Resource Sustainability and its Determinants in the Context of MGNREGA in West Bengal

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ABSTRACT
This study investigates the impact of the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) on the sustainability of resources in rural West Bengal, constructing a Resource Sustainability Index, which is a five-dimensional resource indicator that covers the levels of groundwater, availability of drinking water, land quality, green cover, and asset maintenance. This study uses both primary and secondary data. We collected primary data from April to September 2023 by conducting direct interviews in five districts of West Bengal, chosen based on their NRM expenditure performance from 2018-19 to 2021-22. We categorised the districts into three groups: high-performing, low-performing, and moderate. We adopted a multi-stage sampling method, selecting one block per district, two gram panchayats per block, and two villages per gram panchayat, for a total of 20 villages. We selected 25 beneficiaries from each village, with 60% being individual asset beneficiaries and 40% being community asset beneficiaries. According to beta regression analysis, factors such as per capita income, assets created per household, the number of MGNREGA workers, the percentage of BPL households, and the percentage of general caste households influence the resource sustainability index. These factors have a positive effect on the resource sustainability index under MGNREGA. The resource sustainability index is high in the North 24 Parganas and Hooghly districts, while Bankura and Nadia underperform, and Malda performs moderately. This study emphasises the need for targeted interventions in underperforming districts, such as Bankura and Nadia. Thus, the findings suggest that policies should focus on increasing project shares related to water conservation, land development, and afforestation, as well as sustaining the assets created under MGNREGA for long-term sustainability.

JEL Classification: Q01, Q25, C51.

Key words: Environmental sustainability, groundwater management, MGNREGA, resource sustainability index, rural development, , and water conservation.

1. Introduction
Rapid population increase, industrialisation, and urbanisation have posed serious challenges to the prospects of sustainable resource use in India (Bharath et al., 2017). Such factors have led to resource degradation and environmental degradation, along with varied sources of pollution (Kapur, 2016). Therefore, it is crucial to balance these challenges in order to promote long-term ecological balance and ensure the well-being of future generations. The Mahatma Gandhi National Rural Employment Guarantee Act is the flagship program for the transformation of rural livelihoods in India. Enacted in the year 2005, it provided a legal guarantee of a minimum of 100 days of unskilled wage employment in a financial year to every rural household whose adult members volunteer to do unskilled manual work. While MGNREGA primarily aims to provide employment, it also prioritises sustainable resource use, particularly in environmental conservation and rural development. In this regard, by targeting effective employment opportunities in conjunction with environmental sustainability, MGNREGA will become an exemplary program that will assist in mitigating economic and ecological challenges in rural communities.

Sustainability is essential for the long-term viability of rural development programs (Frisch, 2023; Beaulieu & Jordan, 2007), particularly as climate change and resource degradation are matters of concern (Rahman, 2023; Warner et al., 2010). MGNREGA stands out from other initiatives by prioritising the creation of durable assets through activities such as farm ponds, fruit orchards, afforestation, water conservation, and land development, which significantly contribute to resource sustainability. These interventions effectively address environmental issues like soil erosion, deforestation, and water scarcity (Sharma, 2019).

The program aims at recharging the groundwater table, increasing the availability of drinking water, and giving assurance to land quality, which plays a great role in supporting agricultural productivity and resilience in rural areas (Tiwari et al., 2011; Thangamalar et al., 2016). Groundwater management is essential as it directly relates to agricultural output and community livelihoods (Lawell, 2016). Restoring and rejuvenating groundwater recharge through check dams and rainwater harvesting projects are important for maintaining healthy aquifers (Ganguly & Ganguly, 2021). In several rural

areas that lack accessibility to safe drinking water, availability of sufficient water is of utmost importance. In addition to improving the health of the community, safe water sources also greatly reduce the burden on women and children, who fetch most of the water (Kumar et al., 2011). The quality of land determines agricultural productivity. The considerable focus MGNREGA gives to land development works such as land levelling and soil conservation results in increased yields in agriculture and enhanced sustainability of the soil (Yadav et al., 2024).

The afforestation efforts under MGNREGA have been effective in improving local climates, as increased green cover helps stabilise regional weather patterns (Arora & Montenegro, 2011). This, in turn, helps in regulating local climates and thus makes MGNREGA a crucial adaptation strategy in the fight against climate change (Jha et al., 2017). The forestry renewal and regeneration projects have provided numerous benefits to communities, particularly in regions where ecological degradation has been a concern (Angom & Viswanathan, 2022). The enhanced carbon sequestration potential of afforestation through MGNREGA's contributions to climate mitigation efforts positions it as an intervention approach to environmental sustainability (Ravindranath & Murthy, 2021). Environmentally sustainable projects provide employment opportunities, enabling MGNREGA to enhance the resilience of vulnerable groups against the adverse effects of climate change (Godfrey-Wood & Flower, 2018). Furthermore, afforestation and reforestation fall within the wider increase in forest cover that is vital for national carbon sinks (Cao et al., 2020). MGNREGA's multifunctional character highlights its essential role in developing resource sustainability.

