

ENVIRONMENTAL SUSTAINABILITY ASSESSMENT IN INDIA USING PRESSURE- STATE-RESPONSE FRAMEWORK OVER 2014 - 2024

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**ENVIRONMENTAL SUSTAINABILITY
ASSESSMENT IN INDIA USING
PRESSURE-STATE-RESPONSE FRAMEWORK
OVER 2014 - 2024**

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Partial Fulfilment of the Requirements for the
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Submitted by
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Under the Supervision of
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I, Navya Vajpayee, **1** Roll No. 24/ENE/05 hereby certify that the work which is being presented in the thesis entitled **"ENVIRONMENTAL SUSTAINABILITY ASSESSMENT IN INDIA USING PRESSURE-STATE-RESPONSE FRAMEWORK OVER 2014 - 2024"** **1** in partial fulfilment of the requirements for the award of the Degree of Master of Technology, submitted in the Department of Environmental Science and Engineering, Delhi Technological University, is original and not copied from any source without proper citation. **1** The matter presented in the thesis has not been submitted by me for the award of any other degree of this or any other Institute.

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SUPERVISOR

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**INDEX-BASED ASSESSMENT OF ENVIRONMENTAL SUSTAINABILITY
IN INDIAN STATE CAPITALS USING PRESSURE-STATE-RESPONSE
FRAMEWORK (2014-2024)**

ABSTRACT

In a world that continues to create larger economies, unsinkable infrastructures and consuming huge amounts of resources, an increasing and mounting pressure is exerted on the urban centers, making them environmentally stressed. Each urban center reacts differently under stressors and is controlled by an interdependent environment, policy and governance systems, and assessment of environmental performance is essential. In the study, 'Pressure State Response (PSR)' model is used in conjunction with a holistic approach, the 'Environmental Sustainability Index (ESI)' which was constructed over a decadal scale (2014 and 2024) for capital cities across India. It critically examines the interrelated environmental performance, sustainability pathways and governance response across the cities and inter-city variations in environmental performance. The results show variations within the environmental profiles of the cities through the decade relating to governance and policy interventions. Actual evidence lies in the PSR lens where despite showing a considerable improvement in ESI, cities like Patna (Δ ESI 0.09), Panjim (Δ ESI 0.88), Gandhinagar (Δ ESI 0.06), Imphal (Δ ESI 0.78), Bangalore (Δ ESI 0.15), Trivandrum (Δ ESI 0.38), and Kolkata (Δ ESI 0.09) need to focus on their specific pressure, state and response indicators to accomplish sustainable urban planning. The insights into PSR analysis identify the concerned set of indicators for the mentioned cities. Key areas include air quality management ($PM_{2.5}$ and PM_{10}) in Patna, Panjim, Trivandrum and Bangalore; water availability, drinking water access, and water quality compliance in Gandhinagar, Bangalore and Imphal; and improvement in urban green cover, renewable energy adoption and waste collection efficiency in all the cities. The insights strengthen information on environmental performance, reinforce policies to help the policymakers to act upon loopholes in governance and place adequate checks.

Keywords: *ESI, Indicator Based Framework, PSR model, Urban Environmental Pressure, Decadal Analysis, Environmental Sustainability Index, India.*

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LIST OF ABBREVIATIONS

1. **ESI:** Environmental Sustainability Index
2. **PSR:** Pressure-State-Response
3. **AMR :** Amravati
4. **ITN :** Itanagar
5. **DIS :** Dispur
6. **PAT :** Patna
7. **RAIP :** Raipur
8. **PANJ :** Panjim
9. **GNDNGR :** Gandhinagar
10. **CHND :** Chandigarh
11. **SHM :** Shimla
12. **RNC :** Ranchi
13. **BLR :** Bangalore
14. **TRIV :** Trivandrum
15. **BHO :** Bhopal
16. **MUM :** Mumbai
17. **IMP :** Imphal
18. **SHILL :** Shillong
19. **AIZ :** Aizwal
20. **KOH :** Kohima
21. **BHUB :** Bhubhneswar
22. **JAI :** Jaipur
23. **GNGTK :** Gangtok
24. **CHE :** Chennai
25. **HYD :** Hyderabad
26. **AGT :** Agartala
27. **DDN :** Dehradun
28. **LCKN :** Lucknow
29. **KOL :** Kolkata
30. **DEL :** Delhi

CHAPTER 1 : INTRODUCTION

1.1 Background of the Study

Rapid urbanization has created a mixed flow of environmental challenges which are increasingly posing threats to sustainability of the cities globally. This process of urbanization, which is responsible for economic growth and social development, has also exacerbated stresses on nature. It has come to the fore in the modern era of urban development as one of the primary areas of concern—air and water pollution, waste management, natural resources depletion and environmental instability. Sustaining the public health system, productivity, and the conditions needed for long-term urban sustainability becomes increasingly difficult in the face of these pressures, which are deeply interconnected; each places a strain on the other. In addition to these environmental pressures, urbanization is impacting on energy use and land use trends, which are also increasing. The increasing urban populations, concentration of industry, and physical footprint of cities have an increasing impact on the health and economic efficiency of the urban system. To overcome these challenges, a better knowledge of their size and scope is needed, but so is a structured and evidence-based governance and planning process.

1.2 Evaluation of Environmental Performance in Urban Areas

The term sustainability, which was originally based on three pillars: environmental, social and economic, has become more sophisticated and challenging. The idea of governance has now become an integral part of frameworks that attempt to assess sustainability in a credible way, as is the concept of institutional effectiveness and resilience. Meanwhile, academic and policy studies on urban sustainability evaluation have significantly increased, with cities around the world facing the pressing need to evaluate and change their development pathways. In this overarching context, the assessment of environmental performance has become a pressing and practical need—particularly in metropolitan areas, where the impact on the environment is most severe. This evaluation not only provides an initial snapshot of the environmental status but also helps pinpoint the areas of underperformance in the environmental pillar to direct the appropriate intervention. It uses these assessments to develop developmental trajectories to inform policies to prioritize actions and effectively direct resources.

The Environmental Sustainability Index (ESI) is among the methodological tools that have grown in importance, such as material flow analysis, GIS based on spatial assessment and indicator-based methodologies. It can combine several different environmental indicators into one overall, comparable score, which allows systematic assessment of the different dimensions of the environment, including air quality, water supply, waste management and ecological conditions. Additionally, the ESI allows for comparisons between cities and gap analyses over time and enables policymakers to plan proactively based on facts.

1.3 Pressure-State-Response Framework: Perspective

A detailed ESI can give insight into the environmental conditions that arise from human activities, but to turn the quantitative results into actionable governance intelligence, a conceptual framework is needed that captures the dynamic ⁴² nature of the relationship between human pressures, environmental states and institutional responses. The OECD has developed an instrument called ⁴² the Pressure-State-Response (PSR) framework that provides just this lens. The PSR framework is based on three-part logic: anthropogenic pressures act on the environment, which reacts to change its state, and the institutions respond with policy measures which aim to reduce impacts and restore ecological balance. Raw quantitative data is understood and translated into nuanced governance insight when interpreting ESI; this helps policy makers to not only see what is occurring from an environmental perspective, but why it is occurring and what effective intervention is needed.

1.4 Research Gap and Problem Statement

While there has been a lot of literature published about cities and their environmental sustainability, cities' environmental performance has yet to be systematically and comparatively assessed, especially in rapidly urbanizing regions. Previous research often emphasizes single indicators or single time periods, restricting their ability to develop a comprehensive view of the environment or to monitor change over time. Furthermore, the use of index-based assessment tools in conjunction with the interpretive governance practices like PSR is still underutilized in the context of Indian metropolitan cities.

This study seeks to overcome this issue by developing and applying an Environmental Sustainability Index for a number of selected environmental parameters for several cities and analyzing it over a decade of data (2014–2024) by means of the PSR framework. It seeks to break away from descriptive assessments and provide specific and relevant analyses that can inform future urban environmental governance.

1.5 Objectives of the Study

Based on the thorough background understanding and the identified research gap, the following objectives are addressed:

1. To compare environmental performance of the selected cities in a decadal period from 2014 to 2024.
2. To detect underperforming environmental dimensions and evidence-based policy interventions for targeted actions.
3. To understand the ESI findings in the Pressure-State-Response (PSR) framework to gain governance-relevant insights.

CHAPTER 2 : LITERATURE REVIEW

2.1 Concept of Sustainability Assessment in Urban Areas

Urbanization has become the main trend in modern city development, leading to a range of economic and environmental challenges. The rapid growth of cities has worsened issues like air and water pollution, poor waste disposal, and the depletion of natural resources. In response to these increasing pressures, the idea of urban sustainability assessment has gained significant attention from academics and policymakers [2]. Urban sustainability assessment offers a consistent process for evaluating cities based on environmental, social, economic, and governance goals. This helps policymakers create informed and effective strategies for sustainable development.

¹⁴ The concept of sustainability assessment has expanded considerably over time. It started as a framework focusing on three pillars: environmental, social, and economic aspects. Now, it includes governance, resilience, and institutional effectiveness as vital parts of assessing the overall sustainability of urban areas [3]. This shift shows a greater understanding that urban sustainability cannot be fully understood by looking at environmental factors alone. It must also consider the structural and institutional conditions that influence a city's ability to maintain development in the long run.

2.2 Environmental Sustainability Assessment Frameworks

A variety of methods have been suggested in the literature for assessing urban sustainability. Three main approaches have been identified and used in different contexts: ³⁰ indicator-based assessment, product-related assessment, and integrated assessment. The indicator-based approach evaluates sustainability performance against set environmental, economic, and social standards. The product-related approach, often carried out through Life Cycle Assessment (LCA), looks at the environmental impacts linked to the entire lifespan of infrastructure, materials, and services. In contrast, integrated assessment methods combine various analytical tools to create a thorough evaluation system that captures the complex and multi-faceted nature of urban sustainability [7].

Each of these approaches provides specific benefits based on the assessment goals and the data available. However, indicator-based frameworks have remained popular in both academic

research and policy applications because they are relatively easy to interpret. They can adapt to different urban environments and convey complex environmental information in a way that non-experts can understand. The ability to combine multiple environmental factors into one analytical system while maintaining the details of individual indicators has made these frameworks a favored choice for comparing urban assessments and tracking performance over time.

2.3 Prominent Approach: Indicator-Based Assessment

The indicator-based approach to assessing environmental sustainability has been widely studied in academic literature. It is the most used method for evaluating urban environmental performance. Indicators act as measurable substitutes for environmental conditions, allowing for the monitoring of factors like air quality, water resources, energy use, and waste management across different time periods. By turning qualitative environmental traits into measurable variables, this approach helps cities track their progress toward sustainability goals set in global development frameworks [4].

A major benefit of indicator-based assessment is its ability to compare data over space and time. Indicator frameworks enable cities and regions to assess their performance against each other and to see how they improve over time. This shift from descriptive reports on environmental conditions to data-driven planning and governance has been especially useful for policymakers. It helps them justify regulatory actions or assess how effective current sustainability measures are. Turning environmental data into standardized performance indicators has become a key part of modern urban environmental governance.

A notable development in indicator-based assessment is the creation of indicator benchmarks and the assignment of relative weights. The Delphi method is often used for this, gathering expert opinions from professionals in environmental science, urban planning, and policymaking to assign weights that reflect each indicator's environmental importance. This weighting process ensures that more important factors have a proportional impact on the overall sustainability score. Benchmarking then turns raw indicator data into standardized performance scores that range from poor to excellent. This makes it easier to compare cities and time periods and enhances the relevance of the assessments to policy decisions [8].

2.4 Development of Environmental Sustainability Index (ESI)

Indeed, the creation of composite indices of sustainability is a crucial step towards converting indicators into useful evaluation mechanisms. A composite index combines several sustainability indicators, each of which describes different aspects of the city's environmental performance. For example, the Sustainable Development Index (SDI) is created by choosing key indicators in terms of environmental, economic, and social parameters; transforming these indicators into normalized Z-scores; and combining the resulting values into a composite indicator [5]. Such an approach allows for systematic comparisons of sustainability levels as well as making multidimensional data accessible and understandable to both researchers and practitioners.

