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RESEARCH ARTICLE

THE SCENARIO OF SDGS ACROSS THE STATES OF INDIA: A SPATIAL ANALYSIS

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ABSTRACT

All UN Member States acceded to the 2030 Program for Sustainable Development in 2015, and it prepares an extensive framework for peace and well-being for people and the planet both now and in the coming time. The 17 Sustainable Development Goals (SDGs), a high-priority call to action for all developed and developing nations, are central to this initiative. An array of indicators is used to surveil progress in the direction of each SDG as a part of the National Indicator Framework for the SDGs in India. These indicators align with international hands created by the United Nations and include various social, economic, and environmental characteristics. National surveys, administrative records, censuses, and other data sources are used to assemble information for the SDGs in India. The National Sample Survey (NSS), the Annual Survey of Industries (ASI), the Census of India, the National Data and Analytics Platform (NDAP), NITI Aayog, and several sector-specific surveys performed by various ministries and departments are some of the primary data sources. International organizations, including the World Bank, the United Nations Development Programme (UNDP), and other research institutions, also produce data and scrutinize the SDGs in India in addition to the government. As per their own data gathering and analysis, these organizations offer penetrative assessments of India's progress in reaching the SDGs. A spatial analysis and regression model has been developed on the collected dataset to assess spatiotemporal progress toward achieving the SDGs in the Indian context. This study exhibits the use of geographically referenced information analysis in mapping the SDGs as presented in the SDG India Index: Composite score, reported by the National Data and Analytics Platform. In Spatial Analysis, we have checked the spatial autocorrelation of the SDG India Index Composite score and its supporting indices across 36 states. In Spatial Regression, an OLS model has been developed by taking the SDG India Index: Reduced Inequality as the dependent variable and other SDG Goals as independent variables. However, only 8 SDG Goals have been finalized as independent variables to make the model significant. Spatial dependence in the developed linear model has been checked based on Lagrange multiplier diagnostics. The statistics in Lagrange multiplier diagnostics are the simple LM test for error dependence, the simple LM test for the sake of a missing spatially lagged dependent variable, variants robust to the presence of the other, and a portmanteau test. Lagrange Multiplier Test is the procedure suggested in (Anselin, 2005) to choose the appropriate model form. After estimating the proper model, the hypotheses are tested. After the analysis, we have opted for the OLS model, as suggested by Lagrange multiplier diagnostics. A Spatial Durbin linear model has been constructed on the developed OLS model to probe the impact of neighboring regions' independent variable values on the dependent variable, SDG India Index: Reduced Inequality.

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INTRODUCTION

Harvard T.H. Chan School of Public Health study found that India is not on track to achieve more than half of the Sustainable Development Goals (SDGs), a comprehensive set of international objectives established in 2015 by UN member states, by the organization's 2030 deadline. The researchers examined 33 health and social determinants of health indicators from India's 2016 and 2021 National Family Health Surveys to evaluate the nation's progress toward nine of the seventeen SDGs. After analyzing how the indicators changed from 2016 to 2021, the researchers categorized 707 districts in India and the country as accomplished, on track, or off track for achieving the SDGs by 2030. "Meeting [the SDGs] would require prioritizing and targeting specific areas within India," the researchers observe. "India's emergence and sustenance as a leading economic power depends on meeting some of the more basic health and social determinants of health-related SDGs immediately and equitably."

The UN proposed seventeen SDGs. Adapted from https://www.un.org

In India, Geospatial information and technology are being adopted more widely today than ever. In addition, the Indian government's enthusiasm for geospatial tools and technology, as seen with encouraging regulations, public-private partnerships, and execution of national and state-level development initiatives, is moving the industry forward. This push comes from recognizing Geospatial information as much more than an uncomplicated map. Instead, it is an analytical national information resource with evident benefits for society, the economy, and the environment. Using geospatial information and related location-based servicesregularly benefits citizens, business sectors, communities, governments, and many other stakeholders, whether with or without their knowledge. Geospatial data links a place, its inhabitants, and their actions digitally. It can then be used to estimate the “how,” “where,” and “why” of past, present, and likely future scenarios. This capability can be leveraged to accelerate the combination of Government systems and services covering all verticals and projects that use “location” as a consolidated reference frame, including agriculture, land, infrastructure administration, water resources management, etc. These areas are moving forward by leaps and bounds today with Geospatial information as their bedrock. The UN-GGIM’s Integrated Geospatial Information Framework (IGIF) offers countries the medium to act on these pillars cohesively so that no one is abandoned.

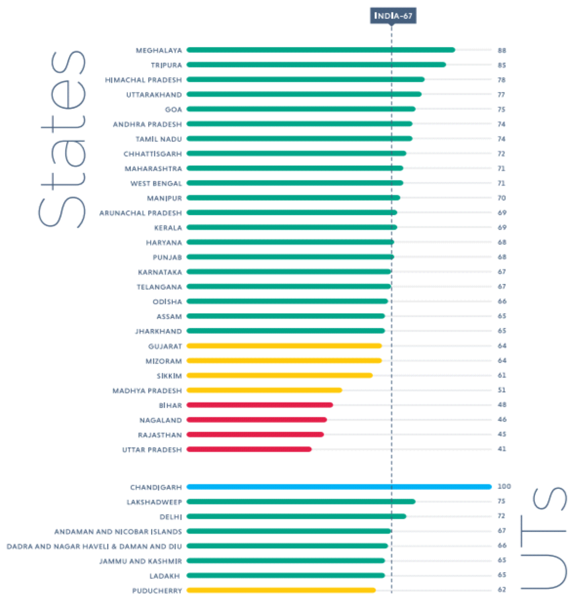
The effective use and management of geospatial information have been confirmed to be helpful throughout all phases of sustainable governance and development – policymaking, on-ground execution of projects, monitoring and feedback, and stakeholder interoperability. The UN-GGIM’s Integrated Geospatial Information Framework (IGIF) and 14 Global Fundamental Geospatial Data Themes act as guiding beacons in this aspect, providing strategic guidance to develop and implement related action plans. The recently announced National Geospatial Policy 2022 by the Government of India incorporates the principles and vision of the IGIF and the 14 Global Fundamental Geospatial Data Themes to boost innovation, quality, liberalization, and industrialization of the Geospatial ecosystem in India, which in turn will lead to a data-driven roadmap to the accomplishment of India’s Sustainable Development Goals.

The Sustainable Development Goals (SDG) index contains information on goal scores computed by aggregating scores under each SDG and composite scores, which are obtained by averaging all goal scores of all the states. Based on the performance scores of states, they were classified into four categories: 0 to 49 are aspirants, 50 to 64 are performers, 65 to 99 are front runners, and 100 are achievers. The Sustainable Development Goals (SDG) Index by Niti Ayog, set up in 2015 by the United Nations General Assembly (UN-GA), is a collection of 17 interconnected global goals outlined to be a "blueprint for achieving a better and more sustainable future for all." Using a globally accepted and robust methodology, the Index measures the progress attained at the country and State/UT levels, offering crucial insights to policymakers on the remaining distance to gaps, travels, and data and statistical challenges.

