual beneficiary work has been done for land levelling in the GP.

Distribution of MGNREGA Works in Gram Panchayat through Bhuvan Geo-MGNREGA Portal

Over the span of 15 years, a total of 232 works have been successfully completed under MGNREGA program in the study area. The peak years for work completion were 2016-17 with 69 works. Quality check has been performed on the data for correctness, completeness, and consistency as it constitutes an essential parameter of large data. The records having missing work category names and those under work on individual land categories were mapped into the corresponding work categories based on the sub-category name available in the attribute table. The sub-category assets include the afforestation, anganwadi centre (AWC), block plantation in fields-Horticulture-Community, boulder removal, cattle shed, construction of earthen contour bund, water harvesting ponds, distributaries canal, embankment, mini percolation tank, development of waste land, earthen bunding, earthen road, farm pond, gravel road, cross drainage, Kharanja (Brick/Stone), Levelling/shaping of wasteland land, renovation of flood/ diversion channel for community, individual household latrines (IHHL), lift irrigation, mini percolation tank, production of building material, roof top rain water harvesting and vermi composting.

Figure-3 explains the trend in the number of geotags recorded annually for MGNREGA work completions from 2009-2010 to 2023-2024. The line graph shows a fluctuating pattern, beginning with a single geotag in 2009-2010 and gradually increasing over the years. There is a noticeable peak of 37 geotags in 2017-2018, followed by a stable period with around 21 geotags annually from 2018-2019 to 2019-2020. A decline is observed in 2020-2021 and 2021-2022, with only 4 and 7 geotags, respectively. However, there is a sharp spike to 57 geotags in 2022-2023, the highest in the entire period.