MGNREGA affects water conservation and agricultural productivity—the crucial constituent elements of sustainable resource management (Nalgire & Chinnasamy, 2022). The initiative has been positively affecting employment and environmental management because of improved irrigation systems, where farmers can now cultivate more extensive lands and face more than one cycle every year (Majeed & Bhat, 2021). However, a few challenges present a threat to the achievement of the sustainability goals under MGNREGA. Experts recommend initiating more impactful and long-term projects rather than doing basic things with a notion of being a short-term measure (Verma & Shah, 2018). Building a check dam, de-silting the water bodies, and designing the irrigation canals have been some of the effective implementation measures of sustainable water management practices that enhanced rural water security (Chakraborty & Das, 2014).

Infrastructure investments in irrigation and water management under MGNREGA have significantly contributed to the revitalisation of agricultural sustainability (Lakshmi & Sundaramari, 2019). Revitalising rain-fed agriculture has considerable potential in this program since it remains the backbone of the rural economy in most areas (Kumar, 2015). MGNREGA has significantly boosted agricultural water availability by promoting land and water development initiatives, including de-siltation projects that have had significant effects in areas with lower water availability (Mandla et al., 2020). Challenges such as overexploitation of groundwater and ill-aligned resource utilisation make the sustainability targets of the program hard to achieve (Gorelick & Zheng, 2015).

Land quality, along with asset maintenance, is yet another critical determinant of the success of MGNREGA schemes. The quality of land is of importance when high-yield agriculture is concerned (Mukherjee & Lal, 2014). Sustainable practices in the maintenance and enhancement of land quality can yield long-term benefits for the rural community. Community involvement in asset maintenance helps instill ownership and responsibility, which then increases the sustainability of the program (Thakur, 2018; Motavalli et al., 2013).

Despite extensive research on individual components of resource management within the context of MGNREGA, such as ground and surface water, irrigation, drinking water availability, land management, and afforestation, studies often focus on these aspects separately without integrating them into a unified framework. This fragmented approach limits the ability to assess MGNREGA's overall effectiveness in promoting sustainable resource management. Developing a multidimensional Resource Sustainability Index (RSI) that combines data on groundwater, drinking water, land quality, green coverage, and asset maintenance into a single measure would provide a comprehensive evaluation of MGNREGA's contributions to resource sustainability. Such an index is crucial for understanding the cumulative effects of various interventions and for enhancing policy decisions aimed at sustainable rural development.

2. Objectives of the study

This study has two objectives. The first objective of this study is to design a resource sustainability index that incorporates key variables such as groundwater level, availability of drinking water, land quality, green cover, and asset maintenance within the context of MGNREGA. Subsequently, we will pinpoint the factors that influence the resource sustainability index (RSI) by assessing elements like per capita income, household assets, the number of MGNREGA workers, the proportion of BPL households, and the proportion of general caste households. These objectives will provide insight into how effective MGNREGA would be in supporting sustainable resource management in rural areas.

3. Data and methodology

The study relies on both primary and secondary sources of data. We collect primary data from field surveys conducted between April and September 2023. We gathered them using the multi-stage sampling technique. We conducted direct interviews with the sample households to collect data. The study selected a total of five districts of West Bengal based on their performance on NRM expenditure as a percentage of total expenditure from 2018–19 to 2021–22. We categorised these districts as high, low, and moderate performers. We selected Hooghly and Bankura as high performers, North 24 Parganas and Nadia as low performers, and Malda as a moderate performer.

In the sampling procedure, we selected one block from each district. We selected two gram panchayats from each block and then selected two villages from each gram panchayat. Performance levels of blocks, gram panchayats, and villages were the same as the respective district's performance category, either high, low, or moderate. The field survey covered a total of 20 villages. We selected 25 beneficiaries for each village. Of them, 60% were individual asset beneficiaries, while 40% constituted community asset beneficiaries. This meant that the MGNREGA program could assess asset creation at both the individual and community levels.

4. Construction of Resource Sustainability Index

The min-max method transformed the responses for various study variables into a normalised index, akin to the UNDP Human Development Index. The min-max method rescales each variable's values to a range of 0 to 1, enabling similar comparisons across different indicators.