Another index of particular interest is the Environmental Sustainability Index (ESI). It has been developed by Dhawan et al. specifically to evaluate the environmental performance of metropolitan cities. Such an index is based on certain environmental dimensions of a city, including pollution, water supplies, waste management, and ecology. Therefore, the index allows one to get a holistic view of how urban environmental governance is organized, what its strengths and weaknesses are. As it turns out, index approaches prove particularly useful when assessing rapidly growing cities that face serious environmental challenges because of intensive urban development [6].

However, one key challenge identified with regards to the sustainability assessment literature is that of the lack of dynamism in the formulation of many of the indices that have been developed. In most of the cases that have been discussed, the sustainability assessment has merely been done at a given point in time without considering changes to the environment at different time points. Due to the nature of sustainability, the importance of assessing environmental conditions at a particular time point is limited. Only through longitudinal studies can the effectiveness of various environmental policies be analyzed [8].

2.5 Origin of Pressure-State-Response (PSR) Framework

Derived from the Organization for Economic Co-operation and Development (OECD), the Pressure-State-Response (PSR) framework provides an interpretative approach that structures the

complex relationship between the interactions of human beings, the state of environmental conditions, and responses of institutions in addressing the issues arising from this relationship. In particular, the framework consists of three main interrelated aspects of environmental indicators: pressures that represent the impacts of human activities such as industrialization, increase in populations, and changes in land use on the environment; states of the environment that pertain to the impacts of those activities such as air quality, water resources, and biodiversity; and response measures undertaken by institutions in mitigating any environmental degradation [9].

The adoption of the PSR framework in sustainability indices analysis has become increasingly common in studies on urban sustainability. By using the PSR framework in the analysis of sustainability indices, one can interpret the quantitative data regarding environmental factors in terms of the institutional response to the pressures on urban environment, thereby evaluating the adequacy of institutions' response to these pressures [10]. Unlike sustainability indices that present data independently, the PSR model contextualizes data within the larger framework of environmental changes and government accountability, hence making the sustainability indices more applicable in practice [11, 14].

2.6 Urban Sustainability Assessment Studies in India

Urban sustainability assessment has become increasingly relevant in the Indian context because of fast-paced urbanization and increasing environmental pressures faced by cities in India. Over the last few decades, the urban population in India has increased significantly, leading to stress on environmental infrastructure, resource management, and governance mechanisms. The need for comprehensive assessment frameworks that can evaluate environmental performance in a variety of urban contexts and aid in the formulation of relevant sustainability strategies has therefore been felt keenly.

Environmental assessment frameworks that rely on the use of indicators represent particularly effective approaches that can be applied across different Indian cities and regions where data and information gaps pose significant challenges [12]. Environmental indicators combined in composite indices create a picture of the performance of cities in terms of their environmental characteristics by allowing different criteria to be incorporated in a common index, which makes comparison of cities at varying levels of development possible [13]. The use of methodologies like the PSR framework adds relevance to environmental data because they create a relationship

between humans, environment, and institutions [14]. Together, all these advances make an excellent base for studying the environment of Indian cities through long-term environmental monitoring, thus paving the way for evidence-based sustainability governance in the cities.

CHAPTER 3 : METHODOLOGY

3.1 Study Area

The capitals of the 28 states of India are diversely covered in the study. These urban centers serve as the fulcrum of major economic, administrative and urban planning and are more vulnerable to the pressure due to urbanization, migration, and urban planning. intensified transportation, energy and industrial demands. **Fig.1** depicts the highlighted study locations. For convenience, cities have been addressed with abbreviations.

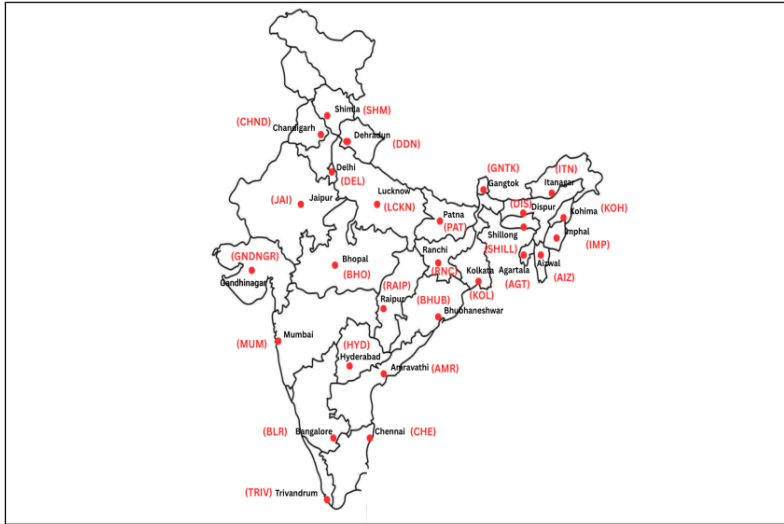


Fig. 1: Marked capital cities of India under study

3.2 Indicator Selection across Environmental Domains

The study employed an indicator-based approach to assessment, which resulted in the development of a holistic Environmental Sustainability Index (ESI) that was combined with interpretation of the PSR model. This holistically explores the conditions of emerging, established, and growing urban cities of India, along with their inter-city variations over a decadal scale - 2014 and 2024. The reason for using this approach is to make the complex web of interrelated spheres of environment, governance and policy interventions more manageable and understandable in terms of measurable indicators and a comparable comprehensive index.

The study is multi-sectoral and comprises the following six selected environmental aspects – Urban Air Quality, Urban Water Quality, Biodiversity, Land Use, Energy Use and Waste Management. For each of these aspects, there are selected indicators to be able to cover the multiple facets of urban sustainability. Indicators were selected based on key criteria that were strategically chosen from extensive peer-reviewed literature, internationally recognized environmental frameworks and were commonly used to describe the environmental performance using the sustainability indices. The selected parameters are quantified equivalents as described by Eq. 1 – 13, the weights have been assigned equal weight for each of the indicators within the parameters using equal weighing methods.

3.3 Interpretation of PSR and corresponding categories

The PSR model would be helpful for studying to report the same results for the purposes of evaluation of the environmental performances of the cities studied and would help the policy makers to make decisions based on detailed environmental monitoring, inclusive and effective policy making and policy implementation within a well-regulated framework to enhance urban resilience. The three elements are described as interacting: Anthropogenic activities (including consumption of energy, resources and emission of pollutants) exert pressure on the environmental parameters (Pressure), the environment is in a certain state or changes the quality of the environment (State), and the institutional and governance actions to enhance the environmental performance or address the environmental problems (Response). **Table 1** summarises the selected parameters aligned with their respective quantified equivalents as described by Eq. 1 – 13.

Table 1: Environmental parameters, their indicators, equation used and respective PSR category

Indicator	Equation Used	PSR Category
Air		
Exceedance of Average Annual Concentration of PM _{2.5}	$\frac{\text{Annual Average Concentration of PM}_{2.5}/\text{PM}_{10}/\text{CO}/\text{SO}_2/\text{NO}_2}{\text{Annual Average Standard for respective pollutants given by CPCB}} \quad (\text{Eq. 1})$	Pressure Indicator (P)
Exceedance of Average Annual Concentration of PM ₁₀		
Exceedance of Average 8 hours Concentration of CO in ppb		
Exceedance Average Annual Concentration of SO ₂		
Exceedance Average Annual Concentration of NO ₂		
CO ₂ Emissions per Capita	$\frac{\text{Total City Emission of CO}_2 \text{ in}}{\text{Total Urban Population* in millions}} \quad (\text{Eq. 2})$	
Water		
Water Availability in the city in Litres per day per person (suitable for consumption)	$\frac{\text{Available or Supplied Volume of Water in LPCD}}{\text{Standard of 135 LPCD specified by CPEEHO**}} \quad (\text{Eq. 3})$	State Indicators (S)
% Water Compliance Quality	$\frac{\text{Regions/Number of Water Sampling Stations meeting National Standards of Water Quality}}{\text{Total Number of Stations sampling water}} \quad (\text{Eq. 4})$	
% of population having access to safe drinking water	$\frac{\text{Population or Number of Households with Access to tap water}}{\text{Total Urban Population in millions}} \quad (\text{Eq. 5})$	
Volume of wastewater generated per Capita	$\frac{\text{Total Volume of Wastewater generated in MLD}}{\text{Total Urban Population in millions}} \quad (\text{Eq. 6})$	Pressure Indicator (P)
Biodiversity		

Protected Area Coverage	<u>Protected area set aside for biodiversity value (in sq Km)</u> Total city area (in sq Km) (Eq. 7)	State Indicators (S)
Land Use		
Land consumption rate	<u>Land area for residential + industrial buildings (sq Km)</u> Total city area (sq km) (Eq. 8)	Pressure Indicator (P)
Green Cover Area	<u>Green space area***</u> Total area (sq Km) (Eq. 9)	State Indicators (S)
Energy		
Energy Use per Capita	<u>Total Energy Consumption (million kWh)</u> Total Urban Population in millions (Eq. 10)	Pressure Indicator (P)
% of Renewable Energy	<u>Total Renewable Energy Produced or Consumed (million kWh)</u> Total Energy Produced or Consumed (million kWh) (Eq. 11)	Response Indicator (R)
Waste		
Hazardous Waste Generation	²³ <u>Amount of Hazardous Waste generated in tonnes per day</u> <u>Amount of Solid Waste Generation in tonnes per day</u> (Eq. 12)	Pressure Indicator (P)
Waste Collection Ratio	<u>Amount of Solid Waste (SW) generated in tonnes per day</u> Number of Household covered by municipality for SW management (Eq. 13)	Response Indicator (R)

*Total Urban population means the number of people living in areas defined as "urban" by national statistical offices.

**CPHEEO: Central Public Health and Environmental Engineering Organization.

***Green Space area collectively refers to the parks, urban green belts around important infrastructure, CSR or forest initiatives for afforestation programmes within the city.

3.4 Calculation of ESI - Weighing and Aggregation of Indicators

Each parameter has been converted into a measurable metric described by Eq. 1 - 13, weight for each of the indicators within the respective parameters have been allocated **equal weights using equal weighing method equation** :

$$W = 1 / N \quad (\text{Eq. 14})$$

N = Number of parameters/indicators or entities

Table 2 describes the weight allocation of the indicators within each parameter.

Table 2: Parameter and indicator wise weight allocation

Parameter	Weight of each indicator under the respective parameter
Air	0.167
Water	0.25
Biodiversity	1
Land Use	0.5
Energy	0.5
Waste	0.5

Here, there are 6 parameters. Hence, N = 6 for each parameter. For air, N = 6, for water, N = 4, for biodiversity, N = 1, for Land use, Energy and Waste each N = 2. Thus, respective weights were calculated using Eq. 14.

Further, the raw values obtained as per the equations 1 -13 applied were normalized using the Min-Max Normalisation to ensure the multi-faceted dataset is standardized into a comparable dimensionless scale - respective Normalised Score (NS). Equal weight eliminates the subjective bias. The max-min normalisation is applied specifically to beneficial and non-beneficial indicators. The beneficial and non-beneficial indicators are listed in **Table 3**. Eq. 15 and Eq. 16 are accordingly applied.

$$\text{For Beneficial Indicators: NS} = \frac{Xi - X_{min}}{X_{max} - X_{min}} \quad \text{Eq. 15}$$

For Non - Beneficial Indicators: $NS = \frac{X_{max} - X_i}{X_{max} - X_{min}}$ Eq. 16

where X_i is the raw value obtained for a city, and X_{max} and X_{min} are the maximum and minimum values within that indicator.

Table 3 : Classification of indicators based on their preferential values.

Indicator	Type
6 Average Annual Concentration of PM _{2.5}	Non-Beneficial Indicators
Average Annual Concentration of PM ₁₀	
Average 8 hours Concentration of CO in ppb	
Average Annual Concentration of SO ₂	
Average Annual Concentration of NO ₂	
CO ₂ Emissions per Capita	
Water Availability in the city in Liters per day per person (suitable for consumption)	Beneficial Indicator
% Water Compliance Quality	
% of population having access to safe drinking water	
Volume of wastewater generated per Capita	Non-Beneficial Indicators
Protected Area Coverage	Beneficial Indicator
Land consumption rate	Non - Beneficial Indicator
Green Cover Area	Beneficial Indicator
Energy Use per Capita	Non - Beneficial Indicator
% of Renewable Energy	Beneficial Indicator
Hazardous Waste Generation	Non - Beneficial Indicator
Waste Collection Ratio	Beneficial Indicator

The Weighted Normalised Score (WNS) is calculated using Eq. 17 applied for all the indicators and their respective weight. **Table 4** summarises the WNS calculation matrix.