Figure-3: Assets with Peak Year of MGNREGA Activities

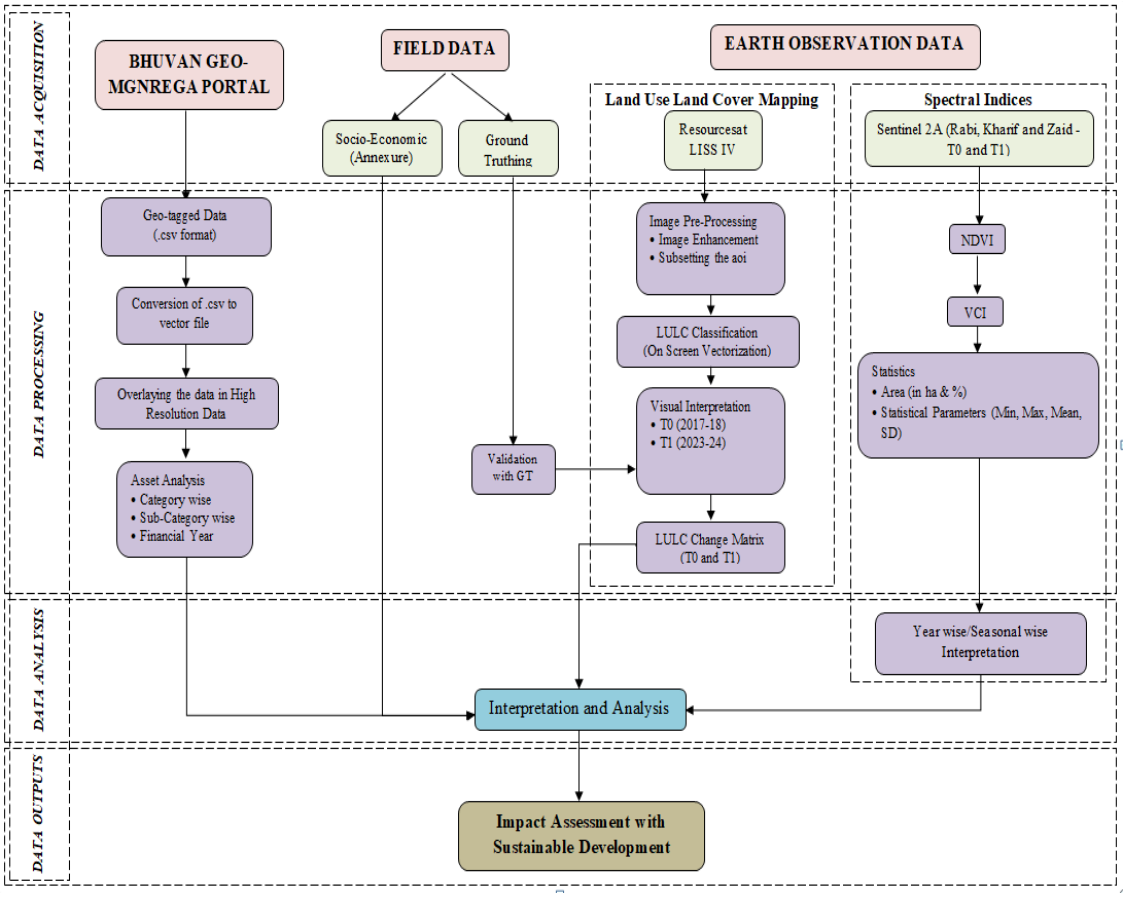


Source: Generated by authors from mentioned data sources

IV. METHODS

The methodology has been formed with remote sensing data, field survey, distribution of MGNREGA works and spectral indices (Figure-4).

Figure-4: Methodology used in the Study



Source: Modelled by authors

Land-Cover Classification

The land cover classification of 2017-18 & 2023-24 with reference to the Space-based Information Support for Decentralized Planning (SIS-DP) at a 1:10,000 was made and ground truthing was performed to validate the satellite image interpretations, ensuring accuracy in the classification of various land cover categories (Figure-5).

Spectral Indices

Spectral Indices such as NDVI and VCI have been used in the present study to analyze vegetation health and dynamics which are as follows:

Normalized Difference Vegetation Index (NDVI)

The NDVI is a numerical measure that leverages the visible and near-infrared bands of the electromagnetic spectrum. NDVI has been widely applied in vegetation research, serving to estimate crop productivity, monitor pasture health, and evaluate rangeland carrying capacities, among other uses. In the context of MGNREGA, NDVI helps assess the impact of land and water conservation projects on vegetation cover and productivity. The higher NDVI values in areas with MGNREGA interventions (e.g., afforestation, agricultures, and water conservation structures) could indicate positive effects on local vegetation and ecosystem health, aligning with MGNREGA's goals of sustainable resource management and livelihood support (Figure-6).

$$NDVI = \frac{(NIR - R)}{(NIR + R)}$$

Vegetation Condition Index (VCI)

The VCI assesses the recent NDVI in relation to the range of values recorded during the same period in previous years. The VCI is presented as a percentage and indicates the position of the observed value between the minimum and maximum values from the previous year. Monitoring the VCI can be an assessment of drought resistance, agricultural productivity, and the effectiveness of drought mitigation efforts, as well as enhancements in land productivity in MGNREGA-implemented areas (Figure-7).

$$VCI = \frac{NDVI - NDVI \underset{min}{\longrightarrow}}{NDVI \underset{max}{\longrightarrow} - NDVI \underset{min}{\longrightarrow}}$$

Relating MGNREGA activities to relevant SDGs

MGNREGA activities contribute significantly to achieving various SDG targets by creating durable assets and enhancing rural livelihoods. The table below illustrates the alignment of specific MGNREGA asset categories with relevant SDG targets and indicators of the study area (Table-3).