Our paper focuses on the 10^{th} goal of the SDG India Index, i.e., reduced inequality, which considers not only income inequalities but also inequalities of the outcome by confirming access to equal opportunities and promoting economic, social, and political incorporation of all, disregarding age, sex, disability, ethnicity, race, religion, origin or financial or any other status relevant within society. Seven national-level indicators have been identified to measure India’s performance towards the Goal of Reduced Inequalities, which have been selected based on data availability at the sub-national level and to ensure comparability throughout the States and UTs. The following section depicts the composite scores of the States and UTs on this Goal. It also shows a categorization of the States and UTs by indicator.

Using spatial analysis, we have checked the spatial variation of all SDG India indices and assessed the significance and magnitude of other SDG India Indices on spatial variation of the 10^{th} goal of the SDG India Index, i.e., reduced inequality.

Figure 10.1: SDG 10 Index Score of States/ UTs



Source: SDG INDIA Index & Dashboard 2020-21

LITERATURE REVIEW

Roychowdhury, Koel & Bhanja, Radhika in their paper “Assessing the progress of India towards sustainable development goals by 2030”, in *Journal of Global Resources*, July 2020, concluded that India must overcome numerous hurdles to achieve the universal targets of sustainable development by 2030. At the sub-national level, 14 out of 29 states have performed well in the PSDG index. In contrast, the other states must focus on developing their people's quality of life and providing infrastructure services and utilities to their rural and urban populations. The PSDG Index throws light upon the primary goals of sustainability that a country needs to achieve by 2030. Assessing its progress before 2015 recognizes the direction in which government interventions and policies are most required. The employment growth rate of economic growth has suffered stagnation from 2000 to 2015 (Papola, 2013). Therefore, a positive shift in this sector is required to help India achieve inclusive and productive economic growth in the coming years. Financial incentives related to water, sanitation, and improvements in the health sector have already been initiated by the Government through Jal Jeevan Mission, Swachh Bharat Mission, and Jan Arogya Yojana. With the help of the National Skill Development Agency, employment focusing on infrastructure and skill development projects will be implemented. Thus, India may seem distant from achieving sustainable development by 2030. Still, effective policy implementation, capacity building, and financial assistance (Bhamra, Shankar, & Niazi, 2015) will help India fulfill these ambitious SDGs by 2030.

Gupta, Stutee, Anand, Shikha,Thanmai, P. Lakshmi, Reddy, K.M & Ravisankar, T in their paper “Spatial Distribution of SDGs Accomplished Under MGNREGA Beyond SDG1”, in *International Journal of Rural Management*, September 2021, has concluded Poverty reduction remains a prime agenda in most developing and underdeveloped countries. Employment generation for the marginal people through the effective creation of rural assets is considered a practical measure towards improving economic and social development, as they could have strong multiplier effects on poverty reduction and environmental development. MGNREGA presents an exemplary program with provisions for alleviating poverty across rural India through employment generation. For this reason, it is also included as an indicator for national-level monitoring of SDG1 under the voluntary national reporting mechanism. Monitoring the progress of SDGs in a real sense is possible only by considering the spatial variability of the initiatives and their interrelationship substantiated with the cause and impact relationship in the targeted areas, thus ensuring evidence-based planning and long-term dividends. The UN SDGs 2030 Agenda also demands that member states undertake new data integration and acquisition approaches and focus on timely, high-quality, reliable, and disaggregated data. Geospatial methods hold immense potential in mapping the achievements of SDGs and developing equally explicit management policies.

Das, Srabani, Ganguly, Kuntal, Mitran, Tarik & Chakraborty, Deb, and Surya, in their book "*Application of Remote Sensing and GIS in Natural Resources and Built Infrastructure Management* (pp.1-27)", in the chapter "Applications of Geospatial and Information Technologies Toward Achieving Sustainable Development Goals," January 2023, have concluded achieving SDGs and their universality would be possible through readily available data from inexpensive sources like remote sensing images and readily available sources. They also remarked that a sustainable society would be better ensured with a proper sustainable development plan. In this context, the UN has set up seventeen SDGs to achieve the target by 2030. Hence, there will be a need to develop new methods and techniques to process enormous earth observation data of various sizes, sources, and formats. Earth observation is crucial in monitoring the SDGs, given its cost-effectiveness on data acquisition on all scales and information richness.

Roy, Ajishnu, Garai, Nandini & Biswas, Kumar, and Jayanta, in their paper "Exploration of Urban Sustainability in India through the Lens of Sustainable Development Goals," in *Discover Sustainability*, Volume 4, article number 41, October 2023, have concluded that Cities are the primary drivers of the worldwide consumption of goods and services. Hence, the metrics utilized in SDG evaluation must be consumption-based. Cities' impact or environmental threshold coherence offers significant wasted potential for influencing sustainable urban development. Interdisciplinary research is needed to measure, explain, and assist in alleviating the effects of urban consumption. This initial step necessitates ongoing collaboration among earth system, natural, environmental, design, and economic scientists to understand better the interlinkages among urban activities, consumption-based environmental footprints, city planetary boundaries, and dynamic interactions and system reactions. The authors suggest that if the sustainability of Indian cities is not taken seriously, it might thwart India's regional and national progress in achieving sustainable development goals by 2030.

Shekhar, Sulochana & Ravi, and Kannan, in their article "Characterizing the slum environment from space for achieving SDGs," in *The International Archives of the Photogrammetry Remote Sensing and Spatial Information Sciences*, April 2023, concluded Chennai experienced significant slum growth during 2001- 2011 and slum expansion during 2011-2021. In this study, Google Earth Pro open-source software was predominantly used for slum mapping and validation. The findings revealed the emergence of slums and indicated that 28% of urban dwellers live on 5.16% of the land. The result also shows that 57,771(4.58%) Katcha houses are in Chennai. Compared to the 2011 census, the present study showed an increase in the number of households living in Katcha houses. This demands an urgent need for affordable housing and the effective implementation of central and state government schemes. The eleventh goal of Sustainable development is exclusively for inclusive slum development.

Zaini, Rahman, Hameedur, Syed & Akhtar, and Asif, in their article "Modelling the Sustainable Development Goals for India -An Interpretive Structural Modeling Approach,"*World Review of Science Technology and Sustainable Development*, January 2019, utilized interpretive structural modeling (ISM) as a technique to develop a hierarchical relationship between the SDGs for their effective Adoption in India. It categorizes the SDGs into different groups, whereby one group is that of enablers having high driving power and low dependence requiring maximum attention and are of strategic importance. In contrast, another group consists of highly reliant variables and are the resultant actions. The categorization of the SDGs into groups is based on inter-relationships between them. The relationships determine the level of interaction between the goals. This information would be helpful to policy-makers in overcoming the challenge of implementing the SDGs in India. The outcome of this study reveals a pathway for efforts to be directed for a more positive development towards adopting the SDGs. Policy-makers may use the emerging hierarchical classification to implement the SDGs effectively in India. The scope of this study is limited to proposing a framework for the implementation of SDGs in India. The ISM methodology is primarily a qualitative technique dependent on expert opinion. The results are tabulated using inputs made using personal views and judgments.