For a given variable, the formula for normalization is as below:

$$\text{Normalized Value} = \frac{X - \text{Min}(X)}{\text{Max}(X) - \text{Min}(X)}.$$

X is the observed value for that variable,
Min is the minimum value recorded for that variable,
Max is the maximum value recorded for that variable,

The resource sustainability index constructs five key variables: the groundwater table, drinking water availability, land quality, green coverage, and maintenance of assets. We measure all the variables on a 5-point Likert scale, with the exception of the last one, which is a binary indicator. The software SPSS employs Principal Component Analysis (PCA) to construct the resource sustainability index (RSI). PCA generally reduces a large number of variables to a smaller set, ensuring the retention of most information from the larger set. The principal component analysis method easily transforms the correlated variables into the uncorrelated orthogonal variables. Kaiser's criterion guides the selection of principal components using eigenvalues. We choose a principal component if its eigenvalue exceeds one. The first principal component takes the majority of explained variance, while the second principal component takes a smaller amount compared to the first principal component, and so on (Abdi & Williams, 2010; Billard & Le-Rademacher, 2012). The Principal Component Analysis (PCA) produces loadings for specific variables, enabling the calculation of weights for these variables in order to create an appropriate index. More specifically, the study considered the extraction value of the communality matrix as a loading of the variable, given that the communality value is a sum of squared loadings on each principal component. We multiplied community values by individual variables to create the resource sustainability index. We formulated the index by computing a weighted average of those variables.

The Kaiser-Meyer-Olkin (KMO) statistic, which is 0.55, indicates the suitability of the data for PCA. We compute the resource sustainability index (RSI) by summing up each variable, multiplying it by its respective weight, and then dividing the result by the total weight:

$$RSI = \frac{\sum_{i=1}^{5} W_i \cdot I_i}{\sum_{i=1}^{5} W_i}.$$

Where W_i (i=1,2,3,...,5) are the weight and the subscript refers to the number of variables and $\sum_{i=1}^{5} W_i = 1$ and I_i (i=1,2,3,...,5) are the variables.

5. Beta Regression Analysis

After constructing the resource sustainability index at the district as well as village level, the study attempts to identify the determinants that are significantly influencing the index. Here, we use STATA software to perform beta regression. This study employs the beta regression econometric model, given the fractional nature of the dependent variable (Schmid et al., 2013; Peterson & Brown, 2005). The resource sustainability index serves as the dependent variable, while the independent variables include per capita income, the asset created per household (in acres), the number of MGNREGA workers per household, the percentage of BPL households, the percentage of general caste households, and the percentage of literate households. The beta-regression equation can be written as follows:

$$g(\mu_i) = X_i\beta$$

Where:

$g(\mu_i)$ is the link function applied to the mean of the resource sustainability index μ_i for observation i, typically the logit link function : $g(\mu_i) = log(\frac{\mu_i}{1-\mu_i})$.

X_i is the vector of independent variables for observation i where :

X_1 = per capita income,

X_2 = asset created per household,

X_3 = MGNREGA worker per household,

X_4 = percentage of BPL household,

X_5 = percentage of general caste household,

X_6 = percentage of literate household

β is the vector of coefficients where : $\beta = (\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6)$

Now, the Beta regression can be presented as:

$$\log\left(\frac{\mu_i}{1-\mu_i}\right) = \beta_0 + \beta_1 \cdot X_{1i} + \beta_2 \cdot X_{2i} + \beta_3 \cdot X_{3i} + \beta_4 \cdot X_{4i} + \beta_5 \cdot X_{5i} + \beta_6 \cdot X_{6i}$$

We place importance on asset creation activities such as land levelling, land reclamation, farm ponds, fruit orchards, afforestation, and pond renovations. We conduct an econometric analysis on the resource sustainability index to understand the direct impact of these variables on the resource base, which includes both land and water. Per capita income represents economic capacity, while the percentage of BPL households signifies socio-economic conditions that have a long-term impact on sustainability. Moreover, this study takes into account the caste-based composition to understand the potential impact of social structure on both resource use and sustainability. Against this backdrop, the present study aims to delve into the critical determinants that policymakers need to focus on to ensure that resources can be sustained through MGNREGA interventions for future assistance.

6. Results and Discussion
6.1 Resource Sustainability Index Across Districts and Villages

Table 1 shows resource sustainability index (RSI) values for the selected districts. North 24 Parganas ranks first with the highest RSI value of 0.71, indicating a stronger sustainability practice compared to the other districts. Hooghly follows closely with an RSI of 0.70, while Malda has a moderate RSI value of 0.68. It lags behind districts Bankura and Nadia.