Table 4: The matrix representing the calculation of weighted normalized score for each indicator

Parameter	Indicator	Weight of the Indicator (W)	Weighted Normalised Score (WNS)
Air	27 Average Annual Concentration of PM _{2.5}	0.167	Weight of each indicator x NS of each indicator (Eq. 17)
	Average Annual Concentration of PM ₁₀		
	Average 8 hours Concentration of CO in ppb		
	Average Annual Concentration of SO ₂		
	Average Annual Concentration of NO ₂		
	CO ₂ Emissions per Capita		
Water	Water Availability in the city in Litres per day per person (suitable for consumption)	0.25	
	% Water Compliance Quality		
	% of population having access to safe drinking water		
	Volume of waste water generated per Capita		
Biodiversity	Protected Area Coverage	1	
Land	Land consumption rate	0.5	
	Green Cover Area	0.5	
Energy	Energy Use per Capita	0.5	
	% of Renewable Energy	0.5	
Waste	Hazardous Waste Generation	0.5	
	Waste Collection Ratio	0.5	

This is calculated for each city and for each of the parameters. Each of these WNS are aggregated using simple arithmetic additives in two ways. In Method 1, WNS are aggregated

parameter wise and it yields ESI_{air} , ESI_{water} , $ESI_{biodiversity}$, $ESI_{land-use}$, ESI_{energy} and ESI_{waste} for each city. In Method 2, The individual ESI_{air} , ESI_{water} , $ESI_{biodiversity}$, $ESI_{land-use}$, ESI_{energy} and ESI_{waste} for each city are added to yield a composite Environmental Sustainability Index for each city as shown in **Annexure**. The ESIs have been calculated for 2014 and 2024. This helps in comparison of the inter-city environmental performance.

3.5 Applying the PSR lens

To evaluate the changes over the decadal timeline. The increment or decrement is therefore calculated for each city from 2014 to 2024 using Eq. 18 .

$$\Delta = \text{Weighted Normalised Score}_{2024} - \text{Weighted Normalised Score}_{2014} \quad (\text{Eq. 18})$$

Where, Δ representing change between the two years.

For each indicator, from the obtained Weighted Normalised Score of each city a maximum, minimum and mean of the values are taken. An arithmetic range is considered for each indicator basis of which, for each city the pressure, state or response indicators were qualitatively described.

CHAPTER 4 : RESULTS & DISCUSSION

4.1 Evaluating the Performance through Decadal Change

Fig. 2 presents comparative radial representation of six environmental parameters Air, Water, Land Use, Biodiversity, Energy and Waste in Indian state capital cities for the year 2014 and 2024. The radar polygons show the decadal evolution of each environmental domain and allow one to visually compare the inter-city variation and intra-city evolution of each domain.

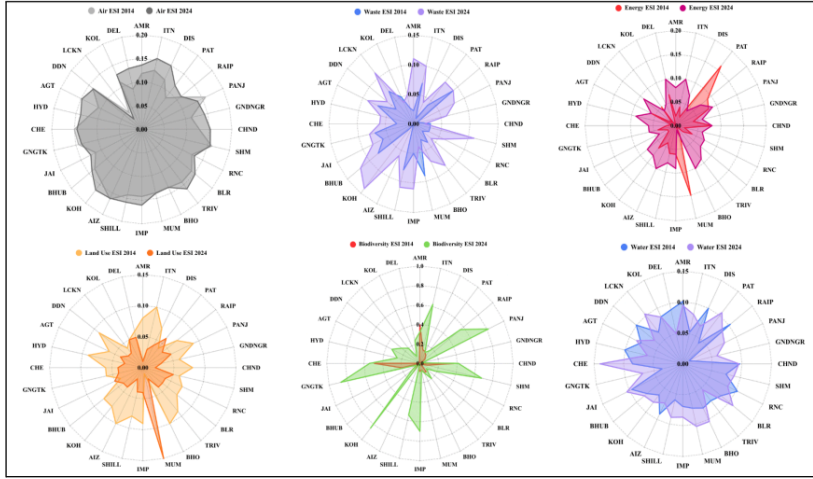


Fig. 2: Parameter wise ESI changes over 2014 and 2024

The ESI_{Air} is low in all major cities and is stable throughout both years. In 2014, cities like Delhi, Mumbai, Patna etc. showed relatively high levels of air quality stress, which is reflected by the very low improvement in AQI by 2024, and reflects the anthropogenic pressure on urban air quality largely due to particulate matter from vehicles, industries and construction activities in the densely populated cities.

There is a high spatial variability in the ESI_{Water} parameter. Cities like ITN, RAIP and PANJ had comparatively better water sustainability scores in 2014, which meant they were experiencing relatively lower water stress and better hydrological conditions. More gains were observed in GNDNGR, BHO, LCKN, RAIP, and PANJ by 2024 and there was no improvement or worsening in larger metropolitan cities, indicating the increasing pressure on urban water infrastructure due to rising demand and limited availability of water resources.

The ESI_{LandUse} component shows the most variations between cities. The radar polygons of the Imphal (IMP), etc. cities extend outward by 2024, indicating better land use management or increased green cover. At the same time, the large urbanization centres still gather around the centre of the polygon, which is a result of uncontrolled urban sprawl, loss of peri-urban green spaces and poor land use management.

The $ESI_{\text{Biodiversity}}$ index has the highest spread of values. The regions of the northeastern capitals of SHILL, AIZ, KOH, and IMP showed a significant improvement in 2024, which can be attributed to the pristine and biologically diverse natural ecosystems in these areas. On the contrary, low biodiversity scores were consistently reported across the peninsular and Indo-Gangetic plains, which are characterized by extensive habitat fragmentation, loss of urban tree cover and ecological degradation in general.

In the energy domain, CHND shows a significant improvement between the two periods, indicating a shift towards cleaner energy sources and improving energy efficiency measures. The other cities show relatively small changes, reflecting the steady increase in pressure from an increased energy demand in urbanising areas. MUM has a relatively high score in 2014, as displayed in the ESI_{Waste} parameter. Improvements in various cities have been noted as a result of the gradual implementation of the Swachh Bharat Mission and Solid Waste Management Rules, 2016 by 2024. However, waste segregation, scientific landfill management and decentralised waste processing remain to be a major constraint across numerous urban centres and continue to drag down scores.

4.2 City Wise Environmental Performance in 2014 and 2024 based on ESI

The ESI has been broken down into six environmental parameters: Air, Water, Land Use, Biodiversity, Energy, and Waste and is shown by city for 2014 in **Fig. 3**. The stacked bar chart

helps to compare the environmental sustainability of cities at the component level at the baseline year.

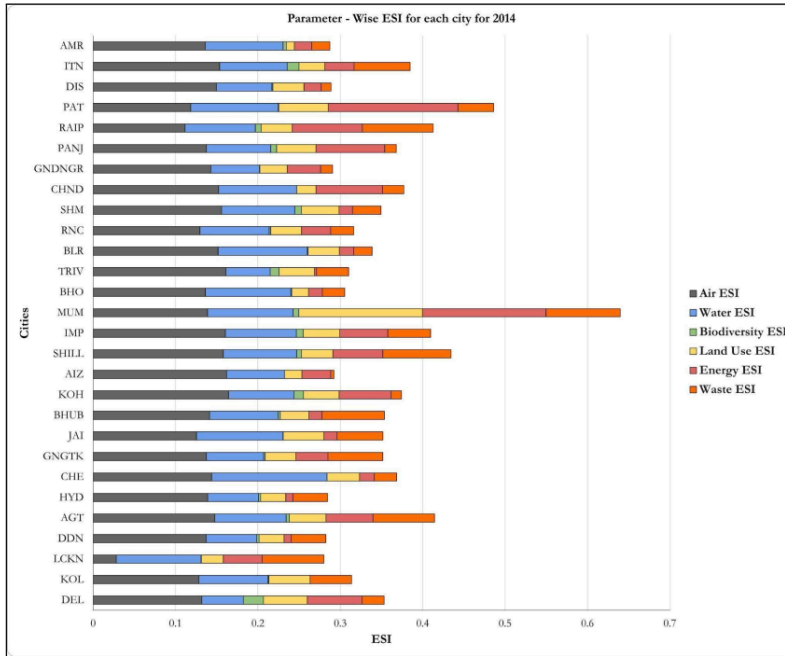


Fig. 3 : Individual reflection of ESI_{air} , ESI_{Water} , $ESI_{Land/Use}$, $ESI_{Biodiversity}$, ESI_{Energy} and ESI_{Waste} in the city's overall Environmental Sustainable Index for 2014.

The overall ESI is highest at MUM mainly due to its high relative Waste and Energy sub-indices. This is representative of the more advanced solid waste management systems and more stable energy supply systems that exist in the larger metropolitan centres at baseline year. Other cities with relatively high cumulative ESI values are PAT, ITN and RAIP, but in these instances the contribution of the Land Use and Biodiversity categories is more significant, presumably due to relatively low population density and a potential close proximity of these cities to green and forested areas. At the other extreme of the spectrum are DEL, KOL and LCKN which have some of the poorest cumulative ESI scores in 2014. This aligns with the serious environmental

challenges that urban areas in the Indo-Gangetic region face, including poor air quality, large volumes of waste and heavily strained water resources. **Fig. 4** shows the parameter-wise ESI for each city in 2024.

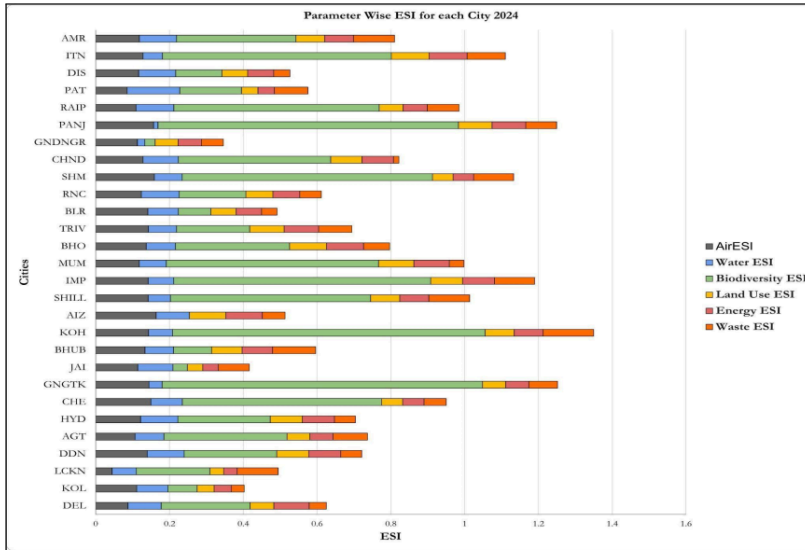


Fig. 4 : Individual reflection of ESI_{air} , ESI_{water} , $ESI_{landuse}$, $ESI_{biodiversity}$, ESI_{energy} and ESI_{waste} in the city's overall Environmental Sustainable Index for 2024.

The cumulative bars for the cities of ITN, KOH, IMP and GNGTK are found to be significantly higher, driven primarily by significant improvements in their Biodiversity sub-index for 2024. Although these have a positive impact on aggregate scores, it does provide an important caveat for the interpretation of these aggregate scores: high total ESI scores in these cities do not indicate that there has been an increase in the effectiveness of governance or pollution control. Instead, they might be mainly due to the ecological legacy of high biodiversity landscapes of the northeast.

Although overall aggregate scores have improved, the Air component has the lowest representation in the overall ESI in almost all the cities in 2024. This chronic lack of

performance in the air domain is of particular concern because the air domain is clearly a key contributor to urban public health problems and urban quality of life. The **annexure** contains the data-set obtained from Eqs. 15 and 16, for each city, each parameter in 2014 and 2024.

