Environmental Sustainability : Scrutinizing the State of States

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Abstract

Purpose : Environmental sustainability has become the most pressing worry for humanity as a result of the race for development's detrimental impacts on the environment. The current study aimed to assess the major Indian states' environmental quality.

Methodology : The 2019–2021 environmental health status was evaluated in this paper. By using principal component analysis (PCA), four composite indexes have been created. Borda's rule is utilized to calculate the composite environmental quality score (CEQS) based on rankings of sub-indices. Spearman's rank correlation has been calculated in order to investigate the relationship between the level of development and environmental sustainability.

Findings : Himachal Pradesh and Goa are the only states that have performed consistently well in all sub-indices and thus achieved the top badge in the overall environmental quality category. The states of Assam, Manipur, and Tripura in the Northeast have done a good job of conserving their resources. The four states with the lowest environmental quality were Uttar Pradesh, Gujarat, Maharashtra, and Delhi. According to the report, states with more development are grouped with those that have more environmental damage.

Practical Implications : In order to create a sustainable and environmentally friendly future, the research recommended that governmental policies incorporate sustainable practices with the goal of striking a balance between environmental concerns and economic realities.

Originality : In contrast to other research, this study looked at disaggregated data and ranked the major Indian states based on how well they performed in terms of environmental sustainability and looked at the relationship between that performance and development level. PCA and cluster analysis are used in this research.

Keywords : **environmental sustainability, principal component analysis, pollution and waste, sustainable development**

JEL Classification Codes : O1, Q56, Q53, Q01

Paper Submission Date : August 10, 2023 ; Paper sent back for Revision : December 21, 2023 ; Paper Acceptance Date : February 10, 2024

The need and desirability of "development" have always remained unquestionable for all countries, irrespective of their political, social, or economic systems. In the process of development, indefinite market-propelled expansion of the production capacity of goods and services culminates in the overuse, misuse, or underuse of natural resources, resulting in the conflict between the developmental process and ecological sustainability. The global decrease in biodiversity and the rise in carbon dioxide emissions are mostly

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DOI : https://doi.org/10.17010/aijer/2024/v13i1/173412

caused by the existing “take-make-waste” development paradigm and the increased consumption of natural resources (Singh et al., 2023). Development is prioritized when it comes to improving people's quality of life to the greatest extent possible through increases in income, equality, productivity, health, and education. However, the potential of the environment to serve as a source and a sink is lost in the course of accomplishing these developmental goals. The lack of knowledge about the monetary worth of these natural resources and services consequently jeopardizes sustainability (Ramesh et al., 2021).

Environmental sustainability is “a set of constraints on the four major activities regulating the scale of the human economic subsystem: the use of renewable and non-renewable resources on the source side, and pollution and waste assimilation on the sink side” (Goodland, 1995). Morelli (2011) defined environmental sustainability as “meeting the resource and services needs of current and future generations without compromising the health of the ecosystems that provide them, as a condition of balance, resilience, and interconnectedness that allows human society to satisfy its need while neither exceeding the capacity of its supporting ecosystems to continue to regenerate the services necessary to meet those needs nor by our actions diminishing biological diversity.”

Environmental sustainability, environmental degradation, environmental performance, sustainable development, quality of the environment, and similar ideas have elicited the attention of researchers since the publication of “Our Common Future” (United Nations, 1987). Sustainable Performance Index (SPI), Living Planet Index (LPI), Ecological Footprint (EF), Fossil Fuel Sustainability Index (FFSI), and other ecosystem-based indices are a few examples of composite indices meant for measuring environmental state. The Sustainable Cities Index, the Environment Sustainability Index (ESI), the Environment Quality Index, the Environmental Performance Index (EPI), the Environmental Vulnerability Index, and the Well-Being Index also assess the quality of the environment of a particular region/ nation (Singh et al., 2009). These environmental indices are used for (a) evaluating the circumstances in which regional or national environmental outcomes fall short or exceed expectations, (b) tracing policy to determine its successes and shortcomings, (c) setting environmental performance benchmarks and identifying best practices, and (d) exploring the connections between the performance of the economy and the environment (Cui et al., 2004).

The present study proposes the following objectives:

(1) To create the various environmental dimension indicators for the 25 largest Indian states between 2019 and 2021.

(2) To construct a composite index for comparison between the levels of environmental quality in major Indian states.

(3) To categorize states according to their environmental performance.

(4) To determine how environmental deterioration and economic growth interact in the Indian states.

Review of Literature

An index is intended to gauge complicated ideas that are difficult to quantify with a single indicator (OECD, 2008). According to Tanguay et al. (2010), the public and other stakeholders find it simpler to understand and study specific occurrences when indices are used in the field of sustainable development. Environmental performance indexing is critical for monitoring the effectiveness of sustainable development programs and the adoption of socially acceptable, commercially feasible, and ecologically friendly policies (Lamichhane et al., 2021).