Objective of the Study

Spatial autocorrelation is used to describe the extent to which a variable is correlated with itself through space. In this study, we have spatial autocorrelation of SDG dimensions of Indian states as available from the NDAP platform of NITI Aayog. The objective of this study can be described as below: -

- Check spatial autocorrelation of SDG variables.
- Identify the SDG Variable with the highest degree of negative spatial autocorrelation, i.e., the variable is dispersed geographically.
- Building a spatial regression model to identify other SDG variables that affect the spatial variation of the selected SDG variable with their magnitude of effect.

RESEARCH METHODOLOGY

Data Sources: This study has been performed on the SDG India Index Composite score. The whole dataset of the Composite score of the SDG India Index has been collected from the National Data and Analytics Platform (NDAP). The National Data and Analytics Platform (NDAP) is NITI Aayog's flagship initiative to improve access and use of government data. NDAP is a user-friendly web platform aggregating and hosting datasets across India's vast statistical infrastructure. The Sustainable Development Goals (SDG) index contains information on goal scores computed by aggregating scores under each SDG and composite scores, which are obtained by averaging all goal scores of all the states. Based on the performance scores of states, they were classified into four categories: 0 to 49 are aspirants, 50 to 64 are performers, 65 to 99 are front runners, and 100 are achievers. The Sustainable Development Goals (SDG) Index by Niti Ayog, set up in 2015 by the United Nations General Assembly (UN-GA), is an assemblage of 17 interlinked global goals designed to be a "blueprint for achieving a better and more sustainable future for all." Using a globally accepted and robust methodology, the Index measures the progress reached at the country and State/UT levels, offering precious insights to policymakers on the remaining distance to gaps, travel, data, and statistical challenges.

Period and Granularity: The Composite score of the SDG India Index has been derived from the SDG INDIA Index & Dashboard 2020-21. It contains data on SDG indices of 28 states and eight union territories.

RESEARCH METHODS

The spatial analysis process begins with the shape file of Indian states and union territories. For our study, the shape file was purchased from the online maps portal of the Ministry of Science and technology, GOI. The data for the composite score of the SDG India Index was taken from NDAP. After the collection of the shape file of Indian states and union territories and SDG indices data, the following steps have been followed to perform the whole analysis:

- Merging of the shape file and dataset based on a common attribute, i.e., state.

- Spatial plots of the relevant SDG indices have been done to visualize the variation of such indices across the selected geographical space.
- The centroid of the states and union territories has been calculated and plotted.
- The spatial weight matrix has been calculated based on the derived centroids to define neighbor connectivity and neighbor weight (i.e., who is your neighbor, and how much does your neighbor matter?)
- Moran's I calculation for all SDG Indices. Calculations for Moran's I are based on a weighted matrix, with units i and j. Moran's I is a correlation coefficient that calculates the overall spatial autocorrelation of a variable. In other words, it measures how one object is homogenous to others surrounding it. Spatial autocorrelation is multi-dimensional and multi-directional, making it helpful in finding patterns in complicated data sets. Like correlation coefficients, it has a value from -1 to 1. -1 is the perfect clustering of dissimilar values (perfect dispersion). 0 is no autocorrelation (perfect randomness.). +1 indicates perfect clustering of similar values (the opposite of dispersion).

Similarities between units are computed as the product of the differences between y_j and y_i with the overall mean.

Similarity = $(y_i - \bar{y})(y_j - \bar{y})$, where $\bar{y} = \Sigma^n_{i=1} y_i/n$

Calculation of Moran's statistic is done using the basic expression, which is divided by the sample variance:

$s^2 = (\Sigma(y_i - \bar{y})^2)/n)$.

$$I = \frac{1}{s^2} \frac{\sum_i \sum_j (y_i - \bar{y})(y_j - \bar{y})}{\sum_i \sum_j w_{ij}}$$

After calculating Moran`I, we can identify the SDG index with the highest spatial non-autocorrelation or dispersion probability.

- Making a Moran scatter plot. This plot shows an association between a variable and its neighbors` same variable. It has four quadrants. The upper right and lower left quadrants imply positive spatial autocorrelation, and the lower right and upper left quadrants imply negative spatial autocorrelation.
- An Ordinary Least Square model is built by considering the SDG index from Step 5 as the dependent variable and other SDG indices as independent variables.
- Finalise the OLS model from step 7 by dropping insignificant variables from the model.
- Calculating Global Moran`I for regression residuals to see whether there is any residual spatial dependence.
- Perform the Lagrange Multiplier Test to select an appropriate model. The flow chart in Fig 1 below shows how to select a model.
- Building Spatial Regression models to check whether neighboring regions' independent values affect Outcome values.

RESEARCH FINDINGS

Our analysis begins with the calculation of Moran`I on the indices of SDG, as available from NDAP. Based on the calculated result, we have found that reduced inequality, the 10th goal of SDG in the Indian context, has the highest degree of spatial dispersion. We have tried to find out the magnitude of the effect of other SDG goals on such spatial distribution of data points. Moran`Ihas been calculated here using three different methods to justify the spatial dispersion of Reduced Inequality. These are Moran`I based on inverse distance weights, Moran I test under randomization, and Monte-Carlo simulation of Moran I.

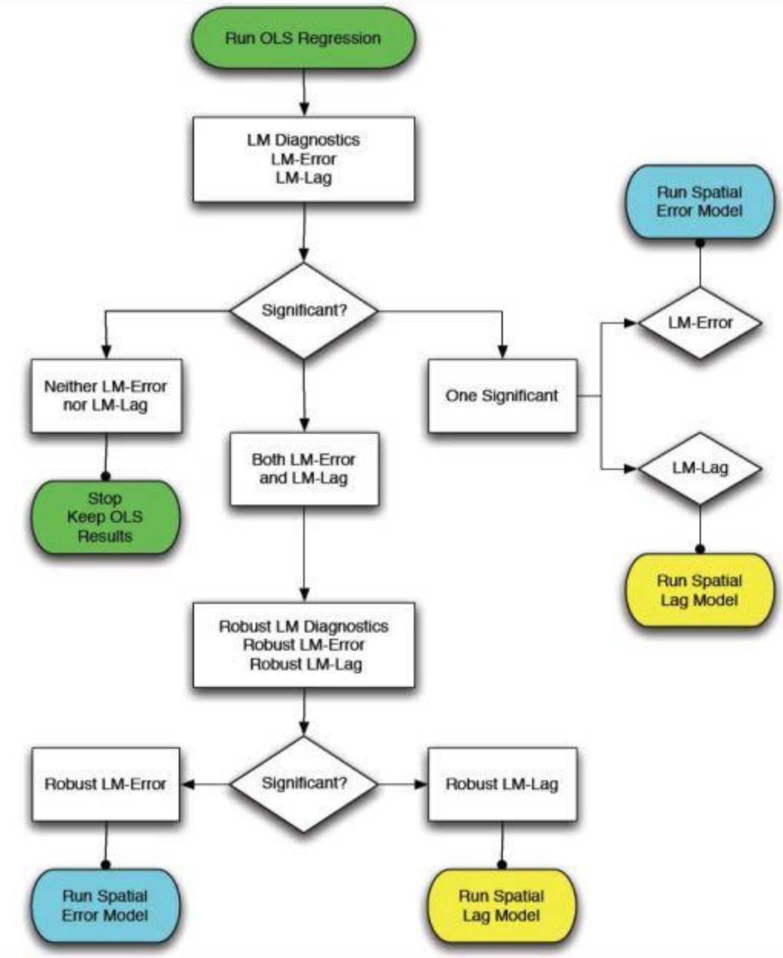
Moran I has a null hypothesis that the variable is randomly disbursed, and the alternative hypothesis is that the variable is spatially clustered. We have considered $\alpha = 0.001$ and accordingly accepted null or alternative hypothesis. Below is the presentation of all three types of Moran`I calculation.