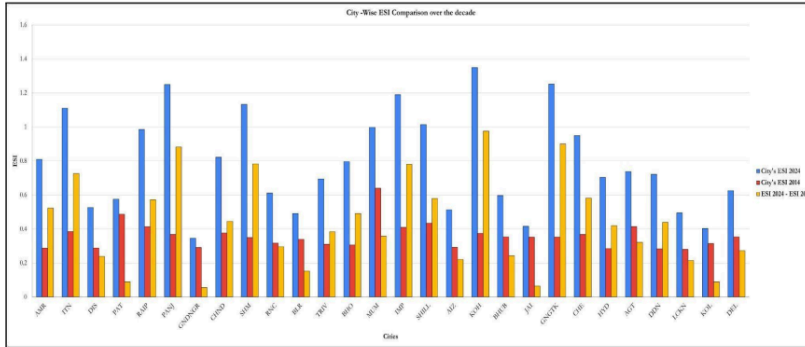


Fig. 5 : The consolidated decadal change consolidated

This three-variable grouped bar chart enables a direct assessment of the magnitude and direction of environmental performance shifts over the study period. All cities register a positive delta ESI, confirming a universal upward trend in ESI values over the decade. The most substantial absolute gains are recorded for cities such as Panaji (PANJ), Chandigarh (CHND), Kohima (KOH), and Gangtok (GNGTK). However, the origins of these improvements vary considerably across cities. For ecologically endowed northeastern and coastal cities, the gains are primarily attributable to biodiversity-driven score enhancements, while for planned cities like Chandigarh, the improvements reflect genuine governance-led environmental management.

Among cities at the lower end of the improvement spectrum, GNDNGR and JAI exhibit the smallest delta ESI values, suggesting limited environmental progress over the decade despite ongoing urbanization pressures. The figure reinforces the central analytical tension of the study — that aggregate ESI improvement is not always commensurate with a reduction in environmental stress, and that disaggregated parameter-level analysis is essential for drawing meaningful policy inferences.

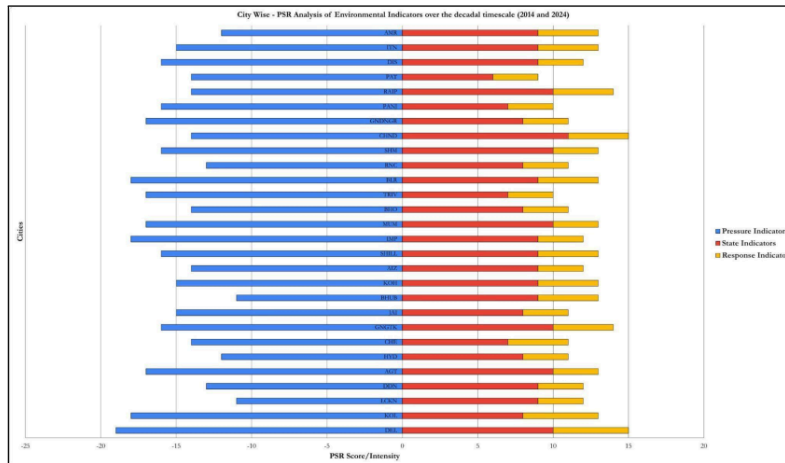


Fig. 6 : Pressure, state and response comparative results

Fig. 6 presents the results of the ²⁵ Pressure-State-Response (PSR) framework, quantifying the intensity of anthropogenic pressure, the resultant environmental state, and the institutional and policy response for each city over the decadal period from 2014 to 2024. The horizontal diverging bar chart, with Pressure indicators plotted on the negative axis and State and Response indicators on the positive axis, provides a clear visual representation of the environmental governance balance across cities. A defining feature of the PSR results is the near-universal dominance of negative Pressure values across all study cities. This indicates that anthropogenic stressors — including air and water pollution, heightened resource consumption, and land use changes driven by urban expansion — intensified significantly between 2014 and 2024. The most pronounced negative Pressure scores are recorded for cities such as Bangalore (BLR), Imphal (IMP), Kolkata (KOL), Mumbai (MUM), Gandhinagar (GNDNGR), and Trivandrum (TRIV), reflecting the disproportionate environmental burden borne by these cities during the study period. The State indicators, represented by moderately positive values, point to marginal improvements in ambient environmental conditions across several cities — such as slight gains in water quality, vegetation cover, or air quality indices. However, the magnitude of these State

improvements is systematically lower than the corresponding deterioration captured under the Pressure dimension, resulting in a net environmental deficit. Cities such as Raipur (RAIP) and Chandigarh (CHND) demonstrate relatively stronger State indicator performance, suggesting more effective environmental resource management and urban planning frameworks in these cities.

The Response indicators, while uniformly positive, are comparatively narrow across all cities. Despite the launch of several major national and urban initiatives during this period — including the Smart Cities Mission, the Atal Mission for Rejuvenation and Urban Transformation (AMRUT), and the National Clean Air Programme (NCAP) — the aggregate institutional response appears insufficient to counterbalance the scale of environmental pressure recorded. Chandigarh (CHND) and Gangtok (GNGTK) register comparatively higher Response scores, reflecting relatively more structured and proactive environmental governance frameworks. In contrast, large metropolitan cities such as Mumbai (MUM), Delhi (DEL), Chennai (CHE), and Hyderabad (HYD) exhibit modest Response scores that are starkly disproportionate to their Pressure loads.

The PSR analysis collectively exposes a critical ESI-PSR paradox: cities that rank highly on aggregate ESI scores — such as Gangtok (GNGTK), Imphal (IMP), Aizawl (AIZ), and Kohima (KOH) — simultaneously exhibit some of the most unfavourable PSR profiles, with heavy Pressure loads and weak Response capacity. The elevated ESI scores for these cities are primarily a product of inherited biodiversity wealth rather than effective environmental management. This paradox underscores the limitations of relying solely on composite ESI values for urban environmental governance assessment, and affirms the complementary value of the PSR framework in revealing the underlying structural drivers and institutional gaps that aggregate indices tend to obscure.

4.3 Application of PSR Model

Annexure contains the date-set obtained from calculating the change in the WNS obtained through Eq. 18 for every parameter in each city. Based on the changes obtained, a qualitative category was allotted to the parameter for that city under “Pressure”, “State” and “Response”

categories. **Tables 5, 6 and 7** summarise the results obtained from application of PSR under Pressure, State and Response categories.

Table 5: Categorical result of pressure indicators

City Wise Relative PSR	PM _{2.5}	PM ₁₀	CO	SO ₂	NO ₂	Total City Emission per Capita	Volume of waste water generated	Land consumption rate that is urbanization volume in sq KM	Energy Use per Capita	Hazardous Waste Generation
AMR	Low	Low	medium	Low	Low	Low	Low	Low	Low	medium
ITN	medium	medium	medium	medium	medium	Low	Low	Low	Low	Low
DIS	medium	medium	medium	medium	medium	medium	Low	Low	Low	Low
PAT	Low	medium	Low	medium	medium	medium	Low	Low	Low	Low
RAIP	High	High	Low	Low	Low	Low	Low	Low	Low	Low
PANJ	High	Low	medium	Low	Low	Low	medium	medium	medium	Low
GNDNGR	medium	medium	medium	Low	medium	medium	Low	Low	medium	medium
CHND	medium	medium	Low	Low	Low	medium	Low	Low	medium	Low
SHM	High	High	medium	Low	Low	Low	Low	Low	Low	medium
RNC	High	Low	medium	Low	Low	Low	Low	Low	Low	Low
BLR	High	High	medium	Low	Low	High	Low	Low	Low	medium
TRIV	High	High	medium	Low	Low	medium	Low	Low	Low	medium
BHO	High	Low	medium	Low	Low	Low	Low	Low	Low	medium
MUM	High	High	medium	Low	Low	medium	Low	Low	medium	Low
IMP	medium	medium	medium	medium	medium	High	Low	medium	Low	Low
SHILL	medium	medium	medium	medium	medium	medium	Low	Low	Low	Low
AIZ	Low	Low	medium	Low	Low	High	Low	Low	medium	Low
KOH	medium	medium	medium	medium	medium	Low	Low	Low	Low	Low
BHUB	Low	Low	medium	Low	Low	Low	Low	Low	Low	Low
JAI	medium	medium	medium	Low	Low	Low	medium	Low	medium	Low
GNGTK	medium	medium	medium	medium	medium	Low	medium	Low	Low	Low
CHE	medium	High	Low	Low	Low	medium	Low	Low	Low	Low
HYD	Low	Low	medium	Low	Low	Low	medium	Low	Low	Low
AGT	medium	medium	medium	medium	medium	medium	Low	medium	Low	Low
DDN	Low	Low	medium	Low	Low	Low	medium	Low	medium	Low
LCKN	Low	Low	Low	Low	Low	medium	Low	Low	Low	Low
KOL	High	Low	medium	Low	Low	medium	medium	medium	medium	medium

Table 6: Categorical result of state indicators

State indicators - S					
City Wise Relative PSR	Per Capita Water Availability	% Water Compliance Quality	% of population having access to safe drinking water	Protected Area Coverage	Green Cover Area
AMR	Moderate	Moderate	Moderate	Moderate	Low
ITN	Moderate	Moderate	Low	Moderate	Moderate
DIS	Moderate	Moderate	Moderate	Low	Moderate
PAT	Low	Moderate	Low	Low	Low
RAIP	Moderate	Moderate	Moderate	Moderate	Moderate
PANJ	Moderate	Moderate	Low	Low	Low
GNDNGR	Moderate	Moderate	Low	Moderate	Low
CHND	Moderate	Good	Good	Low	Moderate
SHM	Moderate	Moderate	Moderate	Moderate	Moderate
RNC	Moderate	Moderate	Moderate	Low	Low
BLR	Moderate	Moderate	Low	Moderate	Moderate
TRIV	Moderate	Moderate	Low	Low	Low
BHO	Moderate	Moderate	Moderate	Low	Low
MUM	Good	Moderate	Low	Moderate	Moderate
IMP	Moderate	Moderate	Low	Moderate	Moderate
SHILL	Moderate	Moderate	Low	Moderate	Moderate
AIZ	Moderate	Moderate	Moderate	Moderate	Low
KOH	Moderate	Moderate	Low	Moderate	Moderate
BHUB	Moderate	Moderate	Low	Good	Low
JAI	Moderate	Low	Low	Low	Good
GNGTK	Moderate	Moderate	Moderate	Moderate	Moderate
CHE	Moderate	Moderate	Low	Low	Low
HYD	Moderate	Moderate	Low	Low	Moderate
AGT	Moderate	Moderate	Moderate	Moderate	Moderate
DDN	Moderate	Moderate	Low	Moderate	Moderate
LCKN	Moderate	Moderate	Moderate	Low	Moderate
KOL	Moderate	Moderate	Low	Low	Moderate
DEL	Moderate	Moderate	Moderate	Low	Moderate

Table 7: Categorical result of response indicators

City Wise Relative PSR	% of Renewable Energy	Waste Collection Ratio
AMR	Progressing	Progressing
ITN	Progressing	Steady Response
DIS	Progressing	Steady Response
PAT	Progressing	Progressing
RAIP	Progressing	Steady Response
PANJ	Progressing	Steady Response
GNDNGR	Good Response	Steady Response
CHND	Progressing	Steady Response
SHM	Progressing	Steady Response
RNC	Progressing	Progressing
BLR	Progressing	Steady Response
TRIV	Progressing	Steady Response
BHO	Progressing	Steady Response
MUM	Progressing	Steady Response
IMP	Progressing	Progressing
SHILL	Progressing	Steady Response
AIZ	Progressing	Progressing
KOH	Progressing	Progressing
BHUB	Progressing	Steady Response
JAI	Progressing	Progressing
GNGTK	Progressing	Progressing
CHE	Progressing	Steady Response
HYD	Progressing	Steady Response
AGT	Progressing	Steady Response
DDN	Progressing	Steady Response
LCKN	Progressing	Good Response
KOL	Progressing	Good Response
DEL	Progressing	Steady Response

On the above mentioned score allotment. The sum for each city has been calculated for a quantitative measure of impacts. Based on the total weight, the cities which have shown consistency in maintaining their ESI are sustainable cities, the ones improving their ESI - are transiting cities. Each of the qualitative categories is thus allotted a corresponding score as summarised in **Table 8**.