The ESI, which incorporates socioeconomic, environmental, and institutional concerns, provides a more comprehensive approach to sustainability measurement. The ESI was the first attempt to use 21 indicators drawn from 76 underlying data sets to classify countries. Given that the ESI's scope is rather broad, the Yale–Columbia research team created the EPI in 2006 to focus on a smaller set of environmental issues for which governments may be held accountable. The EPI monitors outcome-oriented indicators using the best data that is currently available in key policy domains (Wolf et al., 2022). Scholars have thoroughly examined the process of creating an ESI for various geographical regions. Table 1 displays a list of significant studies.

Table 1. ***A Summary Literature Review of Composite Environmental Indices***

Author	Composite Index	Scope	No. of Variables	Index Scope	Method of Indexing
Choi et al. (2015)	Aggregate Air Quality Index (AAQI)	USA	Five indicators	Air Quality	Principal component analysis (PCA), Line segment
Al Asbahi et al. (2019)	Energy Trilemma Index (ETI)	10 countries	Five indicators and three dimensions of ETI	Energy Security, Energy Equity, and Environmental Sustainability.	PCA
Shah et al. (2019)	Energy Security and Environmental Sustainability Index (ESESI)	8 countries	11 indicators and two dimensions	Energy Security and Environmental Sustainability.	Weighted product (WP)
Jain & Mohapatra (2023)	Composite Environmental Sustainability Index (CESI)	20 countries	Seven indicators	Environmental Sustainability.	PCA
Singh et al. (2021)	Global Sustainable Development Index (GSDI)	39 countries	Three dimensions (sub-indices)	Environmental Sustainability, Economic Development, and Social Development.	Composite *Z*-score technique
Cui et al. (2004)	Environmental Sustainability Index (ESI)	Shadong Province, China	22 indicators and 43 variables	Environmental Systems, Environmental Stresses and Risks, Human Vulnerability, Social and Industrial Capacity, and Global Stewardship.	Composite *Z*-score technique
Fakher et al. (2021)	Composite Environmental Quality Index	OPEC and OECD Countries	Six indicators	Ecological Footprint, Environmental Performance, Environmental Sustainability, Environmental Vulnerability, Adjusted Net Saving, and Pressure on Nature Indices.	PCA and Artificial Neural Network (ANN) methods
Adhikary & Hajra (2021)	Composite Environmental Degradation Index (CEDI)	SAARC Countries	Seven indicators (sub-indices)		

Mesagan & Nwachukwu (2018)	Environmental Degradation Index	Nigeria	Two indicators		PCA
Almeida et al. (2017)	Modified Composite Index of Environmental Performance (mCIEP)	152 countries	19 individual indicators grouped into five dimensions		
Jha & Murthy (2003)	Composite Environmental Degradation Index (EDI)	174 countries	Six variables		PCA
Khatun (2009)	Environmental Degradation	51 countries	11 variables	Access to safe drinking water, safe sanitation, GDP per capita, consumption of traditional fuel, total fertility rate and access to electricity, annual freshwater withdrawals, annual renewable water resources, commercial energy use, carbon dioxide emissions, and writing and printing paper consumed.	PCA
Latif (2022)	Comprehensive Environmental Performance Index (CEPI)	48 Asian countries	Six indicators	Ecological Footprint, Environmental Quality, Environmental Vulnerability, Environmental Sustainability, Adjusted Net Savings, and Pressure on Nature.	PCA
Singh et al. (2019)	Environmental Sustainability Index	22 Asian economies	Seven main components with 25 sub-indicators of environmental performance	Air Quality and Pollution, Energy Management, Forest and Biodiversity, Land Use and Agriculture, Human Health and Disaster, Population Pressures on Ecosystem, Water Generation Management.	Composite *Z*-score technique
Mukherjee & Kathuria (2006)	Environmental Quality Score	14 Indian States	63 environmental status indicators are grouped under eight broad environmental variables	Air Pollution, Indoor Air Pollution Potential, Green House Gases (GHG) Emissions, Pollution from Energy Generation and Consumption, Depletion and Degradation of Forest Resources, Depletion and Degradation of Water Resources, Nonpoint Source Water	PCA

The wealth of literature reveals that several attempts at national and international levels have been made to gauge the state of the environment. Diversity in the number and choice of variables, mainly due to the constraint of availability of data, is quite evident. Air, water, forest, and energy are used invariably, the reason for which is the accessibility of comparable data at regular intervals. For the preparation of a composite index, PCA has been a favorite choice; however, the use of an index for further analysis, like examining the relationship between the stage of development and environmental degradation, is very rare.