Table-3: SDG Targets/Indicators Vis-à-vis MGNREGA Assets Categories, Rangaon GP

SDGs	SDG Target & Indicators	MGNREGA Work Category/Sub-Category	Assets Count
SDG 2 (Zero Hunger)	Target: By 2030, make sure that food production systems are sustainable and put in place resilient agricultural practices	Land development: Construction, repair and maintenance of bunds, land levelling, reclamation of land and plantation;	74
	Indicator 2.4.1: Proportion of agricultural area under productive and sustainable agriculture	Micro-irrigation works: Construction, lining, renovation, repair and maintenance of canals	8
SDG 3 (Good Health and Well-being) SDG 4 (Quality Education)	Target 4.2: Make sure that all boys and girls have access to high-quality pre-primary education	Anganwadi/other rural infrastructure Anganwadi centres and construction of Anganwadi for community	1
	Indicator 4.2.1: The percentage of children under five developing normally in health, education, and psychosocial well-being.		
SDG 5 (Gender Equality)	Target 5: Achieve decent work, full and productive employment, and equal compensation for equal work	Gender: There are a total of 450 active workers, among them 49 % is female workers (UK State MGNREGA)	223
	8.3.1 Proportion of informal employment in total employment, by sector and sex		
SDG 6 (Clean Water and Sanitation)	Target 6.2: End open defecation and provide everyone with access to adequate and equitable sanitation and hygiene	Rural sanitation Subcategories: IHHL, toilets and solid and liquid waste management.	29
	Indicator 6.2.1: Proportion of population using safely managed sanitation services.		
SDG 9 (Industry, Innovation and Infrastructure)	Target 9.1: Create dependable, resilient, sustainable, and high-quality infrastructure.	Rural connectivity: Construction, repair and maintenance of various grades of roads	37
	Indicator 9.1.1: Proportion of the rural population who live within 2 km of an all-season road		
SDG 13 (Climate Action)	Target 13.2: improve national preparedness and ability to adjust to risks associated with climate change and natural disasters.	Drought proofing: Plantation, afforestation and nursery raising;	5
	13.1.3: Proportion of local governments that adopt and implement local disaster risk-reduction strategies in line with national disaster risk-reduction strategies	Renovation of traditional water bodies: repair and maintenance of traditional water bodies	1
		Water conservation and water harvesting: Construction of various types of check dams, bunds, tanks etc.	14
SDG 15 (Life on Land)	Target 15.3: Combat desertification, repair damaged land and soil, drought, floods, and desertification.	Flood control and protection: Construction, repair & maintenance of drains, channels, embankments, etc.	6
	Indicator 15.3.1: Proportion of land degraded over total land area		

Source: https://sdgs.un.org/goals

V. ANALYSIS AND FINDINGS

The results present an integrated analysis of geospatial and socio-economic dimensions to evaluate the impacts of MGNREGA interventions. It highlights changes in land use, vegetation health, and socio-economic conditions in the study area.

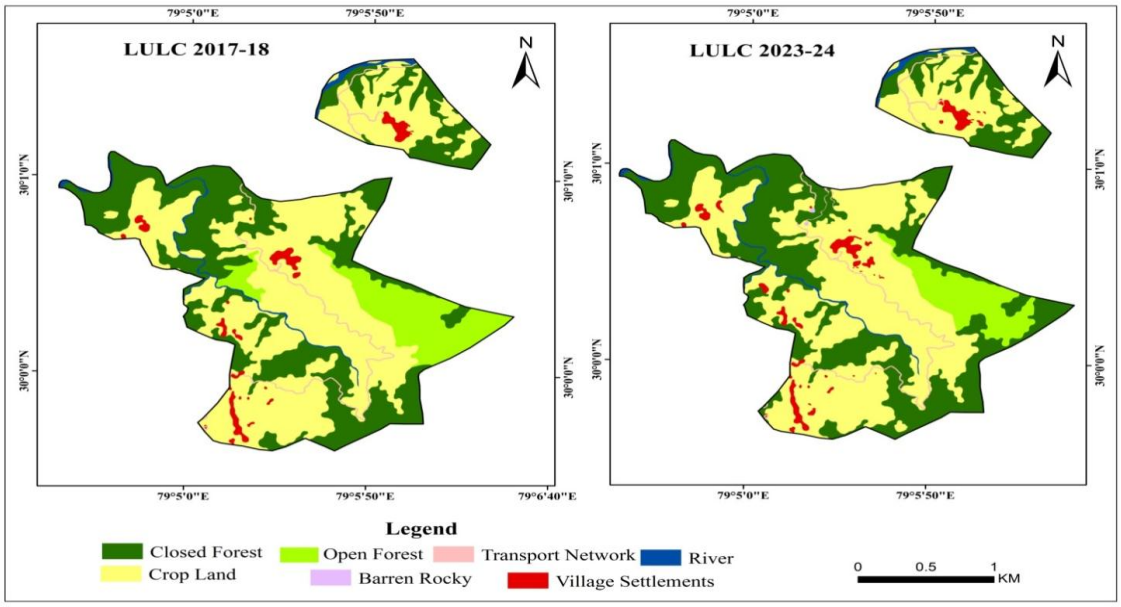
Land-Cover Change

Table-4: Land-Cover Change Matrix of 2017 & 2024

2017-18 Area (ha)	2023-24 Area (ha)							
	Barren Rocky	Closed Forest	Crop Land	Open Forest	River	Transport Network	Village Settlements	Grand Total
Closed Forest		175.34	0.89					176.23
Crop Land	0.26	2.33	260.75				2.32	265.67
Open Forest		18.63		35.93				54.57
River					8.84			8.84
Transport Network						0.37		0.37
Village Settlements							10.54	10.54
Grand Total	0.26	196.31	261.64	35.93	8.84	0.37	12.86	516.20