Table 8 : Matrix of category scores

Pressure Indicators		State Indicators		Response Indicators	
Low	1	Low	1	Steady Response	1
Medium	2	Moderate	2	Progressing	2
High	3	Good	3	Good Response	3

Thus, the net sum of pressure, state and response indicators are taken and a cumulative score is considered. A maximum, minimum and an average value are computed for comparative evaluation. There are three categories under it are, “Environmentally Performing Well”, “Performing Steady”, and “Needs re-assessment on environmentally non-performing parameters”. The policies are proposed for the cities that are under, “Needs re-assessment on environmentally non-performing parameters” in the Policy Recommendation **section 5.2**. The city wise results are summarised in **Table 9**.

Table 9: City-wise categorical inferences of environmental performance

Cities	Score	Inference
AMR	1	Environmentally performing well
ITN	-2	Performing steady
DIS	-4	Performing steady
PAT	-5	Needs re-assessment on environmentally non-performing parameters
RAIP	0	Environmentally performing well
PANJ	-6	Needs re-assessment on environmentally non-performing parameters
GNDNGR	-6	Needs re-assessment on environmentally non-performing parameters
CHND	1	Environmentally performing well
SHM	-3	Performing steady
RNC	-2	Performing steady
BLR	-5	Needs re-assessment on environmentally non-performing parameters
TRIV	-7	Needs re-assessment on environmentally non-performing parameters
BHO	-3	Performing steady
MUM	-4	Performing steady
IMP	-6	Needs re-assessment on environmentally non-performing parameters
SHILL	-3	Performing steady
AIZ	-2	Performing steady
KOH	-2	Performing steady
BHUB	2	Environmentally performing well
JAI	-4	Performing steady
GNGTK	-2	Performing steady

CHE	-3	Performing steady
HYD	-1	Environmentally performing well
AGT	-4	Performing steady
DDN	-1	Environmentally performing well
LCKN	1	Environmentally performing well
KOL	-5	Needs re-assessment on environmentally non-performing parameters
DEL	-4	Performing steady

CHAPTER 5 : CONCLUSION & POLICY RECOMMENDATIONS

5.1 Key Findings

After the holistic evaluation of the parameters for each city consolidated with PSR lens - the two key findings that surface are :

- **ESI-PSR Paradox:** Which showed that despite having high or improving ESI scores, there are continued stressors exerting pressure (primarily due to anthropogenic activities), infrastructural or institutional responses need to improve. These can get masked under rising ESI scores reflecting a paradox. The PSR lens navigates through this and brings out microscopic review on the policies.
- The microscopic review reflects the following areas of the cities requiring improvement listed under **Table 10**. This fortifies the policy structure, allows the policymakers to look at the specific scopes that can drive environmental sustainability in urban planning.

Table 10 : Key areas highlighted in the cities for improvement

Cities	Areas to focus based on PSR Interpretation
AMR	Green Area Cover, Waste Collection Ratio and Renewable Energy Mix
PAT	Green Cover Area, Access to safe drinking water, Renewable Energy Mix
RNC	High PM 2.5 Pressure, per capita water availability, water compliance, renewable energy mix, Biodiversity
BHO	High PM 2.5 Pressure, water compliance, renewable energy mix
BHUB	access to safe drinking water, green area cover, renewable energy mix, waste collection ratio
CHE	High PM 10 pressure, Water compliance quality
DDN	Water compliance quality, access to safe drinking water, waste collection ratio, renewable energy mix
LCKN	Water compliance quality, biodiversity, Renewable energy mix

5.2 Policy Recommendations

The policy recommendations are presented city wise targeting the scopes of improvement.

- **AMR:** Include Green Cover Buffers in AMRUT 2.0 Minimum 15% green area in new development plans. Implement source-segregation at ward level, using SWM Rules 2016 GPS tracked collection vehicles. Implement net metering of rooftop solar in PM-KUSUM residential/commercial areas. Set up a municipal waste to energy pilot plant with the

objective of diverting 30% of waste material from landfill. Implement a City Green Audit process and review by the State Environment Department every 2 years.

- **PAT:** Ensure afforestation on the banks of the Ganga river and on the outskirts of cities under the National Urban Forestry Programme with legally binding forest canopy targets. Water supply through fast-track 24x7 piped water scheme under Jal Jeevan Mission Urban with mandatory third party water quality testing at water points. Install solar micro grid in peri-urban and slum areas under PM Surya Ghar Yojana. Update Patna Master Plan 2031 with inclusion of ecological corridor that connects the flood plain ecosystems. Put in place a separate Urban Water Utility (UWU) for operational accountability, and minimise non-revenue water below 20%.
- **RNC :** Implement BS-VI vehicle compliance and set up low emission zones within the city core with the NCAP targets. Improve water availability per capita by augmenting it from the river basin of the Subarnarekha with the support of IEC programmes on conservation. Ensure compliance of effluent to CPCB norms with real-time effluent monitoring for industries having environmental clearance. Make Dalma Wildlife Corridor a protected urban fringe biodiversity area under the Wildlife Protection Act, 1972. Formulation of Jharkhand Renewable Energy Action Plan with the aim to achieve 40% Renewable energy in the city electricity mix by 2030.
- **BHO :** Establish Real Time Air Quality Monitoring Network (RT-AQMN) having stations connected to CPCB in industrial traffic corridors under NCAP. Implement tougher norms for emission from the industrial stacks in the chemical and pharmaceutical clusters in Bhopal with quarterly compliance checks. Implement full load levels of sewage treatment works to achieve Class B water quality in the Upper and Lower Lakes. Implement Rooftop Solar for all Government Buildings and new buildings with an area of > 500 sq. m. under RESCO model. Implement a Clean Air Action Plan for the City with inter-departmental coordination through a Nodal officer at the Madhya Pradesh Pollution Control Board.
- **BHUB :** Implement Jal Jeevan Mission Urban coverage at 100% functional household tap connections with source and distribution monitoring of the quality level. Implementing the Tree Preservation Orders (TPOs) as per Odisha Municipal Corporation Act for all constructions works in urban areas. Expand the rooftop solar market in Odisha by offering financial support through subsidised rates to below the poverty line customers under Odisha RESCO scheme. Establish waste collection contracts at the ward level with payments linked

to how well waste is segregated at source. The preparation of peri-urban green belt regulations in Bhubaneswar Development Plan 2035 to check urban encroachments in ecological areas.

- **CHE** : Adopt a Construction Dust Management Protocol, including water sprinklers, dust screens and vehicle wheel-washing in all active construction sites. Improve the enforcement of TNPCB for the PM10 emission from industries by incorporating AI-based satellite monitoring in the real-time pollution dashboard. Resuscitate rivers Cooum and Adyar through zero liquid discharge policy for industries in the upstream and commissioning of all the STPs in the rivers. Implement the Chennai Metropolitan Area Water Supply Policy with all requirements for wastewater re-use for industrial and horticultural purposes to include tertiary treatment. Form a statutory Chennai Air Action Taskforce for Cross Sectoral Coordination under the Environment Protection Act, 1986.
- **DDN** : Implement all non-functional Sewage Treatment Plants for implementation of Class B parameters in Rispana and Bindal river stretches as per NMCG guideline. Implement mandatory testing for the quality of groundwater in all households and industries that have their water supply from borewells according to Uttarakhand Water Policy 2019. Implement door to door waste collection system with grievance redressal through digital system for missed waste collection as per SWM Rules 2016. Implement a hill specific rooftop solar programme with UPCL as the implementing agency under the PM-KUSUM component C, which takes into account constraints on the terrain, and enhance the regulatory capacity of the MDDA to ensure that the solar panels are not illegally constructed in ecologically sensitive areas that affect water catchments.
- **LCKN** : Implementing STP capacity under the Namami Gange Programme with accelerated and third party audit for Zero untreated sewage discharge in Gomti river. Identify urban wetlands of Lucknow (Gomti floodplains, Kukrail Reserve) as protected urban biodiversity zones as per Wetlands Conservation Rules, 2017. Ensure ecological impact assessments for all new infrastructure projects in green buffer areas under the UP Environment Protection Act. Expand distributed rooftop solar (DroS) in PM Surya Ghar Yojana with focus on municipal buildings, schools, hospitals as anchor users. Institute a City Biodiversity Index monitoring system within the UP State Biodiversity Board to track baselines periodically and for policy feedback.

5.3 Limitations of the Study & Future Scope of the Study

The study depicts an evaluation based on the sequential evaluation starting from indicator based assessment of selected indicators, weighing and aggregating to construct a comprehensive index. The study has excluded the UTs, and it describes the relative performance of the cities. It nowhere undermines the performance of the cities. Each city is incredibly contributing to its development and progress. The study is just a tool for policymakers that may help them to look at exact needs and help them tailor fine tuned policies.

The study can be extended to Union Territories and environmental performance for each parameter can be studied as an inexhaustive list.

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ANNEXURES

Annexure 1

I. POPULATION AND HOUSE HOLD DATA		
Data Type	Source Link/Site	Remarks
Population	https://censusindia.gov.in/census_website/data/population-finder	2011 population used as base and projected population calculated. Base Year: Census 2011 (Urban population) Dispur exists as a part of Guwahati. Amravati didn't exist as a capital city in 2011. The population has been taken as per the subdistrict level.
Households Estimate*	https://www.indiaspend.com/uploads/2020/12/14/file_upload-356947.pdf	Average Urban Household Size (Census 2011): 4.8 persons Households = Population/household size
II. LAND USE DATA & URBAN MASTER PLANS		
City	Source (Govt / Official)	
Delhi	Census 2011 + Delhi Master Plan 2021	
Mumbai	Census 2011 + MMRDA reports	
Kolkata	Census 2011 + KMDA	
Chennai	Chennai Master Plan	
Bengaluru	BDA Master Plan 2031	
Hyderabad	GHMC + HMDA	
Ahmedabad	AUDA Development Plan	
Jaipur	Jaipur Master Plan	
Lucknow	Lucknow Development Authority	
Bhopal	Bhopal Development Plan	
Patna	Patna Master Plan 2031	
Chandigarh	Chandigarh Master Plan	
Dispur (Guwahati)	Guwahati Metropolitan Dev. Authority	
Dehradun	Dehradun Master Plan	
Raipur	Raipur Dev. Plan	
Ranchi	Ranchi Regional Plan	
Bhubaneswar	BDA Odisha	
Amaravati	AP CRDA reports	
III. ENERGY USE & RENEWABLE ENERGY DATA		

Emission Factors, Equivalent Conversions	https://mnre.gov.in/en/year-wise-achievement/
Electricity Consumption/Production	Central Electricity Authority (CEA) Executive Summary (State-wise kWh, urban est.)
Renewable Energy Statistics	https://mnre.gov.in/en/renewable-energy-statistics/
IV. CO₂ Metric tonnes	
Data Sheet	http://www.sciencedirect.com/science/article/pii/S1364032114010880 ; doi: 10.1016/j.rser.2014.12.036

Annexure 2

CHANDIGARH							
Parameter	2014			2024			Reference
	Observed Value	Reference	Data Value	Observed Value	Reference	Data Value	
Exceedance of Annual Average PM _{2.5} Concentration	36	40	0.9	60.5	40	1.55	https://iforest.global/wp-content/uploads/2025/10/Chandigarh_pollution-factsheet.pdf
Exceedance of Annual Average PM ₁₀ Concentration	80	60	1.33	125.6	60	2.09	
Exceedance of Average 8 hours Concentration of CO	500	2000	0.25	200	2000	0.1	
Exceedance Annual Average SO ₂ Concentration	10	50	0.2	10	50	0.2	
Exceedance Annual Average NO ₂ Concentration	20	40	0.5	20	40	0.5	
CO ₂ Emissions per Capita	2.3	1.11	2.07	2.8	1.30	2.15	https://www.ghgplatform-india.org/wp-content/uploads/2022/09/GHGPI_Trend-Analysis_2005-to-2018_Chandigarh_Sep22.pdf
Water Availability in the city in Litres per day per person (suitable for consumption)	252	135	1.86	245	135	1.81	
% Water Compliance Quality	6	8	0.75	6	8	0.75	https://cgwb.gov.in/old_website/District_Profile/Chandigarh/CHANDIGARH.pdf
% of population having access to safe drinking water	1.29	1.11	1.16	1.11	1.30	0.85	
Volume of waste water generated per Capita	247	1.11	222.52	232	1.30	178.46	https://chandigarh.gov.in/sites/default/files/documents/physical-infra.pdf
Protected Area Coverage	26	114	0.22	26.01	114	0.22	https://chandigarh.gov.in/sites/default/files/updation2024/dc24-dep24-3004.pdf
Land consumption rate	80	114	0.7	111	114	0.97	