Data and Methodology

The variables selected for this study include the effect of socioeconomic activities on the environment. The chosen indicators, based on a list of environmental and socioeconomic indicators created by the United Nations Statistical Division (UNSD) in coordination with the Intergovernmental Working Group on the Advancement of Environmental Statistics, include annual average SO_2, NO_2, PM_{10}, and $PM_{2.5}$concentrations, forest as a percentage of geographical area, change in forest cover, volume of growing stock, fertilizer and chemical pesticide use, the total amount of biomedical waste produced, amount of hazardous waste produced as per annual return, amount of municipal solid waste produced, estimated amount of plastic waste produced, stage of groundwater development, amount of households without sanitation facilities, amount of biochemical oxygen demand, sewage generation in urban areas, and the total number of registered motor vehicles. The four indices, the Waste Index (WI), the Air

Table 2. ***Description of Environmental Indicators***

Index	Variables	Abbreviations Used
AQI	Annual Average Concentrations of SO_2	SO2
	Annual Average Concentrations of NO_2	NO2
	Annual Average Concentrations of PM_{10}	PM10
	Annual Average Concentrations of $PM_{2.5}$	PM2.5
	Total Number of Registered Motor Vehicles	RMV
WQI	Stage of Ground Water Development	SGW
	Percent of Households with no Sanitation Facilities	NSF
	Biochemical Oxygen Demand	BOD
	Sewage Generation in Urban Areas	SGU
WI	Total Quantity of Bio-Medical Waste Generated	BMW
	Quantity of Hazardous Waste as per Annual Return	HW
	Municipal Solid Waste Quantity Generated	MSW
	Estimated Plastic Waste Generation	PW
FSI	Forest as Percentage of Geographical Area	FGA
	Change in Forest Cover	CFC
	The Volume of Growing Stock	VGS
	Consumption of Fertilizers	FERT
	Consumption of Chemical Pesticides in India	PEST

Quality Index (AQI), the Water Quality Index (WQI), and the Forest and Soil Index (FSI), were created using these 17 indicators, which span the years 2019 to 2021, as displayed in Table 2.

The study is based on secondary data gathered from various government reports, mainly EnviStats India, and online databases such as IndiaStat.com. The variables mentioned above have been taken for all major twenty-five states, namely Andhra Pradesh, Assam, Bihar, Chhattisgarh, Delhi, Goa, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Odisha, Punjab, Rajasthan, Tamil Nadu, Telangana, Tripura, Uttar Pradesh, Uttarakhand, and West Bengal. The indicators have been standardized using pertinent measures of the States' size or scope, such as population or geographic area.

The four sub-indices are further used to compute the composite environmental quality score (CEQS), and states are ranked and clustered based on their performance in CEQS.

(1) The 17 variables that make up the CEQS are expressed in different units. As a first step, the indicators are standardized to ensure consistency in the data and to make them unit-free.

(2) To create a composite index of environmental quality for the major Indian states for 2019–2021, the PCA approach has been chosen for the analysis of the multivariate data. "Principal components (Pcs)" are a set of linearly uncorrelated variables created by the orthogonal transformation of a collection of correlated variables (Jolliffe, 2011). The first PC best captures the variance in the chosen variables. The second, third, and so on components are totally independent of the first component, even if all PCs combined account for the majority of the variance in the initial data (Vyas & Kumaranayake, 2006).

The following steps are taken in order to compute the composite indicators: in practice, data on the factors x_1, x_2, up to x_n for all n regions are expressed in a matrix form supposing matrix of x of n observations on k variables, where the observations are expressed as deviations from the corresponding sample means:

(a) Computing $(x'x)$, which is, in fact, the correlation matrix.

(b) Solving for space λ in $|(x'x)-\lambda I|=0$.

(c) Taking the largest characteristics (latent) root and computing the characteristic vector corresponding to it that is:

$$[(x'x)-\lambda I]a_1=0 \qquad (1)$$

$$\text{such that } a_1'a_1=1 \qquad (2)$$

(d) Computing the weighted average of the standard variants is done using the elements of a as weights. Thus, the first principal component is :

$$Z_1=a_{11}x_1+a_{21}x_2+\ldots\ldots\ldots+a_{k1}x_k \qquad (3)$$

It would be possible to exclude the non-significant variables by replacing all low or near-zero loadings with zero so that the resulting scores represent only the influence of the variables that are thought to be important.

(e) The trace of the correlation matrix is the number of original variables that is k. The percentage of variance in these variables explained by the first principal component is $(\lambda_1/k)100$.