Table 4 summarises comments from all three methods of calculation of Moran I. To validate the spatial dispersion of Reduced Inequality, we have created a Moran plot of this variable in Fig. 2. This is a plot of spatial data against its spatially lagged values, augmented by reporting the summary of influence measures for the linear relationship between the data and the lag. The trendline inside the plot validated negative Moran`Ivalues. We can also observe that the data points are primarily concentrated in the upper left and lower right quadrants, implying a negative association with the neighbor`s Reduced Inequality SDG score. Fig 3 is the Choropleth mapping of the SDG India Index: Reduced Inequality. The data has been plotted on the map in quartiles. After identifying the SDG index with the highest degree of spatial dispersion (Reduced Inequality), we built an Ordinary least square (OLS) model. In this model, we have taken reduced inequality as the dependent variable and other SDG Indices as independent variables. However, we have dropped off some of the indices and finalized the model as below. The output of this OLS model is as follows in Table 5.

In the model, we can see that out of 8 independent variables, five variables have been proven to be statistically significant, and the model's goodness-of-fit is moderate (35.72%). We have checked the spatial pattern of the OLS model's residuals using Global Moran' I and found that the residuals are randomly distributed. The null hypothesis of Global Moran's I statistic says that the attribute being examined is randomly distributed among the features in the study area. The alternative hypothesis says that the attribute is spatially clustered. The Global Moran I for regression residuals result is shown in Table 6 below. The spatial regression model has two types: Spatial lag and spatial error. The Lagrange Multiplier Test has been performed to check whether any models fit the OLS model. The test results are as follows in Table 7. Considering Table 7 and Figure 1, we conclude that the OLS model is appropriate among all proposed and built-up models. Additionally, we have built one spatial regression model, which denotes the independent values of neighboring regions that affect outcome values. We have two sets of results. The first set is our region's independent (X) variables, while set 2 (the lag set) defines the X values of the neighboring area. Here, the results can be interpreted as the typical OLS model. However, all the independent variables have insignificant effects, which are known as direct and indirect effects.

CONCLUDING REMARKS

In the analysis, while building the regression model, we focused on the Reduced inequality of SDG goals. But when we compare reduced equality with the composite score of all SDG objectives, we found that their distribution across the geographical boundary is opposite. Reduced quality is spatially dispersed, whereas the Composite score of SDG indices is clustered, as derived from Fig. 4 below. Fig 4 combines the choropleth map, Moran scatter plot of reduced inequality, and the SDG India Indices composite score. This implies that the overall success of SDG achievement is restricted to some states and union territories in India. Still, measurement and schemes of reduced inequality have been successful only in some states and union territories, irrespective of their cardinal directions. In Table 1, we see that out of 15 SDG variables, only six are spatially autocorrelated, and the rest (nine) are not spatially autocorrelated, i.e., spatially dispersed. That means policy implications have not been practical and progressive enough to achieve SDG goals on a pan-Indian basis. Regarding spatial regression on the 10^{th} goal of the SDG India Index, i.e., reduced inequality, the Lagrange Multiplier Test suggests no spatial pattern (spatial lag or spatial error) between reduced inequality and other selected SDG indicators. Despite that, we attempted to develop a spatial cross regressive model (Table 8) on the OLS model, which was futile with statistically insignificant variables.



Source: Anselin (1988), Burkey (2018)

Fig. 1.

Table 1.

	Moran.I based on inverse distance weights				
SDG Variables	Observed Value	Expected Value	Standard Deviation	P Value	Comments
SDG.India.Index..No.Poverty	0.0838	-0.0286	0.0350	0.0013	Zero Spatial Autocorrelation
SDG.India.Index.Zero.Hunger	0.0870	-0.0286	0.0349	0.0009	Spatial Autocorrelation
SDG.India.Index..Good.Health.and.Well.being	0.0776	-0.0286	0.0351	0.0025	Zero Spatial Autocorrelation
SDG.India.Index..Quality.Education	0.1697	-0.0286	0.0351	0.0000	Spatial Autocorrelation
SDG.India.Index..Gender.Equality	0.0930	-0.0286	0.0349	0.0005	Spatial Autocorrelation
SDG.India.Index..Clean.water.and.sanitation	0.0513	-0.0286	0.0342	0.0196	Zero Spatial Autocorrelation
SDG.India.Index..Affordable.and.clean.energy	0.0530	-0.0286	0.0334	0.0148	Zero Spatial Autocorrelation
SDG.India.Index..Decent.work.and.economic.growth	0.1484	-0.0286	0.0348	0.0000	Spatial Autocorrelation
SDG.India.Index..Industry..Innovation.and.Infrastructure	0.2083	-0.0286	0.0354	0.0000	Spatial Autocorrelation
SDG.India.Index..Reduced.Inequality	-0.0127	-0.0286	0.0341	0.6425	Zero Spatial Autocorrelation
SDG.India.Index..Sustainable.cities.and.communities	0.1829	-0.0286	0.0350	0.0000	Spatial Autocorrelation
SDG.India.Index..Responsible.consumption.and.production	0.0316	-0.0286	0.0350	0.0858	Zero Spatial Autocorrelation
SDG.India.Index..Climate.Action	-0.0171	-0.0286	0.0347	0.7421	Zero Spatial Autocorrelation
SDG.India.Index..Life.on.Land	-0.0338	-0.0286	0.0346	0.8797	Zero Spatial Autocorrelation
SDG.India.Index..Peace..justice.and.strong.institutions	-0.0372	-0.0286	0.0338	0.7984	Zero Spatial Autocorrelation
Composite.score.of.SDG.India.Index	0.1662	-0.0286	0.0350	0.0000	Spatial Autocorrelation
				α	0.001

Table 2.