Green Cover Area	34	114	0.29	46.18	114	0.40	https://chandigarh.gov.in/sites/default/files/uptation2024/dc24-dep24-3004.pdf
Energy Use per Capita	1,812.000	1.11	1,632	1,987	1.30	1529	During Diwali 2025, CPDL reported meeting 97% of power demand from non-fossil sources and ~90% from renewable energy (solar, wind, hydro) for a period, showing peak potential.
% of Renewable Energy	117	1,812	0.0645695	60	1,987	0.030	
Hazardous Waste Generation	4383561644	450	0.009	8904109589	525	0.016	
Waste Collection Ratio	450	0.65	692.3076923	525	0.67	783.5	

Annexure 3

GANDHINAGAR							
Parameter	2014			2024			Reference
	Observed Value	Reference	Data Value	Observed Value	Reference	Data Value	
Exceedance of Annual Average PM _{2.5} Concentration	52	40	1.3	62.5	40	1.59	https://www.igair.com/us/india/gujarat/gandhinagar
Exceedance of Annual Average PM ₁₀ Concentration	85	60	1.41	160	60	2.6	
Exceedance of Average 8 hours Concentration of CO	528.5	2000	0.26	0.9	2000	0.45	
Exceedance Annual Average SO ₂ Concentration	11	50	0.22	7.5	50	0.15	
Exceedance Annual Average NO ₂ Concentration	20	40	0.5	30	40	0.75	
CO ₂ Emissions per Capita	0.7	0.23	3.04	1	0.30	3.33	
Water Availability in the city in Litres per day per person (suitable for consumption)	310	135	2.29	140	135	1.03	¹⁸ https://cgwb.gov.in/cgwbpm/public/uploads/documents/1751249317592418424file.pdf
% Water Compliance Quality	7	15	0.46	14	15	0.93	
% of population having access to safe drinking water	0.126	0.23	0.54	92510	300000	0.30	⁴³ https://www.who.int/india/health-topics/water-sanitation-and-hygiene-washi https://www.indiawaterportal.org/amp/story/health-and-sanitation/urban-sanitation/what-are-major-challenges-facing-urban-drinking-water-supply-india
Volume of waste water generated per Capita	36	0.23	156.52	109	0.30	363.33	

Protected Area Coverage	4	326	0.01	5	326	0.01	https://www.adb.org/sites/default/files/linked-documents/56039-001-icab.pdf
Land consumption rate	128	326	0.39	265	326	0.81	https://id.elsevier.com/authorize/auth2?platSite=SD%2Fscience&additionalPlatSites=GH%2Fgeneralhospital%2FCMDY%2Femendev%2FSC%2Fseopus%2FCRX%2Frcayxs&scope=openid%20email%20profile%20els_auth_info%20els_idp_info%20els_idp_analytics_attr%20urn%3Acom%3Aelsevier%3Aidp%3Apolicy%3Aproduct%3Ainst_assoc&response_type=code&redirect_uri=https%3A%2F%2Fwww.sciencedirect.com%2Fuser%2Fidentity%2Fplanning&authType=SINGLE_SIGN_IN&prompt=none&client_id=SDFE-v4&state=retryCounter%3D0%26csrfToken%3D3d3ca284c-db87-49d7-b6c7-26c28f3c192e%26idPolicy%3Durn%253Acom%253Aelsevier%253Aidp%253Aproduct%253Ainst_assoc%26returnUrl%3D%262Fscience%252Farticle%252Fpii%252F%26222658562100106P%253Aurn_source%253Dchaptent.com%26prompt%3Dnone%26cid%3Darp-3fd5cc4-7dab-46d8-b237-59eddd318b79
Green Cover Area	198	326	0.60	61	326	0.18	https://www.ceiddata.com/en/india/electricity-consumption-utilities/electricity-consumption-utilities-gujarat
Energy Use per Capita	302	0.23	1313.04	128	0.3	0.41	
% of Renewable Energy	51.4	302	0.17	33	128	0.10	
Hazardous Waste Generation	1.3	80	0.01	1.5	95	0.01	
Waste Collection Ratio	80	0.05	1600	95	0.18	527.77	

PATNA							
Parameter	2014			2024			Reference
	Observed Value	Reference	Data Value	Observed Value	Reference	Data Value	
Exceedance of Annual Average PM _{2.5} Concentration	122	40	3.05	92.5	40	2.31	Air Pollution Knowledge Assessment (APnA) report for Patna (2015 data).
Exceedance of Annual Average PM ₁₀ Concentration	162	60	2.7	170	60	2.83	

Exceedance of Average 8 hours Concentration of CO	1061	2000	0.5305	484	2000	0.242	SO₂ is below the Indian permissible limit but of concern for respiratory irritants. 22 Average annual conc of PM 2.5, PM 10, SO₂ AND NO₂ are in microgram/per cubic metre. CO has been taken 8hour average and in ppb
Exceedance Annual Average SO ₂ Concentration	5	50	0.1	7.5	50	0.15	
Exceedance Annual Average NO ₂ Concentration	33	40	0.825	500	40	12.5	
CO ₂ Emissions per Capita	3.5	1.81	1.93	4.6	2.32	1.98	This falls below the Bureau of Indian References (BIS) recommendation of 135 liters per capita per day (lpcd) for urban areas. Source: https://www.scribd.com/document/725770667/Assessing-Availability-and-Consumption-of-Water-Resource-Dynamics-in-Selected-Districts-of-Bihar-India
Water Availability in the city in Litres per day per person (suitable for consumption)	72.6	135.00	0.55	110	135	0.8148148148	Population in millions; Source: https://www.scribd.com/document/725770667/Assessing-Availability-and-Consumption-of-Water-Resource-Dynamics-in-Selected-Districts-of-Bihar-India. Approximately 99-100% of Patna's urban population has access to tap water in 2024, with all urban households connected to the piped water network under initiatives like Har Ghar Nal Ka Jal and AMRUT.
% Water Compliance Quality	10	18.00	0.77	14	18	0.83	
% of population having access to safe drinking water	1.55	1.81	0.85	1.67	2.32	0.71	No Reference reports provide the total volume of recycled water in Patna for 2014, in liters or cubic meters. In 2014, Patna generated an estimated of wastewater. The sewerage network covered around 20% of Patna Municipal Corporation area, and there were four operational sewage treatment plants with a combined capacity of about 109 MLD, indicating a treatment gap given the wastewater generated. This wastewater volume reflects the city's growing urban demand and infrastructure challenges during that period.
Volume of waste water generated per Capita	210	1.81	116.02	350	2.32	150.86	In 2014, the recorded forest area in Patna district was approximately 28.03 square kilometers.
Protected Area Coverage	28.03	320.00	0.087	30	325	0.09	There are no distinct Reference reports specifying the exact total area of zoos, national parks, or botanical gardens within Patna city limits for 2014, but the forest cover provides a good estimate of green land area relevant to environmental and conservation purposes in the district.

							Patna's total geographical area is around 320 square kilometers, making the forest cover about 8.75% of its land area at that time
Land consumption rate	265	320.00	0.82	256	325	0.78	In 2014, approximately 74.11% of the Patna Municipal Corporation area was occupied by built-up land, which predominantly consisted of residential buildings. Industrial land area within Patna at that time was relatively small; for instance, the Pataliputra Industrial Area had about 0.20 acre (0.08 hectares) of land on offer, and Bihar Industrial Area Development Authority (BIADA) controlled roughly 197 acres (79.7 hectares) of industrial land statewide with little availability in Patna itself. Overall, residential land covered the majority of urban built-up area, with industrial land constituting a minor fraction within the total urban footprint. Total land area of Patna is around 320 sq km
Green Cover Area	55	320.00	0.17	69	325	0.21	Patna's approximate green space area in 2014, including parks, public gardens, stretches of trees, and other open green areas, was around 55 square kilometers within the Patna Municipal Corporation (PMC) limits of about 109 square kilometers. This encompasses dense tree canopy (about 14-16 km²), parks/gardens/agricultural fields (around 19-32 km² based on trends), and fallow/open lands, though it had declined from 68 km² in 1988 due to urban expansion. A 2014 master plan proposal aimed for over 400 km² green cover in the expanded Greater Patna region (1,167 km² total), but Observed2014 PMC green space remained closer to the observed 53-55 km² figure
Energy Use per Capita	5,211	1.81	2879.	9,000	2.32	3879.31	Regarding renewable energy, Bihar's renewable share was very low (~1-2%) at the time, mostly from small hydro and biomass with solar efforts in early stages, so Patna's total renewable energy produced or consumed was minimal compared to overall consumption, likely under 2% of total energy use.
% of Renewable Energy	104	5211.00	0.019	900	4,380	0.20	

							18 https://www.pib.gov.in/newsite/PrintRelease.aspx?relid=103216&reg=3&lang=2
Hazardous Waste Generation	22	1100.00	0.02	30	1750	0.01	Household coverage for solid waste collection was approximately 70-80%, with door-to-door collection limited and reliance on 550 community bins serving the urban population of around 1.68 million
Waste Collection Ratio	1100	1.36	810.31	1750	0.323	5417.95	

Annexure 5

LUCKNOW							
Parameter	2014			2024			Reference
	Observed Value	Reference	Data Value	Observed Value	Reference	Data Value	
Exceedance of Annual Average PM _{2.5} Concentration	122	40	3.05	98	40	2.45	
Exceedance of Annual Average PM ₁₀ Concentration	244	60	4.066	196	60	3.26	
Exceedance of Average 8 hours Concentration of CO	10	2000	0.005	8	2000	0.004	
Exceedance Annual Average SO ₂ Concentration	32	50	0.64	38	50	0.76	
Exceedance Annual Average NO ₂ Concentration	700	40	17.5	900	40	22.5	
CO ₂ Emissions per Capita	4.5	3.00	1.5	5.9	4.60	1.28	
Water Availability in the city in Litres per day per person (suitable for consumption)	105	135	0.77	125	135	0.92	https://up-rera.in/ViewDocument?Param=PRJ521742427CTE.pdf
% Water Compliance Quality	15	20	0.75	17	20	0.85	
% of population having access to safe drinking water	1.97	3.00	0.65	4002000	4600000	0.87	
Volume of waste water generated per Capita	226	3.00	75.33	320	4.60	69.565	
Protected Area Coverage	0.5	631	0.00079	0.7	635	0.001	
Land consumption rate	350	631	0.554	460	635	0.724	22 https://japh.tums.ac.ir/index.php/japh/article/view/802
Green Cover Area	281	631	0.44	175	635	0.275	
Energy Use per Capita	2,465	3.00	822	5,750	4.60	1250	

% of Renewable Energy	296	2,465	0.120	592	5,750	0.102	
Hazardous Waste Generation	28.5	1400	0.020	2.5	1750	0.0014	https://japh.tums.ac.ir/index.php/japh/article/view/809
Waste Collection Ratio	1400	0.63	2222.22	1750	0.81	2160.493	