(3) In all, four indices, namely, AQI, WQI, WI, and FSI, are prepared. The basic idea is that when all the indicators of a group are aggregated, they should accurately represent the state's environmental condition about that specific criterion. Therefore, a total of four PCA models are created. The Kaiser–Mayer–Olkin (KMO) and Bartlett's tests are used to evaluate the sample suitability and data dependability, and PCA is utilized to achieve this. The STATA software version 13 was utilized to finish the exercise. The PCA scores are normalized so that their values fall between 0 and 100, with 100 denoting the worst possible environmental quality and 0 denoting the best possible.

$$AQIi = \frac{AQIi - Min\,[AQIi]}{Max[AQIi] - Min[AQIi]} * 100 \quad (4)$$

$$WQIi = \frac{WQIi - Min\,[WQIi]}{Max[WQIi] - Min[WQIi]} * 100 \quad (5)$$

$$WIi = \frac{WIi - Min\,[WIi]}{Max[WIi] - Min[WIi]} * 100 \quad (6)$$

$$FSIi = \frac{FSIi - Min\,[FSIi]}{Max[FSIi] - Min[FSIi]} * 100 \quad (7) \text{ where, } i = 1 \text{ to } 25$$

Using the scores, the states are ranked for each environmental dimension.

(4) In the next step, a CEQS is prepared using Borda's rule, which is an aggregation of the ranks of four indices prepared. If E_{ij} is the rank of the *i*th State concerning *j*th environmental index (group), then $CEQS_i$ is the rankof the *i*th state combining all four computed environmental indices:

$$CEQS_i = \sum_{j=1}^{4} E_{ij} \quad (8)$$

(5) Next, all 25 states are ranked according to their environmental quality score, where the environmental quality rank (CEQS RANK) of the *i*th state is the rank of the state concerning CEQS.

(6) To categorize 25 states into four clusters, a clustering technique, specifically the hierarchical cluster analysis, is performed. It uses Euclidean distance interval to study the homogeneity of the states according to their performance in the CEQS. Cluster analysis is an exploratory technique that finds *n p*-dimensional observations of similar groups of units without presuming that the data collection contains such homogenous groupings. The goal of the analysis is to interpret the reduced dimensions of *Rn* to produce *g* homogeneous groups $(g<n)$ while demonstrating the existence of group structures found by statistical methodology. Its main objective is to group units into homogenous subsets (Amicarelli et al., 2021; Zani & Cerioli, 2007).

(7) Spearman's rank correlation between the rankings of the states based on the net state domestic product (NSDP) factor cost (at constant 2011–2012 prices) and the CEQS scores is calculated in order to investigate the relationship between development and environmental quality.

Analysis and Results

Four sub-indices for the states of India are created in this study using PCA, one of the core and fundamental methods of factor analysis that has been widely used by researchers (Fakher et al., 2021; Jha & Murthy, 2003; Khatun, 2009; Latif, 2022; Mukherjee & Kathuria, 2006). Various environmental quality parameters are measured using the 17 environmental indicators listed in Table 2. Data acceptability for PCA has been evaluated using the KMO coefficient, whose value is always between 0 and 1. The data are evaluated for suitability for

Table 3. ***Results of KMO Statistics and Bartlett's Test***

Index	KMO Value	Bartlett's Test of Sphericity		
		Chi-square	Degree of freedom	Significance
AQI	0.588	66.200	10	0.000
FSI	0.602	26.637	10	0.003
WQI	0.743	12.300	6	0.056
WI	0.587	55.727	6	0.000

factor analysis using Bartlett's sphericity test in addition to the KMO coefficient. In order to determine whether there is a relationship between the variables, Bartlett's sphericity test is used. A practical model needs to have correlated variables in order to be useful and intelligible; otherwise, the factor model wouldn't need to be explained (Fakher et al., 2021). The results of these tests are presented in Table 3.

The data are appropriate for PCA based on the KMO values for the sub-indices FSI, WI, AQI, and WQI. The null hypothesis is disproved, and significant results from Bartlett's test show a genuine relationship between the variables. Thus, all four sub-indices should be subjected to PCA. Table 4 presents the PCA findings for the sub-indices.

The principal components generated by individual sub-indices are shown in Table 5. Five principal components were produced when PCA was performed on the FSI and AQI sub-indices. In the case of the WI and WQI sub-indices, only four major components were created concurrently. Only the first principal components