Source: Generated by authors from mentioned data sources

Figure-5: Land-cover Map of 2017-18& 2023-24



Source: Generated by authors from mentioned data sources

Table-4 and Figure-5 illustrate changes in land cover between 2017-18 and 2023-24. It shows an increase in closed forest area from 176.23 to 196.31 hectares, indicating forest densification, while open forest area has decreased from 54.57 to 35.93 hectares, suggesting a reduction in open forest cover. Village settlements

have expanded from 10.54 to 12.86 hectares, reflecting rural development. The river and transport network areas remain constant at 8.84 and 0.37 hectares, respectively. Crop land has slightly decreased and contributed into village settlements and rural development.

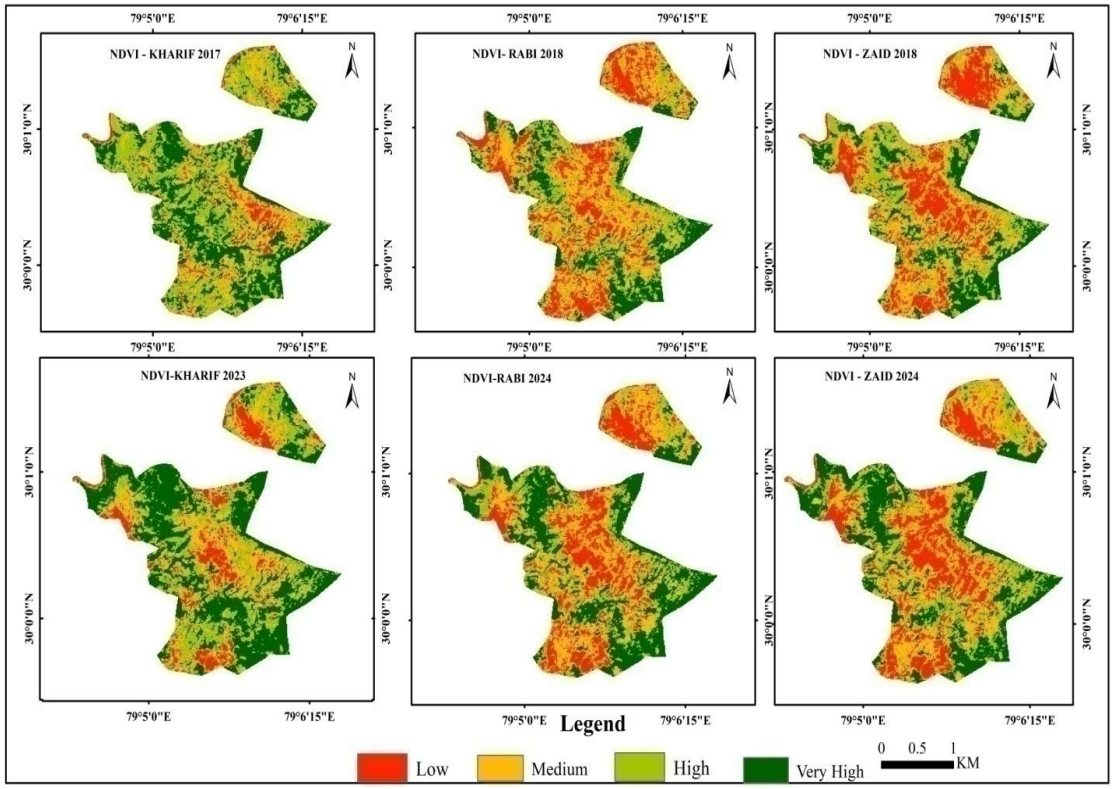
Normalized Difference Vegetation Index (NDVI)