	Moran I test under randomisation					
SDG Variables	Moran I statistic standard deviate	p-value	Moran I statistic	Expectation	Variance	Comments
SDG.India.Index..No.Poverty	2.3967	0.0083	0.0911	-0.0286	0.0025	Zero Spatial Auto Correlation
SDG.India.Index.Zero.Hunger	2.7254	0.0032	0.1072	-0.0286	0.0025	Zero Spatial Auto Correlation
SDG.India.Index..Good.Health.and.Well.being	2.9347	0.0017	0.1184	-0.0286	0.0025	Zero Spatial Auto Correlation
SDG.India.Index..Quality.Education	4.7178	0.0000	0.2079	-0.0286	0.0025	Spatial Autocorrelation
SDG.India.Index..Gender.Equality	3.5547	0.0002	0.1485	-0.0286	0.0025	Spatial Autocorrelation
SDG.India.Index..Clean.water.and.sanitation	3.1471	0.0008	0.1253	-0.0286	0.0024	Spatial Autocorrelation
SDG.India.Index..Affordable.and.clean.energy	3.0732	0.0011	0.1185	-0.0286	0.0023	Zero Spatial Auto Correlation
SDG.India.Index..Decent.work.and.economic.growth	4.3939	0.0000	0.1899	-0.0286	0.0025	Spatial Autocorrelation
SDG.India.Index..Industry..Innovation.and.Infrastructure	6.9814	0.0000	0.3246	-0.0286	0.0026	Spatial Autocorrelation
SDG.India.Index..Reduced.Inequality	-0.8468	0.8014	-0.0699	-0.0286	0.0024	Zero Spatial Auto Correlation
SDG.India.Index..Sustainable.cities.and.communities	5.9317	0.0000	0.2683	-0.0286	0.0025	Spatial Autocorrelation
SDG.India.Index..Responsible.consumption.and.production	0.4387	0.3305	-0.0066	-0.0286	0.0025	Zero Spatial Auto Correlation
SDG.India.Index..Climate.Action	0.2695	0.3938	-0.0152	-0.0286	0.0025	Zero Spatial Auto Correlation
SDG.India.Index..Life.on.Land	0.1455	0.4422	-0.0214	-0.0286	0.0025	Zero Spatial Auto Correlation
SDG.India.Index..Peace..justice.and.strong.institutions	-1.1622	0.8774	-0.0847	-0.0286	0.0023	Zero Spatial Auto Correlation
Composite.score.of.SDG.India.Index	5.2514	0.0000	0.2341	-0.0286	0.0025	Spatial Autocorrelation
				α	0.001	

Table 3.

SDG Variables	Monte-Carlo simulation of Moran I			Comments
	statistic	observed rank	p-value	
SDG.India.Index..No.Poverty	0.0911	976	0.0240	Zero Spatial Autocorrelation
SDG.India.Index.Zero.Hunger	0.1072	981	0.0190	Zero Spatial Autocorrelation
SDG.India.Index..Good.Health.and.Well.being	0.1184	985	0.0150	Zero Spatial Autocorrelation
SDG.India.Index..Quality.Education	0.2079	1000	0.0010	Zero Spatial Autocorrelation
SDG.India.Index..Gender.Equality	0.1485	993	0.0070	Zero Spatial Autocorrelation
SDG.India.Index..Clean.water.and.sanitation	0.1253	992	0.0080	Zero Spatial Autocorrelation
SDG.India.Index..Affordable.and.clean.energy	0.1185	990	0.0100	Zero Spatial Autocorrelation
SDG.India.Index..Decent.work.and.economic.growth	0.1899	997	0.0030	Zero Spatial Autocorrelation
SDG.India.Index..Industry..Innovation.and.Infrastructure	0.3246	1000	0.0010	Zero Spatial Autocorrelation
SDG.India.Index..Reduced.Inequality	-0.0699	183	0.8170	Zero Spatial Autocorrelation
SDG.India.Index..Sustainable.cities.and.communities	0.2683	1000	0.0010	Zero Spatial Autocorrelation
SDG.India.Index..Responsible.consumption.and.production	-0.0066	727	0.2730	Zero Spatial Autocorrelation
SDG.India.Index..Climate.Action	-0.0152	702	0.2980	Zero Spatial Autocorrelation
SDG.India.Index..Life.on.Land	-0.0214	620	0.3800	Zero Spatial Autocorrelation
SDG.India.Index..Peace..justice.and.strong.institutions	-0.0847	69	0.9310	Zero Spatial Autocorrelation
Composite.score.of.SDG.India.Index	0.2341	1000	0.0010	Zero Spatial Autocorrelation
		α	0.001	

Table 4.

SDG Variables	Moran.I based on inverse distance weights	Moran I test under randomisation	Monte-Carlo simulation of Moran I
SDG.India.Index..No.Poverty	Zero Spatial Autocorrelation	Zero Spatial Auto Correlation	Zero Spatial Autocorrelation
SDG.India.Index.Zero.Hunger	Spatial Autocorrelation	Zero Spatial Auto Correlation	Zero Spatial Autocorrelation
SDG.India.Index..Good.Health.and.Well.being	Zero Spatial Autocorrelation	Zero Spatial Auto Correlation	Zero Spatial Autocorrelation
SDG.India.Index..Quality.Education	Spatial Autocorrelation	Spatial Autocorrelation	Zero Spatial Autocorrelation
SDG.India.Index..Gender.Equality	Spatial Autocorrelation	Spatial Autocorrelation	Zero Spatial Autocorrelation
SDG.India.Index..Clean.water.and.sanitation	Zero Spatial Autocorrelation	Spatial Autocorrelation	Zero Spatial Autocorrelation
SDG.India.Index..Affordable.and.clean.energy	Zero Spatial Autocorrelation	Zero Spatial Auto Correlation	Zero Spatial Autocorrelation
SDG.India.Index..Decent.work.and.economic.growth	Spatial Autocorrelation	Spatial Autocorrelation	Zero Spatial Autocorrelation
SDG.India.Index..Industry..Innovation.and.Infrastructure	Spatial Autocorrelation	Spatial Autocorrelation	Zero Spatial Autocorrelation
SDG.India.Index..Reduced.Inequality	Zero Spatial Autocorrelation	Zero Spatial Auto Correlation	Zero Spatial Autocorrelation
SDG.India.Index..Sustainable.cities.and.communities	Spatial Autocorrelation	Spatial Autocorrelation	Zero Spatial Autocorrelation
SDG.India.Index..Responsible.consumption.and.production	Zero Spatial Autocorrelation	Zero Spatial Auto Correlation	Zero Spatial Autocorrelation
SDG.India.Index..Climate.Action	Zero Spatial Autocorrelation	Zero Spatial Auto Correlation	Zero Spatial Autocorrelation
SDG.India.Index..Life.on.Land	Zero Spatial Autocorrelation	Zero Spatial Auto Correlation	Zero Spatial Autocorrelation
SDG.India.Index..Peace..justice.and.strong.institutions	Zero Spatial Autocorrelation	Zero Spatial Auto Correlation	Zero Spatial Autocorrelation
Composite.score.of.SDG.India.Index	Spatial Autocorrelation	Spatial Autocorrelation	Zero Spatial Autocorrelation