Table 4. ***Principal Components Obtained in Different Indices***

Index	Variables	Principal Components				
		PC1	PC2	PC3	PC4	PC5
AQI	*SO2*	0.3619	0.4534	–0.7445	–0.2506	–0.2152
	NO2	0.5063	0.0905	0.5666	–0.6091	–0.2086
	PM2.5	0.5644	–0.1851	–0.0953	0.0809	0.7974
	PM10	0.5403	–0.2654	0.0386	0.6182	–0.5039
	RMV	0.0460	0.8355	0.3378	0.4213	0.1572
FSI	*FGA*	–0.5992	0.0859	0.0143	0.4621	0.6480
	CFC	0.2454	0.5232	–0.7138	0.3830	–0.0998
	VGS	–0.0300	0.8333	0.3777	–0.3823	0.1260
	FERT	0.6065	–0.1395	–0.1170	–0.2231	0.7411
	PEST	0.4604	0.0711	0.5779	0.6663	–0.0716
WI	*HW*	0.3633	–0.8878	0.2802	–0.0351	
	MSW	0.5487	–0.2710	0.0484	–0.7894	
	PW	0.5416	0.0365	–0.7780	0.3162	
	BMW	0.5231	–0.3701	0.5602	0.5250	
WQI	*SGW*	0.3855	–0.5993	0.6991	0.0594	
	BOD	0.5677	–0.1913	–0.5281	0.6018	
	SGU	0.6269	0.0872	–0.2076	–0.7458	
	HSF	0.3689	0.7724	0.4350	0.2793	

Table 5. ***Variance Explained by First Principal Component for Four Environmental Indices***

	Eigenvalue	Difference	Proportion of Variance Explained
AQI	2.76787	1.46931	**0.5536**
FSI	2.17559	1.04124	**0.4351**
WI	2.83839	2.0703	**0.7096**
WQI	1.85509	0.903684	**0.4638**

Table 6. ***Descriptive Statistics of Indices***

Variables	Mean	*SD*	CV
AQI	37.3104	26.78751	1.392
FSI	54.09516	28.34395	1.908
WQI	32.03624	29.44801	1.087
WI	33.97667	23.4188	1.450

were utilized to create the sub-indices because they account for a sizable enough percentage of the total variation. Table 5 presents the total variance explained by the first principal components of each sub-indices.

Table 5 shows that the first component in the case of AQI, which has an eigenvalue of 2.76, explains 55.36% of the total variance. The second and fourth sub-indices, i.e., FSI and WQI, with eigenvalues of 2.17 and 1.85, respectively, explain 43.51 and 46.38% variation. The third sub-index, having an eigenvalue of 2.83, explains the maximum variation, i.e., 70.96%.

Table 6 displays the descriptive statistics for the four sub-indices: FSI, WI, WQI, and AQI. These statistics include mean, standard deviation *(SD),* and coefficient of variation (CV). These descriptive statistics significantly help our capacity to properly interpret the research findings since they reveal important details about the data.

The FSI displays the highest variance and mean score among the environmental indicators. With respect to mean score and variation, the WQI shows the lowest values. With the vast area of the country and the wide range of environmental variables, all four indices show a significant dispersion, which is in accordance with expectations.

Table 7 provides the ranking of states in four sub-indices. In the AQI, Himachal Pradesh, Kerala, and Goa are the best-performing states, whereas Delhi, Jharkhand, and Uttar Pradesh are the worst-performing states. In the

Table 7. ***Ranking of States for Four Sub-Indices and Calculation of CEQS***

States/UTs	Rank AQI	Rank FSI	Rank WI	Rank WQI	CEQ Score	CEQS Rank
I	II	III	IV	V	VI	VII
Andhra Pradesh	6	20	14	8	48	10
Assam	8	5	7	6	26	5
Bihar	17	19	12	16	64	14
Chhattisgarh	4	11	6	7	28	6
Delhi	**25**	14	19	18	76	22
Goa	3	3	3	3	**12**	**1**
Gujarat	18	17	24	23	82	23