Table 1: Resource Sustainability Index for selected West Bengal districts.

District	Resource Sustainability (RSI)
Malda	0.68
North 24 Parganas	0.71
Bankura	0.64
Nadia	0.54
Hooghly	0.70

Source: author's calculation

While at the village level, as indicated in Table 2, the highest RSI value is 0.75 in Barajpur of the North 24 Parganas; Alipur in Hooghly has a 0.76 value. Other villages in Malda, North 24 Parganas, and Hooghly with scores ranging from 0.66 to 0.73 seem good; thus, there is a moderate degree of sustainability. However, the RSI at Sahapur is the lowest at 0.50, followed by Manikdighi with a score of 0.53. The results from Bankura are also moderate, with RSIs ranging between 0.62 and 0.66. Scores reflect that some areas use resources better and enhance sustainability. However, most villages in Nadia and Bankura need targeted help to build the foundation of sustainability measures.

Table 2: Resource Sustainability Index for selected villages within West Bengal districts.

District	Village	Resource Sustainability (RSI)
Malda	Mahendrapur	0.70
	Gangnadia	0.68
	Bhingole	0.68
	Konar	0.68
North 24 Parganas	Barajpur	0.75
	Chapatala	0.71
	Bhurkunda	0.69
	Sulkani	0.68
Bankura	Jamsuli	0.62
	Bogdahara	0.65

	Ajodhya	0.66
	Antara	0.64
Nada	Adampur	0.58
	Nowda Chutipur	0.56
	Sahapur	0.50
	Manikdighi	0.53
Hooghly	Alipur	0.76
	Dudhkalmi	0.73
	Krishnarampur	0.66
	Jangalpara	0.65

Source: author's calculation

The resource sustainability index thereby indicates considerable variation across districts and villages and demonstrates relatively stronger sustainability practices in North 24 Parganas and Hooghly. However, the lower scores in districts such as Bankura and Nadia, especially in villages like Sahapur and Manikdighi, suggest the need for specific interventions to enhance resource management and sustainability in these areas.

6.2 Analysis of Factors Influencing Resource Sustainability Index

A Wald chi-squared statistic of 47.97 and a p-value of 0.000 confirm that the overall model is statistically significant at the 1% level, meaning the independent variables, taken together, have a significant impact on the resource sustainability index. Further, the log pseudolikelihood value of 37.41 indicates that there is a satisfactory fit between the model and the observed data.

Table 3: Findings of Beta regression analysis

Variable	Coefficient (Std. Error)	z-value	P-value
Per capita income	0.0000748 (0.000026)	2.88	0.004***
Asset created per household (in acre)	0.6830482 (0.2844293)	2.40	0.016**
MGNREGA worker per household	0.564546 (0.1581534)	3.57	0.000***
Percentage of BPL household	0.0075898 (0.0041477)	1.83	0.067*
Percentage of general caste household	0.0064215 (0.0025269)	2.54	0.011**
Percentage of literate household	0-.0032362 (0.0042485)	-0.76	0.446
Constant	-1.718221 (0.6197293)	-2.77	0.006***
Scale Constant	5.067953 (0.2573471)	19.69	0.000***
Wald chi2(5) = 47.97,	Prob > chi2 = 0.0000		
Number of observation = 20	Log pseudolikelihood = 37.417964		

Source: author's calculation from primary data

The econometric analysis reveals that per capita income, asset created per household (in acres), MGNREGA workers per household, the percentage of BPL households, and the percentage of general caste households are positively associated with the resource sustainability index, and the literacy rate is negatively associated with the resource sustainability index. The results indicate that per capita income and MGNREGA workers per household are significant at the 1% level; asset created per household (in acres) and percentage of general households are significant at the 5% level; the percentage of BPL households is significant at the 10% level, and the percentage of literate households is insignificant.

Per capita income has a positive and significant impact on the resource sustainability index, with a coefficient of 0.0000748 (p-value: 0.004). This implies that, given other factors remain constant, a unit increase in per capita income results in an increase of 0.0000748 units of the resource sustainability index. The coefficient for assets created per household (in acres) is 0.6830482, with a p-value of 0.016. This means that the resource sustainability index increases (RSI) by 0.6830482 units when ceteris paribus. One acre increases the assets created per household. The number of MGNREGA workers in households has a positive and significant effect on the resource sustainability index with a coefficient of 0.564546 (p-value: 0.000). That means, assuming all other factors remain constant, an additional MGNREGA worker in a household would lead to a 0.564546 unit increase in the RSI. The below-poverty-line (BPL) percentages do have a positive effect, with a coefficient of 0.0075898 (p-value: 0.067). When BPL household percentages increase by 1%, the resource sustainability index rises by 0.0075898 units, while all other variables remain unchanged. The percentage of general caste bears a positive and significant relationship with the resource sustainability index, with a coefficient of 0.0064215 (p-value: 0.011). When other variables remain constant, an increase of 1% in general-caste households leads to a corresponding increase of 0.0064215 units in the resource sustainability index.