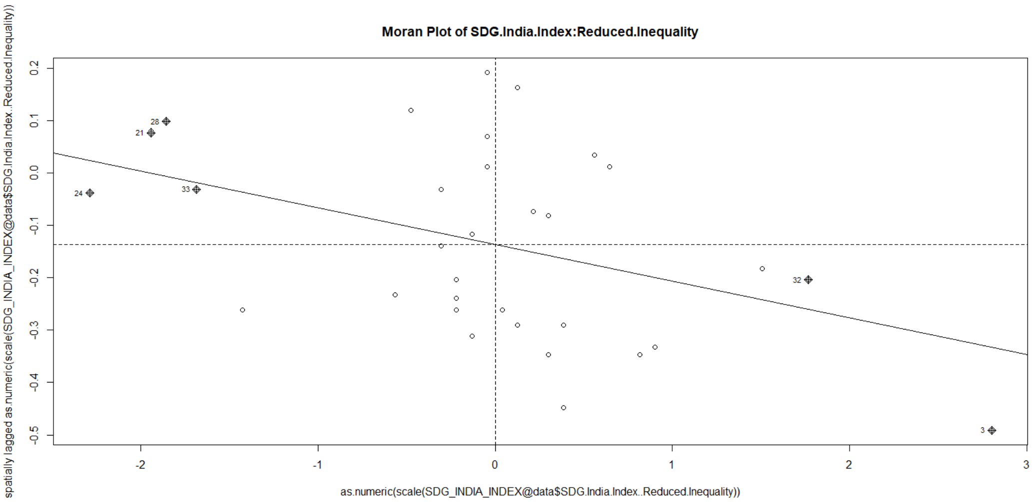


Fig. 2.

There is no spatial regression between the reduced inequality and other relevant dimensions of India's SDG indices.

Further Recommendations and policy Implications: The international community has taken notable steps towards uplifting people from poverty. The most vulnerable nations, the least developed countries, the small island developing states, and the landlocked developing countries – continue to make inroads into poverty reduction. However, inequality persists, and significant inconsistencies remain in access to health services, education services, and other assets. There is growing consensus that economic growth is inadequate to reduce poverty if it is not all-in and does not require the three dimensions of sustainable development – economic, social, and environmental. Fortunately, income inequality has been minimized both between and within countries. The UNDP has set SGD goal 10 to reduce within-group and between-group inequalities; through this analysis, we have seen that in India and its states, the within-group is most significant, and some states, like Kerala and Punjab, have more than 95% within-group inequality.

However, it indicates less consumer expenditure disparity between rural and urban individuals. Especially in Kerala, within-group inequality touches the siling. Although the between-group gap is small, it should not be ignored, as an increase in between-group inequality beyond a specific limit can result in social disharmony and instability in the nation (Kanbur, 2008). Some states like West Bengal, Assam, and Odisha need proper care to reduce rural and urban disparity or between-group inequality. Considering the COVID-19 pandemic, India has demonstrated notable growth across all sectors, signaling a positive trajectory. However, India must address the consumer expenditure inequality to achieve sustainable development goals (SDGs). It can be accomplished through several key measures. Firstly, implementing a policy framework to increase the income of individuals dependent on agriculture and unorganized sectors is essential. By uplifting these segments of society economically, we can reduce inequality. Secondly, providing access to education for all individuals play a significant role in mitigating inequality. Ensuring equal educational opportunities empowers individuals with the

Table 4

SDG Variables	Moran.I based on inverse distance weights	Moran I test under randomisation	Monte-Carlo simulation of Moran I
SDG.India.Index..No.Poverty	Zero Spatial Autocorrelation	Zero Spatial Auto Correlation	Zero Spatial Autocorrelation
SDG.India.Index.Zero.Hunger	Spatial Autocorrelation	Zero Spatial Auto Correlation	Zero Spatial Autocorrelation
SDG.India.Index..Good.Health.and.Well.being	Zero Spatial Autocorrelation	Zero Spatial Auto Correlation	Zero Spatial Autocorrelation
SDG.India.Index..Quality.Education	Spatial Autocorrelation	Spatial Autocorrelation	Zero Spatial Autocorrelation
SDG.India.Index..Gender.Equality	Spatial Autocorrelation	Spatial Autocorrelation	Zero Spatial Autocorrelation
SDG.India.Index..Clean.water.and.sanitation	Zero Spatial Autocorrelation	Spatial Autocorrelation	Zero Spatial Autocorrelation
SDG.India.Index..Affordable.and.clean.energy	Zero Spatial Autocorrelation	Zero Spatial Auto Correlation	Zero Spatial Autocorrelation
SDG.India.Index..Decent.work.and.economic.growth	Spatial Autocorrelation	Spatial Autocorrelation	Zero Spatial Autocorrelation
SDG.India.Index..Industry..Innovation.and.Infrastructure	Spatial Autocorrelation	Spatial Autocorrelation	Zero Spatial Autocorrelation
SDG.India.Index..Reduced.Inequality	Zero Spatial Autocorrelation	Zero Spatial Auto Correlation	Zero Spatial Autocorrelation
SDG.India.Index..Sustainable.cities.and.communities	Spatial Autocorrelation	Spatial Autocorrelation	Zero Spatial Autocorrelation
SDG.India.Index..Responsible.consumption.and.production	Zero Spatial Autocorrelation	Zero Spatial Auto Correlation	Zero Spatial Autocorrelation
SDG.India.Index..Climate.Action	Zero Spatial Autocorrelation	Zero Spatial Auto Correlation	Zero Spatial Autocorrelation
SDG.India.Index..Life.on.Land	Zero Spatial Autocorrelation	Zero Spatial Auto Correlation	Zero Spatial Autocorrelation
SDG.India.Index..Peace..justice.and.strong.institutions	Zero Spatial Autocorrelation	Zero Spatial Auto Correlation	Zero Spatial Autocorrelation
Composite.score.of.SDG.India.Index	Spatial Autocorrelation	Spatial Autocorrelation	Zero Spatial Autocorrelation