Table-5 NDVI Statistics of 2017-18 and 2023-24

	Kharif				Rabi				Zaid			
Year	Min	Max	Mean	STD	Min	Max	Mean	STD	Min	Max	Mean	STD
T0	0.14	0.76	0.62	0.6	0.01	0.69	0.38	0.11	0.13	0.69	0.4	0.1
T1	0.1	0.96	0.67	0.16	0.1	0.87	0.55	0.17	0.06	0.94	0.52	0.19

Source: Generated by authors from mentioned data sources

Figure-6: Normalized Difference Vegetation Index of 2017-18& 2023-24



Source: Generated by authors from mentioned data sources

The NDVI statistics of Kharif, Rabi, and Zaid for the years of 2017-18 (T0) and 2023-24 (T1) which are indicates of vegetation health conditions. In the Kharif season, T0 had a mean NDVI of 0.62 with high variability (0.60), while T1 showed a slightly higher mean of 0.67 with much lower variability (0.16). For the Rabi season, T0 had a mean NDVI of 0.38 with low variability (0.11), and T1 had a higher mean of 0.55, with slightly more variability (0.17). In the Zaid season, T0 had a mean of 0.40 with minimal variability (0.10), while T1 shows an increased mean of 0.52 with

higher variability (0.19). This reveals that vegetation health in T1 generally improved across all seasons compared to T0, with less variability in Kharif but more variability in the other seasons (Table-5 and Figure-6).

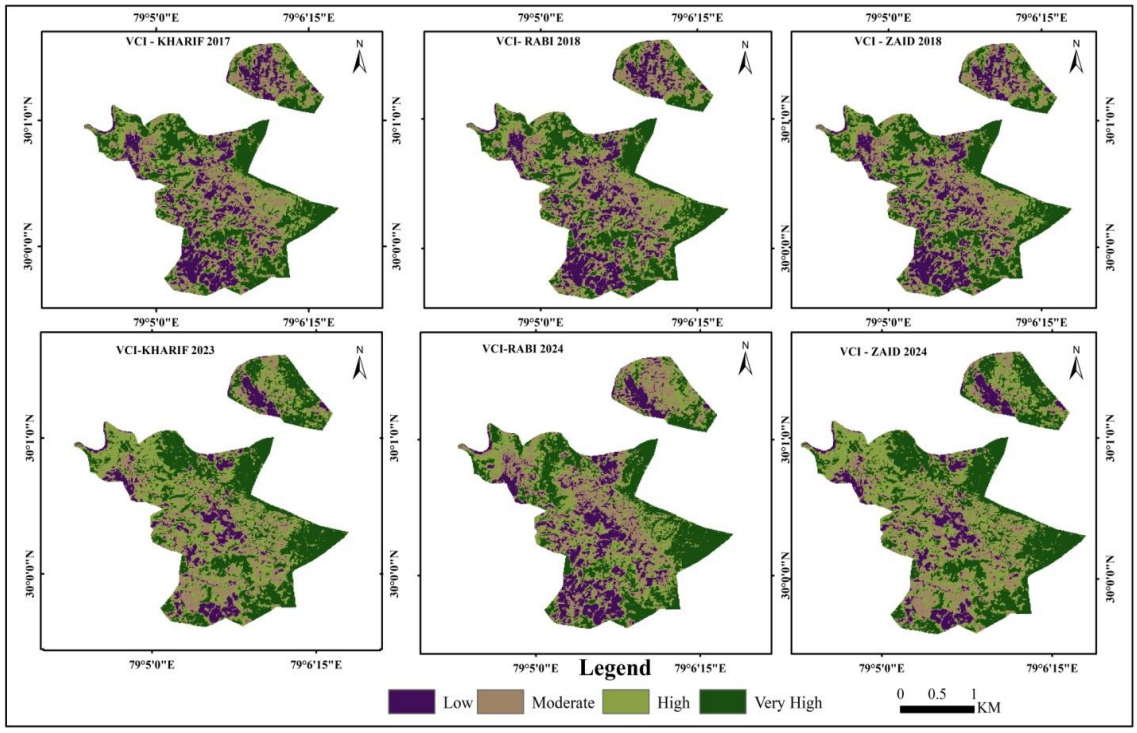
Vegetation Condition Index (VCI)