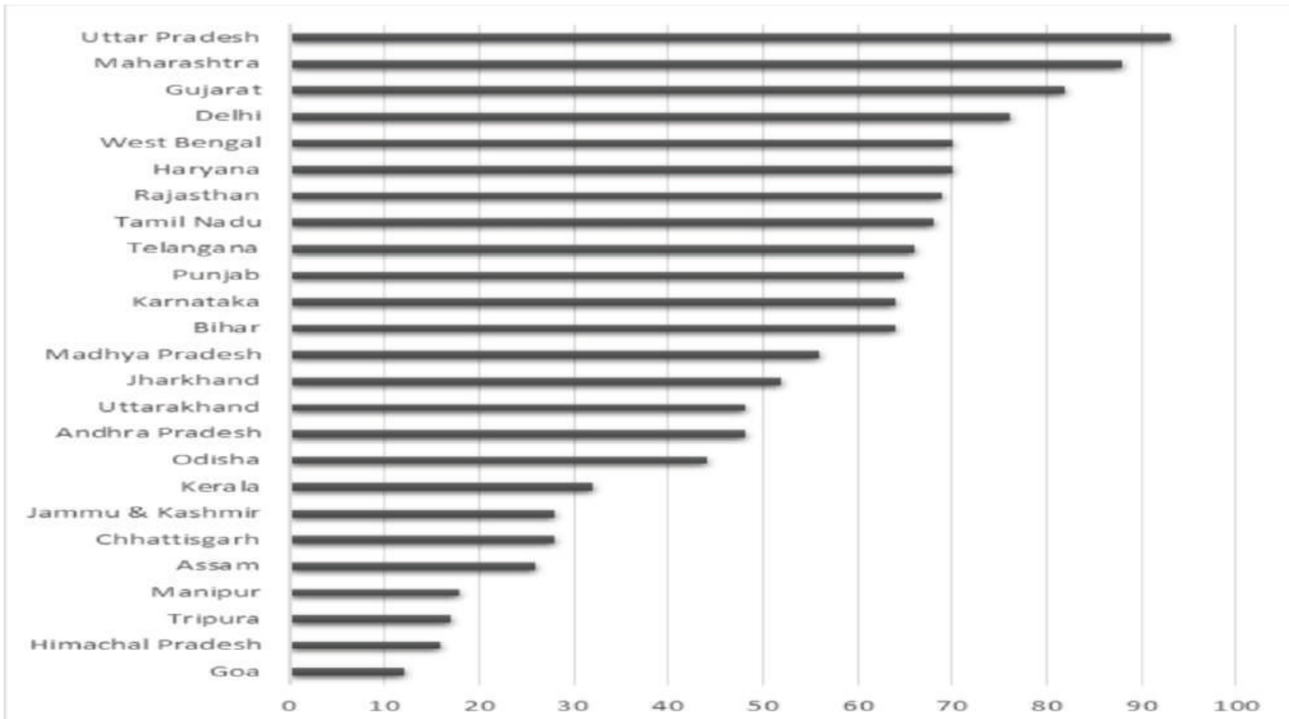
Haryana	22	21	13	14	70	20
Himachal Pradesh	**1**	6	4	5	16	2
Jammu & Kashmir	10	9	5	4	28	6
Jharkhand	24	8	8	12	52	12
Karnataka	7	15	22	20	64	14
Kerala	2	4	17	9	32	8
Madhya Pradesh	13	10	16	17	56	13
Maharashtra	19	22	**25**	22	88	24
Manipur	14	**1**	2	**1**	18	4
Odisha	9	12	10	13	44	9
Punjab	11	24	11	19	65	16
Rajasthan	20	13	15	21	69	19
Tamil Nadu	5	16	23	24	68	18
Telangana	15	23	18	10	66	17
Tripura	12	2	**1**	2	17	3
Uttar Pradesh	23	**25**	20	**25**	**93**	**25**
Uttarakhand	21	7	9	11	48	10
West Bengal	16	18	21	15	70	20

FSI, Manipur, Tripura, and Goa top the list, and Uttar Pradesh, Punjab, and Telangana are the lagging states. In terms of the WI and WQI, Tripura, Manipur, and Goa stand as the best performers. In contrast, Maharashtra, Gujarat, Tamil Nadu, and Uttar Pradesh are the bad performers. Delhi shows the worst performance in AQI but has average performance in other indices, as also shown in earlier studies (Arora & Swain, 2020). Andhra Pradesh's rank in FSI and WI is poor in comparison to its rank in AQI and WQI, whereas Haryana's performance in AQI and FSI is very poor compared to its performance in WQI and WI. Tamil Nadu and Karnataka both have excellent AQIs, but they still need to make improvements in other areas of the environment. In contrast, Manipur and Tripura have outperformed in every single sub-index except for the AQI. The state of Bihar has regularly demonstrated medium environmental quality overall across all sub-indices.

The CEQS were obtained by applying Borda's rule, and the scores were used to rank the states (Figure 1). Based on the scores, West Bengal, Uttar Pradesh, Maharashtra, Gujarat, and Delhi are the five states with the lowest performance. The only two states to continuously score highly across all sub-indices and receive the highest badge in the category of overall environmental quality are Himachal Pradesh and Goa. Assam, Manipur, and Tripura, three Northeastern states, have performed exceptionally well across all sub-indices and have risen to the top of the list of 25 states. In the following phase, cluster analysis was carried out to confirm the results of the unrefined ranking approach.