7. Conclusion and Policy Suggestions:

Higher incomes may help a household be able to achieve sustainability through efficient use of resources. Increased financial capacity enables proper management of land, asset creation, and promotes sustainable use. Therefore, the positive influence of income on sustainability means that the growth in the economy can be distributive and supportive of the environment's well-being, especially in the rural areas where MGNREGA is crucially beneficial. The growth in per capita income appears to be the bottom line for improving resource use sustainability. Such growth will offer numerous benefits both to the local population and the local environment.

The rationale behind the positive effect of assets created per household (in acres) on the resource sustainability index (RSI) is their contribution to better management of land and water resources. Land levelling, land development, the construction of farm ponds, and pond renovation bring about improvements in the physical quality of land and water resources. Land levelling enhances water distribution and reduces soil erosion, preparing well-rolled land for more sustainable agriculture. Farm ponds and renovated ponds collect and store rainwater, facilitating a smoother irrigation process and increasing the certainty of water availability. This ultimately leads to stronger potential for sustainable agriculture's productivity and resource utilisation in the long run. The likelihood of risk as a result of soil and water degradation decreases with an investment in these areas. Investing in these areas leads to a more resilient and productive environment, which essentially accounts for much of the sustainability of resources.

The high and positive sign of MGNREGA workers per household indicates the significance of the program in the enhancement of resource sustainability. Actually, MGNREGA projects specifically involve a significant proportion of land and water management activities, such as the construction of farm ponds, water conservation structures, and soil conservation measures, as well as a large number of natural resource management projects that directly contribute to better management of natural resources and, consequently, improved environmental outcomes. This increases the workforce engaged in such activities, raising the potential for sustainable practices and the better utilisation and conservation of resources. Thus, more participation in MGNREGA will have direct short-term economic benefits while creating the long-run sustainability effect through better resource management.

The positive relationship between the SRI and the percentage of BPL households may be attributed to targeted government initiatives aimed at improving the living conditions of these households. These initiatives typically involve training in efficient agricultural practices, providing access to conservation methods, and providing support for environmental management that promotes sustainable resource use. The positive correlation between RSI and general-caste households likely stems from their superior resource access and sustainability. Over history, these households would have had greater economic and social capital, which facilitated their participation and adoption in sustainable resource management practices. Better education and infrastructural and financial support enable the households to adopt more effective environmental conservation measures and also imply higher resource sustainability. Despite its modest impact, this dynamic illustrates the role that social dynamics play in the adoption of sustainable practices and resource management.

The MGNREGA framework can implement several policy measures to enhance resource sustainability. Increase the share of projects under MGNREGA targeted toward land development, water conservation, afforestation, and soil management. This would directly improve indicators such as the water table, green cover, and land quality, thereby contributing to the sustainability of resources. Establish precise guidelines for MGNREGA, enabling the allocation of a specific portion of the fund for the upkeep of assets established under this program. This approach will ensure the maintenance of long-term community assets, such as farm ponds and irrigation systems. We can extend MGNREGA further to encompass comprehensive management of watersheds, including groundwater recharging and surface water management, thereby promoting positive trends in water table and drinking water availability indicators. As a supporting strategy for the implementation of MGNREGA, every village should prepare a sustainability plan focusing on resource improvement regarding land, water, and vegetation. Such an MGNREGA framework could integrate the activities of tree plantation and water conservation structures. Under MGNREGA, we can develop a monitoring and evaluation framework to track the condition and performance of the assets we create over time. This approach allows for the timely maintenance of assets like irrigation systems and improvements in land development, thereby ensuring their ongoing benefits. Encourage MGNREGA projects that focus on land development, water harvesting, and soil conservation. These activities significantly improve the quality and sustainability of land and water resources, as indicated by the positive impact of assets created per household (in an acre) on the RSI. Given the positive impact of per capita income on the RSI, we should promote diversified income-generating activities like skill development, agro-processing, and small-scale industries alongside MGNREGA to sustainably increase household income. We should primarily target BPL households for participation in NRM projects. The positive association between BPL households and RSI also demonstrates the benefits of improving livelihoods and enhancing the sustainability of local resources.

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