Table-6: VCI Statistics of 2017-18 and 2023-24

	Kharif				Rabi				Zaid			
Year	Min	Max	Mean	STD	Min	Max	Mean	STD	Min	Max	Mean	STD
T0	21.49	90.45	60.4	13.13	21.49	90.45	60.4	13.13	21.49	90.45	60.4	13.13
T1	17.25	114.5	76.21	15.16	18.28	97.24	63.27	15.23	18.04	92.07	63.98	14.74

Source: Generated by authors from mentioned data sources

Figure-7: Vegetation Condition Index of 2017-18 & 2023-24

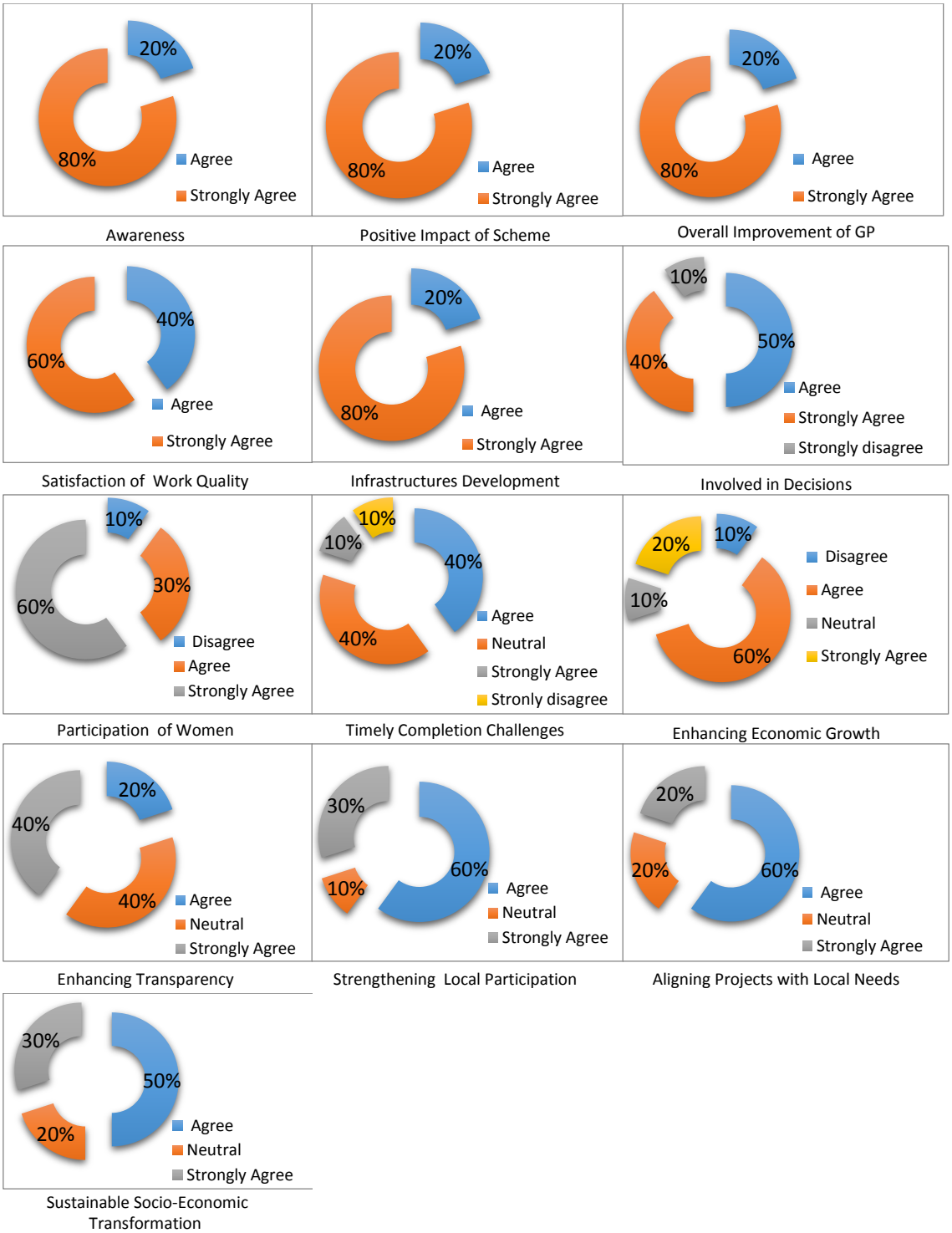


Source: Generated by authors from mentioned data sources

Table-6 and Figure-7 show an improvement in vegetation health from 2017-18 (T1) to 2023-24 (T2) across all agricultural seasons. In the Kharif season, the mean VCI increased from 60.40 to 76.21, with a significant rise in the maximum value from 90.45 to 114.50 and higher variability (from 13.13 to 15.16). Similarly, during the Rabi season, the mean VCI increased from 60.40 to 63.27, accompanied by slight increases in the maximum value and standard deviation. In the Zaid season, the mean VCI rose from 60.40 to 63.98, with minor changes in maximum values and variability. These trends suggest an overall improvement in vegetation conditions, indicative of healthier and more vigorous plant growth over the years.

Socio-Economic Survey

Figure-8: Social perspectives on MGNREGA Scheme



Source: Generated by authors from mentioned data sources

For socio economic data analysis and interpretation the mixed method questionnaire was being used.Qualitative information was collected through comprehensive interviews conducted with chosen beneficiaries, providing nuanced insights into project impacts and implementation experiences. Quantitative surveys utilized a 5-point Likert scale to assess impacts and satisfaction levels among respondents, including both project beneficiaries and job card holders who completed 100 days of employment. Following data collection, analysis involved generating donut charts (Figure-8) to visually depict survey findings. These charts effectively illustrate the distribution of responses regarding project impacts and beneficiary satisfaction. This comprehensive methodology facilitated a thorough examination of qualitative insights and quantitative data, offering valuable perspectives for further analysis and decision-making processes concerning the project's effectiveness and future directions.

VI. DISCUSSION