Annexure 6

MUMBAI							
Parameter	2014			2024			Reference
	Observed Value	Reference	Data Value	Observed Value	Reference	Data Value	
Exceedance of Annual Average PM _{2.5} Concentration	55	40	1.37	47.5	40	1.18	
Exceedance of Annual Average PM ₁₀ Concentration	110	60	1.83	95	60	1.58	
Exceedance of Average 8 hours Concentration of CO	1500	2000	0.75	1400	2000	0.70	
Exceedance Annual Average SO ₂ Concentration	10	50	0.2	8	50	0.16	
Exceedance Annual Average NO ₂ Concentration	52	40	1.30	50	40	1.25	
CO ₂ Emissions per Capita	22.78	12.40	1.83	28	14.20	1.97	
Water Availability in the city in Litres per day per person (suitable for consumption)	3400	12.40	274.19	4200	14.20	295.7	
% Water Compliance Quality	17	20	0.85	13	15	0.86	https://www.mpcb.gov.in/sites/default/files/Establishment%20of%20MPCB/Seniority%20list/2014/Feb24_Water_Eng.pdf
% of population having access to safe drinking water	11.16	12.40	0.90	13490000	14200000	0.95	https://www.freepressjournal.in/mumbai/bmc-reports-improved-mumbai-water-quality-unfit-drinking-water-samples-drop-to-046-in-202425
Volume of waste water generated per Capita	2720	12.40	219.35	3360	14.20	236.61	

Protected Area Coverage	60	603	0.0995	25	603	0.041	Destruction of Aarey forests.
Land consumption rate	315	603	0.52	570	603	0.94	https://resilientcitiesnetwork.org/wp-content/uploads/2024/11/UrbanOcean_ProjectStatement_Mumbai%20(1).pdf
Green Cover Area	288	603	0.47	33	603	0.054	
Energy Use per Capita	18,000	12.40	1451.6129	24,000	14.20	1690.14	
% of Renewable Energy	2160	18,000	12.0000	2880	24,000	12.0000	
Hazardous Waste Generation	4.52	226	0.0200	0.085	2.85	0.0298	35 RTI (Right to Information Act) , ESR (Mumbai Environmental Status Report) and CPCB website (Central Pollution Control Board)
Waste Collection Ratio	226	2.79	81.003	2.85	3.57	0.79	https://www.mpcb.gov.in/en/waste-management/municipal-solid-waste

Annexure 7

AGARTALA							
Parameter	2014			2024			Reference
	Observed Value	Reference	Data Value	Observed Value	Reference	Data Value	
Exceedance of Annual Average PM _{2.5} Concentration	52	40	1.3	65	40	1.625	
Exceedance of Annual Average PM ₁₀ Concentration	95	60	1.58	120	60	2	
Exceedance of Average 8 hours Concentration of CO	900	2,000	0.45	1100	2,000	0.55	
Exceedance Annual Average SO ₂ Concentration	9	50	0.18	11	50	0.22	
Exceedance Annual Average NO ₂ Concentration	22	40	0.55	30	40	0.75	
CO ₂ Emissions per Capita	0.5	0.40	1.25	0.7	0.55	1.27	
Water Availability in the city in Litres per day per person (suitable for consumption)	60	135	0.44	95	135	0.70	
% Water Compliance Quality	11	15	0.73	11	15	0.73	https://icrier.org/pdf/tripura.pdf
% of population having access to safe drinking water	0.24	0.40	0.6	0.528	0.55	0.96	
Volume of waste water generated per Capita	45	0.40	112.5	75	0.55	136.36	

Protected Area Coverage	12	58	0.20	14	76	0.18	
Land consumption rate	38	58	0.65	40	58	0.68	https://dcmsme.gov.in/dips/District%20Industrial%20proforma.pdf https://icrier.org/pdf/tripura.pdf
Green Cover Area	20	58	0.34	18	58	0.31	
Energy Use per Capita	280	0.40	700	520	0.55	945.45	
% of Renewable Energy	40	280	0.14	120	520	0.23	
Hazardous Waste Generation	4	180	0.02	8	320	0.025	https://www.academia.edu/4728471/SOLID_WASTE_MANAGEMENT_IN_AGARTALA_CITY_Introduction
Waste Collection Ratio	180	0.3	642.85	320	0.083	3878.78	https://www.environmentaljournal.org/4-4/ijert-4-4-5.pdf https://icrier.org/pdf/tripura.pdf

Annexure 8

AIZWAL							
Parameter	2014			2024			Reference
	Observed Value	Reference	Data Value	Observed Value	Reference	Data Value	
Exceedance of Annual Average PM _{2.5} Concentration	28	40	0.7	22	40	0.55	
Exceedance of Annual Average PM ₁₀ Concentration	62	60	1.03	48	60	0.8	
Exceedance of Average 8 hours Concentration of CO	600	2,000	0.3	520	2,000	0.26	
Exceedance Annual Average SO ₂ Concentration	8	50	0.16	6	50	0.12	
Exceedance Annual Average NO ₂ Concentration	18	40	0.45	15	40	0.375	
CO ₂ Emissions per Capita	0.3	0.29	1.03	0.5	0.36	1.38	
Water Availability in the city in Litres per day per person (suitable for consumption)	36	0.29	124.13	50	135	0.37	ADA 2030 plan baselines (water bodies 60% non-urban). https://assamtribune.com/aizawl-bid-to-become-model-capital-of-ne-by-2030 MISTIC climate vuln assessment (clean water access low in blocks); AMC draft master plan. https://mistic.mizoram.gov.in/wp-content/uploads/2025/06/ICC-202-final.pdf
% Water Compliance Quality	9	12	0.7500	12	15	0.8	https://amcmizoram.com/uploads/files/draft-master-plan-and-strategic-zonal-ward-development-plan_21042017103706.pdf

% of population having access to safe drinking water	190,000	0.29	655172.41	275,000	0.36	763888.89	
Volume of waste water generated per Capita	29	0.29	100	40	0.36	111.11	
Protected Area Coverage	28	129	0.21	32	129	0.24	
Land consumption rate	32	129	0.24	40	129	0.31	ADA model capital plan (15k ha planning, 40% urban, 2.38% commercial). https://assamtribune.com/aizawl-bid-to-become-model-capital-of-ne-by-2030 AMC Draft Master Plan (zoning/ward dev); MISTIC vuln (slope/forest area); GHGPI waste CH4 emissions. https://amcmizoram.com/uploads/files/draft-master-plan-and-strategic-zonal-ward-development-plan_21042017103706.pdf 11 https://www.ghrplatform-india.org/wp-content/uploads/2022/09/GHGPI_Trend-Analysis_2005-to-2018_Mizoram_Sep22.pdf
Green Cover Area	22	129	0.17	26	129	0.20	https://mistic.mizoram.gov.in/wp-content/uploads/2025/06/JC-C-202-final.pdf
Energy Use per Capita	420	0.29	1433.447	560	0.26	2153.84	
% of Renewable Energy	30	420	0.071	70	560	0.125	
Hazardous Waste Generation	2	110	0.01	3	150	0.02	Pre-2015 urban waste. 11 GPI waste emissions; MSPCB/NGT compliance reports. https://www.ghrplatform-india.org/wp-content/uploads/2022/09/GHGPI_Trend-Analysis_2005-to-2018_Mizoram_Sep22.pdf
Waste Collection Ratio	110	0.19	588.23	150	0.3	535.71	9 https://www.greentribunal.gov.in/sites/default/files/news_updates/REPORT%20BY%20MIZORAM%20PCB%20IN%20Q4%20NO.%20475%20oP%202024%20NEWS%20ITEM%20TITLED%20MOUNTAINS%20OF%20PLASTIC%20ARE%20CHOKING%20THE%20HIMALAYAN%20STATES.pdf

Annexure 9

AMRAVATI							
Parameter	2014			2024			Reference
	Observed Value	Reference	Data Value	Observed Value	Reference	Data Value	
Exceedance of Annual Average PM _{2.5} Concentration	75	40	1.875	60	40	1.5	https://crda.ap.gov.in/apcrdav2/views/home.aspx

Exceedance of Annual Average PM ₁₀ Concentration	130	60	2.166	105	60	1.75	
Exceedance of Average 8 hours Concentration of CO	800	2,000	0.4	650	2,000	0.325	
Exceedance Annual Average SO ₂ Concentration	10	50	0.2	8	50	0.16	
Exceedance Annual Average NO ₂ Concentration	32	40	0.8	28	40	0.7	
CO ₂ Emissions per Capita	10.2	1.60	6.375	12.2	1.80	6.77	
Water Availability in the city in Litres per day per person (suitable for consumption)	120	135	0.888	140	135	1.037	40 World Bank CCDP water planning (217 sq km). https://documents1.worldbank.org/curated/en/099102424060019798/pdf/P50750818939c90d186811db229ce45074.pdf
% Water Compliance Quality	5	8	0.625	5	8	0.625	APCRDA master plan water bodies (33% green). https://www.scribd.com/document/623909694/AMRAVATI-05022023
% of population having access to safe drinking water	47.6	1.60	29.75	1.53	1.8	0.85	
Volume of waste water generated per Capita	98	1.60	61.25	200	1.8	111.11	
Protected Area Coverage	66	217	0.30	66	217	0.30	Krishna River corridor
Land consumption rate	189	217	0.87	190	217	0.87	40 WB CCDP (217 sq km, 33% green, solar energy). https://documents1.worldbank.org/curated/en/099102424060019798/pdf/P50750818939c90d186811db229ce45074.pdf Foster+Partners master plan (themed cities, land pooling). https://www.scribd.com/document/623909694/AMRAVATI-05022023
Green Cover Area	28	217	0.12	27	217	0.12	https://ru.scribd.com/presentation/619088259/amaravati
Energy Use per Capita	900	1.60	562.5	1,600	1.8	888.8	
% of Renewable Energy	80	900	0.088	500	1,600	0.31	
Hazardous Waste Generation	5	184	0.027	10	550	0.018	https://www.researchgate.net/publication/292695435_SOLID_WASTE_MANAGEMENT_IN_AMRAVATI_CITY_AND_ITS_IMPACT_ON_COMMUNITY_HEALTH#:~:text=Assistant%20Professor%20in%20Civil%20Engineering,and%20Solid%20waste%20management%20strategies APCRDA themed cities waste systems. https://www.scribd.com/document/623909694/AMRAVATI-05022023
Waste Collection Ratio	184	0.84	219.04	550	1.66	332.12	Master plan waste infra planning. https://ru.scribd.com/presentation/619088259/amaravati

Annexure 10

BANGALORE							
Parameter	2014			2024			Reference
	Observed Value	Reference	Data Value	Observed Value	Reference	Data Value	
Exceedance of Annual Average PM _{2.5} Concentration	36	40	0.9	30	40	0.75	
Exceedance of Annual Average PM ₁₀ Concentration	78	60	1.3	68	60	1.133	
Exceedance of Average 8 hours Concentration of CO	900	2000	0.45	750	2000	0.375	
Exceedance Annual Average SO ₂ Concentration	9	50	0.18	7	50	0.14	
Exceedance Annual Average NO ₂ Concentration	32	40	0.8	29	40	0.725	
CO ₂ Emissions per Capita	19.8	9.60	2.06	24.5	12.30	1.9918	
Water Availability in the city in Litres per day per person (suitable for consumption)	112	135	0.829	155	135	1.148	
% Water Compliance Quality	88	110	0.8	95	110	0.8636	https://cwejournal.org/vol10no1/assessment-of-ground-water-quality-in-rajajinagar-of-bangalore
% of population having access to safe drinking water	7.7	9.60	0.80	10.6	12.30	0.8617	
Volume of waste water generated per Capita	1037	9.60	108.02	1520	12.30	123.577	
Protected Area Coverage	33	709	0.046	36	741	0.48	
Land consumption rate	450	709	0.63	550	741	0.7422	Bangalore Development Authority
Green Cover Area	259	709	0.36	191	741	0.2577	
Energy Use per Capita	13,200	9.60	1375	21,500	12.30	1747.96	https://www.niti.gov.in/sites/default/files/2021-12/Waste-Wise-Cities.pdf
% of Renewable Energy	1,600	13,200	0.12	4,200	21,500	0.19	
Hazardous Waste Generation	110	3700	0.02	150	5200	0.02	
Waste Collection Ratio	3700	2	1761.9	5200	3	1793.10	