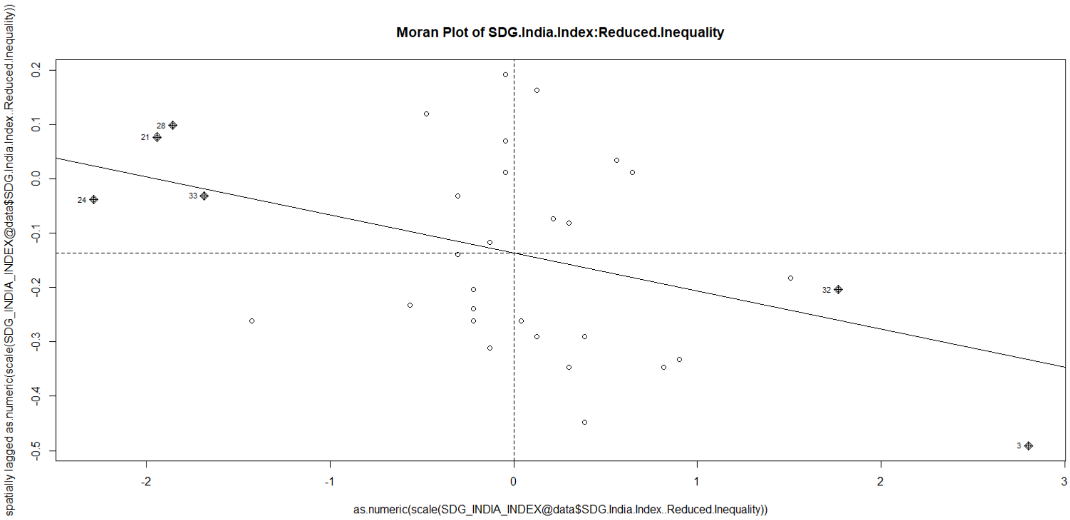


Fig. 2.

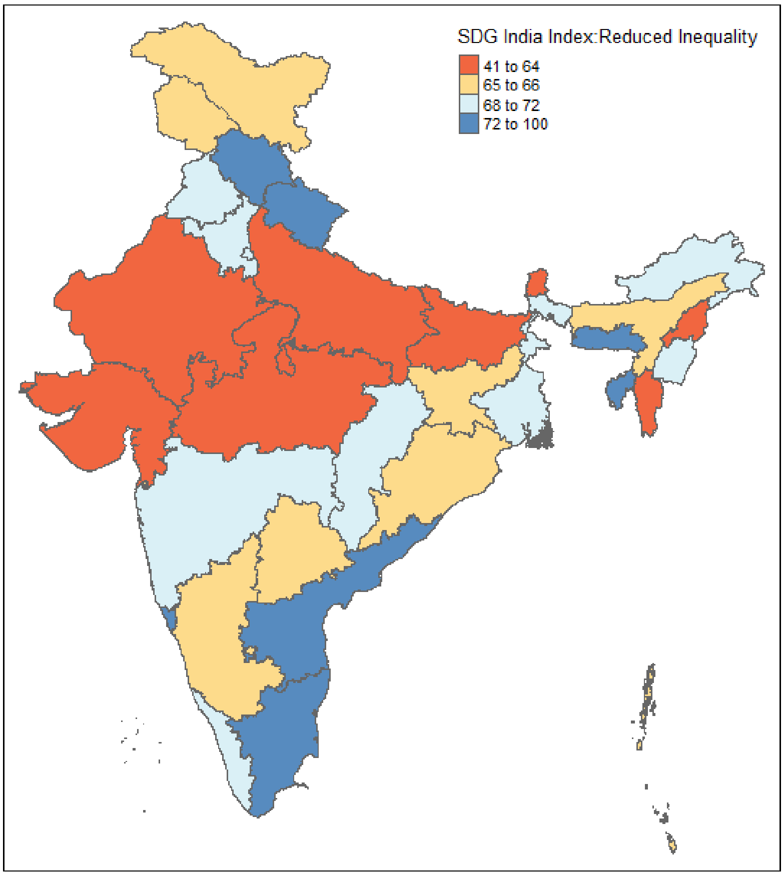


Fig. 3.

Table 5

Residuals:					
Min	1Q	Median	3Q	Max	
-22.69	-4.129	1.404	5.467	16.808	
Coefficients:					
	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	21.3058	28.8768	0.738	0.467	
SDG.India.Index..Good.Health.and.Well.being	0.5273	0.274	1.925	0.0649	.
SDG.India.Index..Quality.Education	0.5434	0.2096	2.593	0.0152	*
SDG.India.Index..Gender.Equality	-0.3288	0.206	-1.596	0.1221	
SDG.India.Index..Affordable.and.clean.energy	-0.3849	0.1893	-2.034	0.0519	.
SDG.India.Index..Decent.work.and.economic.growth	0.6233	0.2685	2.322	0.028	*
SDG.India.Index..Industry..Innovation.and.Infrastructure	-0.2589	0.2027	-1.277	0.2124	
SDG.India.Index..Responsible.consumption.and.production	0.3032	0.145	2.092	0.046	*
SDG.India.Index..Peace..justice.and.strong.institutions	-0.2484	0.2214	-1.122	0.2717	
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					
Residual standard error: 9.297 on 27 degrees of freedom					
Multiple R-squared: 0.5042, Adjusted R-squared: 0.3572					
F-statistic: 3.432 on 8 and 27 DF, p-value: 0.007517					

Table 6.

Global Moran I for regression residuals	
Moran I statistic standard deviate	0.3437
p-value	0.7310
Observed Moran I	-0.0247
Expectation	-0.0390
Variance	0.0017

Table 7

Lagrange multiplier diagnostics for spatial dependence		
LMerr	Lmerr_df	Lmerr_p-value
0.14604	1	0.7023
LMlag	Lmlag_df	Lmlag_ p-value
1.4599	1	0.227
RLMerr	RLMerr_df	RLMerr_p-value
2.9909	1	0.08374
RLMlag	RLMlag_df	RLMlag_p-value
4.3047	1	0.03801
SARMA	SARMA_df	SARMA_p-value
4.4507	2	0.108

Table 8.

Residuals:				
Min	1Q	Median	3Q	Max
-15.359	-5.23	0.219	4.849	1
Coefficients:				
	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	-65.0751	344.7326	-0.189	
SDG.India.Index..Good.Health.and.Well.being	0.4974	0.5438	0.915	
SDG.India.Index..Quality.Education	0.3145	0.3498	0.899	
SDG.India.Index..Gender.Equality	-0.1547	0.319	-0.485	
SDG.India.Index..Affordable.and.clean.energy	-0.2418	0.3297	-0.734	
SDG.India.Index..Decent.work.and.economic.growth	0.5361	0.5574	0.962	
SDG.India.Index..Industry..Innovation.and.Infrastructure	-0.0987	0.3666	-0.269	
SDG.India.Index..Responsible.consumption.and.production	0.3144	0.2049	1.534	
SDG.India.Index..Peace..justice.and.strong.institutions	0.0251	0.3613	0.069	
lag.SDG.India.Index..Good.Health.and.Well.being	-1.7094	6.2358	-0.274	
lag.SDG.India.Index..Quality.Education	-2.2515	2.5654	-0.878	
lag.SDG.India.Index..Gender.Equality	1.4682	2.5679	0.572	
lag.SDG.India.Index..Affordable.and.clean.energy	0.7043	2.8076	0.251	
lag.SDG.India.Index..Decent.work.and.economic.growth	-1.2073	4.1515	-0.291	
lag.SDG.India.Index..Industry..Innovation.and.Infrastructure	1.741	3.6854	0.472	
lag.SDG.India.Index..Responsible.consumption.and.production	0.5782	2.1814	0.265	
lag.SDG.India.Index..Peace..justice.and.strong.institutions	1.5368	3.8343	0.401	
Residual standard error: 9.884 on 19 degrees of freedom				
Multiple R-squared: 0.6056, Adjusted R-squared: 0.2736				
F-statistic: 1.824 on 16 and 19 DF, p-value: 0.1057				