The combined analysis of LULC, NDVI, and VCI along with socio-economic survey data provides insight to the state of SDG as mapped in the study area through the lenses of MGNREGA works. The LULC changes (Fig. 5) from 2017-18 to 2023-24, particularly the expansion of agricultural land, align with SDG 2 (Zero Hunger) by supporting Target 2.4, which focuses on sustainable food production and resilient agricultural practices (FAO, 2017; UN, 2023). The land development and micro-irrigation efforts of MGNREGA, as detected through changes in land cover and water bodies, support enhanced agricultural productivity and contribute to SDG 2 (FAO, 2017). The modest expansion of rural built-up areas and infrastructure, such as the transport network, reflects progress towards SDG 9 (Industry, Innovation and Infrastructure), which emphasizes resilient infrastructure development (World Bank, 2021). As the foundation of expressway networks, rural roads play a crucial strategic role in advancing regional economic growth, raising rural inhabitants' quality of life, and boosting rural consumption. Evaluating the extent of transportation infrastructure development and its effects on economic growth and people's well-being is the main objective of SDG 9 (Xu, Bai & Chen, 2019). The satellite-based monitoring of infrastructure developments, such as roads and sanitation facilities, aligns with improvements in rural connectivity and access to essential services, strengthening the survey findings related to SDGs 9 and 6 (UN, 2023; WHO, 2021). The stable retention of a significant portion of closed forest area indicates efforts towards achieving SDG 15 (Life on Land) is necessary for effective forest conservation and combating land degradation as maintain intake forest areas (FAO, 2020; IPBES, 2019).

The NDVI (Fig. 6) improvements across the Kharif, Rabi, and Zaid seasons indicate better vegetation improvement and increased agricultural production, due to the work undertaken are mainly linking to SDG 2 (Zero Hunger), SDG 13 (Climate Action), and SDG 15 (Life on Land) that are interrelated. The most noticeable trade-offs between SDG 15 and SDG 2—"Zero hunger—End hunger, achieve food security and improved nutrition, and promote sustainable agriculture"—were noted by Fonseca et al. (2020). This is due to the fact that increasing and intensifying agricultural land use is thought to be a major contributor to deforestation, biodiversity loss, and land degradation. The rise in NDVI reflects more productive and sustainable agricultural practices (FAO, 2017; IPCC, 2019; UN, 2023) aligning with Target 2.4 of SDG 2, which emphasizes sustainable food production systems.

MGNREGA initiatives, such as land development and micro-irrigation, have likely enhanced soil quality and water availability, contributing to these improvements. The improved NDVI across three seasons have led to overall improvement in vegetation condition as seen from VCI (Figure-7).