The outcomes of the hierarchical cluster analysis performed on the CEQ scores in order to prepare four clusters are displayed in Figure 2. The first cluster, which comprises Assam, Chhattisgarh, Goa, Himachal Pradesh, Jammu & Kashmir, Kerala, Manipur, and Tripura, represents the nation's top performance on environmental factors. The second cluster manifesting fairly good performance includes Andhra Pradesh, Jharkhand, Madhya Pradesh, Odisha, and Uttarakhand. The third cluster comprises Bihar, Haryana, Karnataka, Punjab, Rajasthan, Tamil Nadu, Telangana, and West Bengal. The fourth cluster showing poor environmental quality includes Delhi, Gujarat, Maharashtra, and Uttar Pradesh. Figure 2 shows the results of the hierarchical cluster analysis that was done on the CEQ scores to create four clusters. Assam, Chhattisgarh, Goa, Himachal Pradesh, Jammu & Kashmir, Kerala, Manipur, and Tripura make up the first cluster, which is indicative of the best

Figure 1. ***Composite Environmental Quality Scores (CEQS)***



Note. Based on Table 7.

Figure 2. ***Map Showing Clusters of States Based on CEQS***

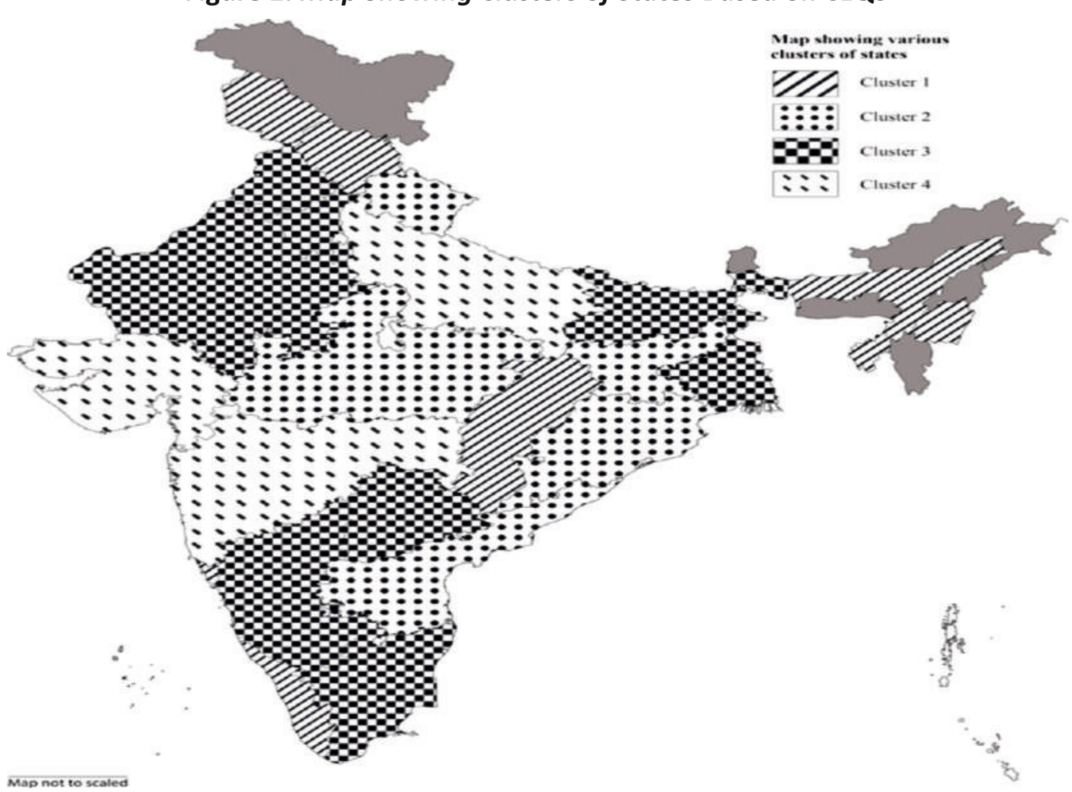


Table 8. ***Comparison of Ranking of States Based on NSDP and CEQS***

States/UTs	Net State Domestic Product (NSDP) at Factor Cost 2020–21 (At Constant 2011–2012 Prices)	NSDP Rank	CEQS Rank
Andhra Pradesh	595,658	8	10
Assam	212,315	18	5
Bihar	359,196	15	14
Chhattisgarh	220,624	17	6
Delhi	521,994	10	22
Goa	48,509	23	1
Gujarat	1,110,179	2	23
Haryana	507,776	13	20
Himachal Pradesh	102,613	21	2
Jammu & Kashmir	90,791	22	6
Jharkhand	209,913	19	12
Karnataka	1,030,357	4	14
Kerala	521,455	11	8
Madhya Pradesh	508,146	12	13
Maharashtra	1,782,903	1	24
Manipur	177,56	25	4
Odisha	346,106	16	9
Punjab	367,558	14	16
Rajasthan	598,550	7	19
Tamil Nadu	1,099,402	3	18
Telangana	572,736	9	17
Tripura	33,695	24	3
Uttar Pradesh	980,106	5	25
Uttarakhand	166,351	20	10
West Bengal	697,554	6	20

performance in the country with regard to environmental concerns. The central region, including Madhya Pradesh and Chhattisgarh, shows medium levels of environmental quality. The Northwestern states, including Rajasthan, Haryana, and Punjab, and Southern states, like Andhra Pradesh, Telangana, and Karnataka, also show a medium level of deterioration in the environmental quality. The results suggest that states with higher levels of development also have higher rates of environmental degradation. An attempt has been made to rank and correlate NSDP and CEQS in order to support this relationship further.