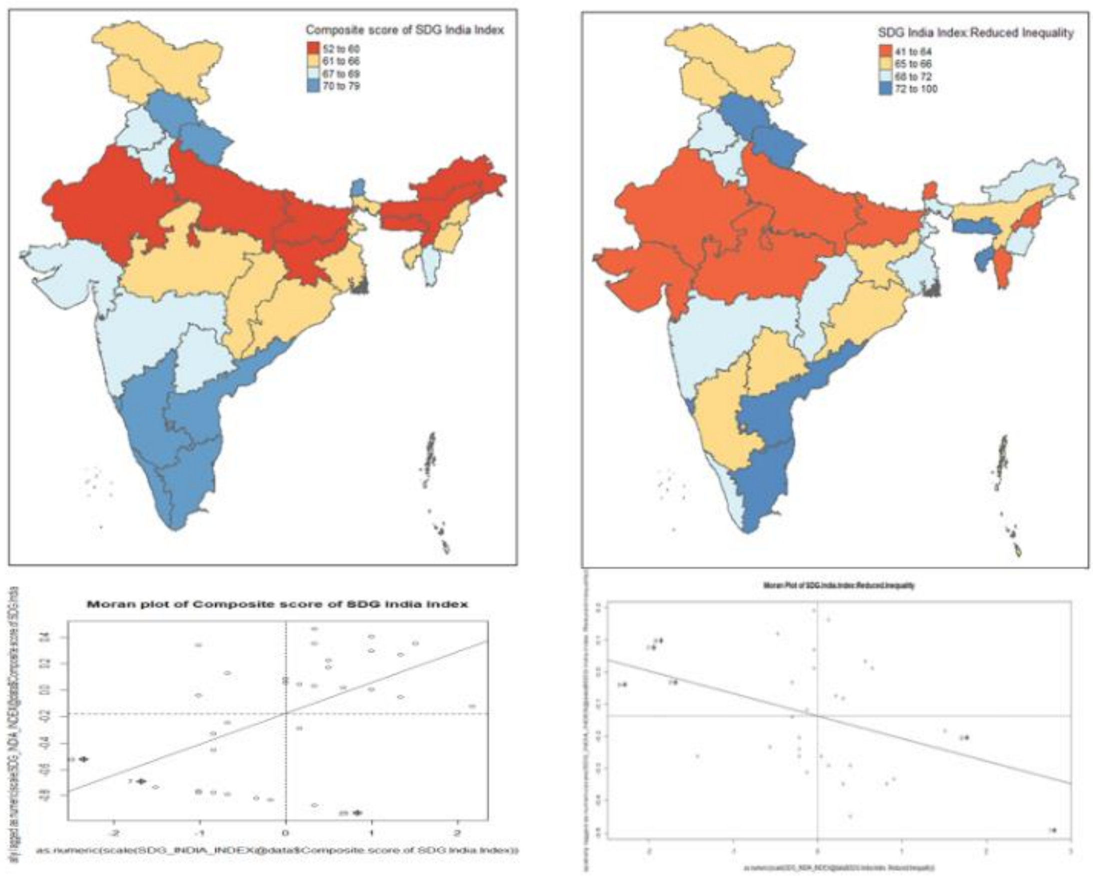


Fig. 4.

necessary skills and knowledge for economic advancement. Thirdly, efforts should be made to reduce family size in rural and urban areas. Addressing population growth can alleviate strain on resources while promoting more equitable distribution within households. By adopting these strategies and prioritizing inclusive policies focused on income enhancement, education provision, and family planning initiatives, India can substantially reduce consumer expenditure inequality and work towards achieving Sustainable Development Goal 10. Since 1991, the growth rates in states 'output have increased significantly after 1993 compared to the earlier decades. Economic growth thus seems to have increased income inequality. As rising income inequality tends to slow the process of poverty reduction in Indian states, this has been a cause for economists and policymakers. However, thus far, only a few studies have attempted to inspect the causes of rising inequalities in Indian states. The study comes up with many exciting results. It shows that structural transformation causes a high imbalance in Indian states. While trade liberalization is found to have exacerbated state-level inequality, infrastructure development has not led to trade and structural change toward services to be more inclusive. These indicative findings have essential policy implications requiring carefully designed policies for inequality reduction across Indian states, which is envisaged in SDG 10. The findings also call for differential approaches to policy for inequality reduction across Indian states. Policies should be universal in principle to reduce inequality, paying attention to the requirements of underprivileged and marginalized populations. Duty-free treatment needs to rise, and exports from developing countries should continue to be favored. In addition, the portion of developing countries' vote within the IMF needs to increase. Finally, technological modernizations can help reduce the cost of transferring money for migrant workers. Fake news, disinformation, and propaganda (FDP) present an essential threat to modern democratic societies and critically impact the quality of public life. The UN Common Guidance on Helping Build Resilient Societies aims to strengthen coherence in UN resilience-building efforts at the country level to support Governments' sustainable development objectives.

Resilience is reflected in a range of explicit and implicit SDG targets. Target 1.5 represents the core resilience target, aiming at building "the resilience of the poor and those in vulnerable situations, and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters." Resilience is also a central feature of target 13.1 which look for "strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries." Resilience further underpins several other Goals and targets regarding hunger, infrastructure, urbanization, and, ultimately, all SDGs. Building resilience is thus a multidimensional obstacle and a cross-cutting issue that will affect progress towards the SDGs and attaining the 2030 Agenda for Sustainable Development.

Building sustainable and resilient societies is central to eliminating poverty, augmenting shared prosperity, and leaving no one behind; it needs to be pursued by concentrating on the economic, social, and environmental aspects of sustainable development in an integrated manner. Sudden, disruptive events caused by internal or external factors expose vulnerabilities in countries' economic, social, political, environmental, geographic, and institutional situations. Such shocks include financial crises, natural disasters, other ecological (or climate-related events), health-related occurrences, and human-made (including technological) hazards. Within countries, specific regions, population groups, or individuals may be more vulnerable than others. When shocks occur, the severity of their impact on individuals, society, and the environment depends on vulnerability and exposure, preparedness, and recovery capacities. This cuts across multiple areas, including urban planning and infrastructure, food security, economic structures, insurance mechanisms, social protection systems, and public institutions that are key to recovery.

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