The link between the findings of remote sensing application and the output of the socio-economic survey (Figure-8) provides a comprehensive view of MGNREGA's impact on various Sustainable Development Goals (SDGs). The study reveals that the high levels of awareness (80%) and women's participation (60%) contribute to SDG 4 (Quality Education) and SDG 5 (Gender Equality) by empowering communities and promoting inclusivity. This empowerment aligns with the government's commitment to transforming Anganwadi Centres (AWCs) into vibrant hubs for early childhood development, serving as the primary village outpost for health, nutrition, and early learning. The positive impacts of AWCs on children's health and education, as well as on participating mothers, have been substantiated by multiple studies across the country (Chudasama et al. 2015; Rajsinh and Vinayak 2020; Singh et al. 2015). Women's empowerment is positively impacted by MGNREGA, benefiting them both individually and at the community level. Women gain on an individual basis as they can work for themselves, save money for their personal needs; contribute to family expenses and more (Chatterjee. S, 2014). Positive impacts on employment (80%) and economic growth (60%) align with SDG 1 (No Poverty) and SDG 8 (Decent Work and Economic Growth), while infrastructure development (80%) and addressing local needs (60%) support SDG 9 (Industry, Innovation, and Infrastructure). Enhancing economic growth and achieving durable socio-economic change (60%) contribute to SDG 10 (Reduced Inequalities). Improving rural infrastructure supports sustainable poverty alleviation initiatives while also promoting employment opportunities through industrial development (Samanta, 2015). The scheme's focus on transparency (80%) and governance strengthens SDG 16 (Peace, Justice, and Strong Institutions), and its role in addressing environmental challenges indirectly supports SDG 13 (Climate Action) and SDG 15 (Life on Land). The contribution of MGNREGA as an effective safety net that enhances climate change resilience through asset creation has been widely acknowledged (Godfrey Wood and Flower, 2018). The program's works on both community and individual lands, particularly those related to natural resource management, provide multiple environmental benefits (Tiwari et al. 2011).

However, measuring socioeconomic impacts with remote sensing has few limitations and restrictions. Improved health, education, and empowerment are examples of socio-economic advantages that may not be fully captured and quantified by remote sensing data, which largely reflects physical and environmental changes. Limitations in the availability, cost, licensing, and access to high-resolution real-time imagery and image processing tools, for instance, make it difficult to map and analyze sustainable transportation in developing countries; estimating income distribution using remote sensing data remains difficult for assessing quality of life; and the impact of Anganwadi centres on child health or the economic empowerment of women through employment may not be directly observable through satellite imagery (A. Ram et al. 2020). Furthermore, ground-truthing is frequently necessary to validate results from remote sensing data, particularly when assessing the socioeconomic effects of initiatives like gender equality or rural sanitation, which entail localized and subjective evaluations that are difficult to measure using satellite observations alone.

VII. CONCLUSION

The comprehensive analysis of MGNREGA's impact within the study area emphasizes the pivotal role of the scheme in advancing multiple Sustainable Development Goals (SDGs), particularly in rural India. The land cover changes, along with improvements in NDVI and VCI indicators showcase the schemes' success in supporting sustainable agricultural practices and improving vegetation health, directly relates to Zero Hunger (SDG 2), Climate Action (SDG 13), and Life on Land (SDG 15). A balanced approach to development that places equal emphasis on environmental preservation and economic growth is demonstrated by the stabilization of forest areas and the rise of agricultural land. Furthermore, the socio-economic benefits observed, including increased employment opportunities for women, infrastructure development, availability of portable water and enhanced access to education and healthcare emphasizes MGNREGA's substantial contributions to Good Health and Well-being (SDG 3), Quality Education (SDG 4), Gender Equality (SDG 5), Clean Water and Sanitation (SDG 6), and Industry, Innovation, and Infrastructure (SDG 9). The high participation of women in MGNREGA project also reflects progress toward gender equality, while the infrastructure improvements, particularly in rural connectivity, support sustainable economic growth and social equity.

Promoting eco-friendly livelihoods like eco-tourism and expanding capacity building in sustainable practices will reduce land pressure. Utilizing geospatial technology can further improve planning and decision-making.

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