Table 8 presents the rankings of the states according to the CEQS and the rankings that the NSDP 2020–21 at constant prices 2011–2012 received. The list's highest NSDP is shown by rank 1, while its lowest NSDP is indicated by rank 25. The rank correlation is found to be (–) 0.8395 at a 1% significance level, showing that there is a strong negative correlation between the ranks of the two variables, i.e., the higher the NSDP rank, the lower the environmental quality rank representing lower environmental deterioration or better environmental quality. The result "higher the development, higher the environmental degradation" is commensurate with previous studies (Murthy & Gambhir, 2018; Pal & Mitra, 2017; Sinha & Bhatt, 2017), which show that India is on the rising part of the "inverted U shape" Environmental Kuznets Curve (EKC) and efforts must be made to leapfrog to the declining part of EKC, which is quite possible with the use of new technologies, now available and also affordable for India with the renewable energy systems becoming the preferred method of power generation due to the growing environmental and sustainability consciousness (Nag & Chowdhary, 2019). Environmental sustainability could be India's next major concern, given the high costs of deterioration (Saarangapani & Sripathi, 2015).

Conclusion

Enhancing people's quality of life and maintaining the environment's quality are two of the biggest problems facing humanity today. We are interested in how developmental activities impact the environment and render it unsustainable. The ESI, a pioneering effort in this manner to classify nations using a variety of metrics, was completed in 2005. There have been numerous attempts to utilize the composite index to assess the state of environmental quality. Policymakers can assess environmental results, monitor progress, and establish performance standards with their help. This might significantly disrupt the conventional route of the "inverted U-shaped" Environmental Kuznets Curve (EKC).

This paper examines the current state of environmental health of major Indian states, specifically concerning air quality, water quality, waste, forest, and soil. Applying PCA on 17 environmental indicators, four composite indices have been prepared, which describe the relative position of the states of India. Furthermore, rankings of sub-indices are used for the computation of the CEQS with the help of Borda's rule. All states have been grouped into four categories as per their CEQS, reflecting the stage of environmental sustainability. Finally, Spearman's rank correlation between States' rank based on NSDP at constant prices and CEQS has been computed to investigate the relationship between the stage of development and environmental sustainability.

A total of 25 states have been categorized into four clusters based on CEQS. The first cluster representing the best performance in the country on environmental parameters includes Assam, Chhattisgarh, Goa, Himachal Pradesh, Jammu & Kashmir, Kerala, Manipur, and Tripura. The second cluster manifesting fairly good performance includes Andhra Pradesh, Jharkhand, Madhya Pradesh, Odisha, and Uttarakhand. The third cluster comprises Bihar, Haryana, Karnataka, Punjab, Rajasthan, Tamil Nadu, Telangana, and West Bengal. The fourth cluster showing poor environmental quality includes Delhi, Gujarat, Maharashtra, and Uttar Pradesh. Spearman's rank correlation between NSDP and CEQS shows a strong negative correlation that is significant at a 1% level, putting states with higher development in the club of higher environmental degradation.

Environmental sustainability has certainly become a buzzword today. Since the publication of "Our Common Future" (United Nations, 1987), the debate about the interaction between economic ecology and the call for action has been ever-growing. The concept of sustainability pertains to our responsibility toward the future. All stakeholders, especially governments and civil society, must have a clear commitment to upholding the moral obligation we have to future generations. An effort has been made to incorporate as many states as possible in the analysis in order to increase its reach. The study's primary shortcoming, however, was the inability to create a full data set for each state in the nation due to a lack of consistent data over an extended period.

Authors' Contribution

Prof. Alpana Kateja originated the study concept and developed the quantitative design for the empirical investigation. Poorvi Medatwal, on the other hand, curated research papers of high repute and filtered them based on specific keywords. Prof. Kateja validated the analytical methods and provided overall supervision for the study. Numerical computations were a joint effort undertaken by both authors using SPSS 20.0. The manuscript was collaboratively written, with Prof. Kateja taking the lead in consultation with Ms. Medatwal.

Conflict of Interest

The authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest, or non-financial interest in the subject matter or materials discussed in this manuscript.

Funding Acknowledgment

The authors received no financial support for the research, authorship, and/or for the publication of this article.

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