Annexure 11

BHOPAL							
Parameter	2014			2024			Reference
	Observed Value	Reference	Data Value	Observed Value	Reference	Data Value	
Exceedance of Annual Average PM _{2.5} Concentration	62	40	1.55	52	40	1.3	
Exceedance of Annual Average PM ₁₀ Concentration	128	60	2.13	102	60	1.7	
Exceedance of Average 8 hours Concentration of CO	900	2000	0.45	700	2000	0.35	
Exceedance Annual Average SO ₂ Concentration	11	50	0.22	9	50	0.18	
Exceedance Annual Average NO ₂ Concentration	34	40	0.85	29	40	0.725	
CO ₂ Emissions per Capita	3.2	1.80	1.778	4.2	2.40	1.75	
Water Availability in the city in Litres per day per person (suitable for consumption)	148	135	1.096	152	135	1.125	³⁶ DP financials (2013 baselines for supply/sampling). https://www.academia.edu/4365091/Bhopal_CDP_Final
% Water Compliance Quality	22	25	0.88	23	25	0.92	³ UN-Habitat strategy (water management). https://unhabitat.org.in/sites/default/files/2024-11/sustainable_city_strat_egy_bhopal.pdf
% of population having access to safe drinking water	1.35	1.80	0.75	2	2.40	0.833	
Volume of waste water generated per Capita	280	1.80	155.5	384	2.40	160	
Protected Area Coverage	25	463	0.053	28	463	0.065	
Land consumption rate	225	463	0.48	320	463	0.69	³⁶ CDP Final (2013 land/financials). https://www.academia.edu/4365091/Bhopal_CDP_Final ³ UN-Habitat strategy (CO ₂ -eq 3.66M Mt 2015-16 baseline, updated). https://unhabitat.org.in/sites/default/files/2024-11/sustainable_city_strat_egy_bhopal.pdf
Green Cover Area	238	463	0.514	143	463	0.308	
Energy Use per Capita	2,400	1.80	1333.33	3,600	2.40	1500	
% of Renewable Energy	120	2,400	0.05	3.6	3,600	0.001	
Hazardous Waste Generation	12	800	0.015	16	1100	0.014	MSW project PFR (~2016 baselines, 2014 est. 800-1000 TPD). https://enviroclearance.nic.in/writeraddata/Online/EDS/24_Jan_2018_142327410XA0Q0Q5QBhopalProjectPFRCommissionerletterTopomap.pdf MSWPL reports. https://www.mppcb.mp.gov.in/proc/847-F-%20S%20(ENG)%20BMSWPL.pdf

Waste Collection Ratio	800	0.40	2000	1100	0.52	2115.3	https://www.scribd.com/document/575145550/ward-zone-of-bhopal
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Annexure 12

BHUBHANESHWAR							
Parameter	2014			2024			Reference
	Observed Value	Reference	Data Value	Observed Value	Reference	Data Value	
Exceedance of Annual Average PM _{2.5} Concentration	58	40	1.45	45	40	1.125	
Exceedance of Annual Average PM ₁₀ Concentration	105	60	1.75	85	60	1.416	
Exceedance of Average 8 hours Concentration of CO	800	2000	0.4	600	2000	0.3	
Exceedance Annual Average SO ₂ Concentration	9	50	0.18	7	50	0.14	
Exceedance Annual Average NO ₂ Concentration	30	40	0.75	26	40	0.65	
CO ₂ Emissions per Capita	2	0.91	2.197	2.7	1.16	2.327	https://cstep.in/wp-content/uploads/2025/06/Resource-use-and-greenhouse-gas-emissions-profiles-for-districts-of-Odisha.pdf
Water Availability in the city in Litres per day per person (suitable for consumption)	250	135	1.851	220	135.00	1.62	
% Water Compliance Quality	17	20	0.85	30	35	0.85	Orissa State Pollution Control Board monitoring Data https://ospceboard.odisha.gov.in/environmental-monitoring-data/
% of population having access to safe drinking water	0.637	0.91	0.7	1.04	1.16	0.9	
Volume of waste water generated per Capita	200	0.91	219.78	330	1.16	284.48	
Protected Area Coverage	25	186	0.355	60	256	0.78	https://www.researchgate.net/publication/398423048_Economic_Evaluation_of_Biodiversity_Conservation_in_Nandankanan_Zoological_Park_Bhubaneswar_Odisha
Land consumption rate	110	186.00	0.59	200	256	0.78	https://iigco.org/IIG%20journals%20Vol%2036%20year%202014%20to%2046%20year%202024/vol%2044-2/Paper_3_KCRath.pdf
Green Cover Area	76	186.00	0.408	56	256	0.21875	
Energy Use per Capita	1,200	0.91	1318.619	2,200	1.16	1896.5	
% of Renewable Energy	150	1200.00	0.125	1,000	2200.00	0.45	
Hazardous Waste Generation	8	400.00	0.02	15	750.00	0.02	https://www.ijltet.org/wp-content/uploads/2014/02/50.pdf

Waste Collection Ratio	400	0.14	2923.9	750	1.02	734.73	https://sd.scione.com/cms
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Annexure 13

CHENNAI							
Parameter	2014			2024			Reference
	Observed Value	Reference	Data Value	Observed Value	Reference	Data Value	
Exceedance of Annual Average PM _{2.5} Concentration	45	40	1.12	40	40	1	
Exceedance of Annual Average PM ₁₀ Concentration	64	60	1.06	56	60	0.93	
Exceedance of Average 8 hours Concentration of CO	800	2000	0.4	700	2000	0.35	
Exceedance Annual Average SO ₂ Concentration	10	50	0.2	8	50	0.16	
Exceedance Annual Average NO ₂ Concentration	32	40	0.8	30	40	0.75	
CO ₂ Emissions per Capita	22.09	8.65	2.55	26.5	11.50	2.30	
Water Availability in the city in Litres per day per person (suitable for consumption)	180	135	1.33	1200	135.00	8.88	
% Water Compliance Quality	75	100	0.75	85	100	0.85	https://mpcb.gov.in/PDF/Information/Compendium/Compendium_Vol_03_11117.pdf
% of population having access to safe drinking water	6	8.65	0.69	9.8	11.50	0.85	
Volume of waste water generated per Capita	144	8.65	16.64	960	11.50	83.47	
Protected Area Coverage	15	426	0.03	21	426	0.04	
Land consumption rate	290	426	0.68	350	426	0.82	https://www.cmdachennai.gov.in/LUMaps/Index
Green Cover Area	136	426	0.31	76	426	0.17	
Energy Use per Capita	12,000	8.65	1387.28	18,500	11.50	1608.69	https://chennaiacorporation.gov.in/gcc/departement/solid-waste-managemnt/
% of Renewable Energy	1800	12,000	0.15	5500	18,500	0.29	
Hazardous Waste Generation	90	4500	0.020	120	6000	0.020	
Waste Collection Ratio	4500	2	2250	6000	3	2000	

Annexure 14

DISPUR							
Parameter	2014			2024			Reference
	Observed Value	Reference	Data Value	Observed Value	Reference	Data Value	
Exceedance of Annual Average PM _{2.5} Concentration	42	40	1.05	58	40	1.45	
Exceedance of Annual Average PM ₁₀ Concentration	78	60	1.3	125	60	2.08	
Exceedance of Average 8 hours Concentration of CO	900	2,000	0.45	1330	2,000	0.66	
Exceedance Annual Average SO ₂ Concentration	9	50	0.18	11	50	0.22	
Exceedance Annual Average NO ₂ Concentration	22	40	0.55	36	40	0.9	
CO ₂ Emissions per Capita	2.5	1.03	2.42	3.4	1.32	2.57	
Water Availability in the city in Litres per day per person (suitable for consumption)	90.6	135	0.67	102	135	0.75	
% Water Compliance Quality	5	8	0.625	6	8	0.75	12 Kamrup Metro DSR irrigation/agri water. https://kamrupmetro.assam.gov.in/sites/default/files/public_utility/DRAFT%20DSR%20OF%20KAMRUP%20METROPOLITAN%2018.09.2024_compressed.pdf
% of population having access to safe drinking water	0.528	1.03	0.51	1.02	1.32	0.78	Basundhara MB reforms (urban water). https://basundhara.assam.gov.in/Docs/mb2.0_review_2024.pdf
Volume of waste water generated per Capita	72.48	1.03	70.36	81.6	1.32	61.81	
Protected Area Coverage	82.4	216	0.381	85	216	0.39	" https://gscl.assam.gov.in/information-services/guwahati-biodiversity#:~:text=The%20city%20of%20Guwahati%20is,a%20thriving%20centre%20for%20biodiversity.
Land consumption rate	135.648	216	0.628	139	216	0.64	https://gscl.assam.gov.in/information-services/guwahati-biodiversity#:~:text=The%20city%20of%20Guwahati%20is,a%20thriving%20centre%20for%20biodiversity. Basundhara land reforms. https://basundhara.assam.gov.in/Docs/mb2.0_review_2024.pdf
Green Cover Area	80.352	216	0.372	77	216	0.35	12 Kamrup DSR (soil/land use pattern, forest/agri/mining). https://kamrupmetro.assam.gov.in/sites/default/files/public_utility/DRAFT%20DSR%20OF%20KAMRUP%20METROPOLITAN%2018.09.2024

							compressed.pdf
Energy Use per Capita	1,200	1.03	1165.04	2,100	1.25	1680	
% of Renewable Energy	40	1,200	0.033	220	2,100	0.10	
Hazardous Waste Generation	8	350	0.02	14	600	0.02	Guwahati Metro Swachh reports.
Waste Collection Ratio	350	0.605	578.99	600	0.86	701.75	12 Kamrup Metro DSR urban waste. https://kamrupmetro.assam.gov.in/sites/default/files/public_utility/DRAFT%20DSR%20OF%20KAMRUP%20METROPOLITAN%2018.09.2024_compressed.pdf

Annexure 15

KOHIMA							
Parameter	2014			2024			Reference
	Observed Value	Reference	Data Value	Observed Value	Reference	Data Value	
Exceedance of Annual Average PM _{2.5} Concentration	42	40	1.05	58	40	1.45	
Exceedance of Annual Average PM ₁₀ Concentration	78	60	1.3	125	60	2.08	
Exceedance of Average 8 hours Concentration of CO	900	2,000	0.45	1330	2,000	0.66	
Exceedance Annual Average SO ₂ Concentration	9	50	0.18	11	50	0.22	
Exceedance Annual Average NO ₂ Concentration	22	40	0.55	36	40	0.9	
CO ₂ Emissions per Capita	2.5	1.03	2.42	3.4	1.32	2.57	
Water Availability in the city in Litres per day per person (suitable for consumption)	90.6	135	0.67	102	135	0.75	
% Water Compliance Quality	5	8	0.625	6	8	0.75	Inferred from waste/env reports.
% of population having access to safe drinking water	0.528	1.03	0.51	1.0296	1.32	0.78	https://icrier.org/pdf/nagaland.pdf
Volume of waste water generated per Capita	72.48	1.03	70.36	81.6	1.32	61.81	
Protected Area Coverage	82.4	216	0.38	85	216	0.39	
Land consumption rate	135.648	216	0.628	139	216	0.64	Waste projections to 2041 land needs. https://kuey.net/index.php/kuey/article/download/9420/7160/17891 NPCB urban air/vehicular sources. https://npcb.nagaland.gov.in/?p=118

Green Cover Area	80.352	216	0.372	77	216	0.35	
Energy Use per Capita	1,200	1.03	1165.04	2,100	1.25	1680	
% of Renewable Energy	40	1,200	0.033	220	2,100	0.104	
Hazardous Waste Generation	8	350	0.022	14	600	0.023	Case study projections (75 TPD 2041, per capita 408g); open burning noted. https://kuev.net/index.php/kuev/article/download/9420/7160/17891 KMC outsourcing EOI (60 TPD baseline, decentralized collection Rsl/HH); NPCB waste burning concern. https://nagaland.gov.in/storage/tenders/EOI%20Outsourcing%20of%20Kohima%20SWM.pdf
Waste Collection Ratio	350	0.605	578.99	600	0.86	701.754	https://icrier.org/pdf/nagaland.pdf https://morungexpress.com/open-burning-of-waste-a-major-concern-for-air-quality-in-nagaland

Annexure 16

ITANAGAR							
Parameter	2014			2024			Reference
	Observed Value	Reference	Data Value	Observed Value	Reference	Data Value	
Exceedance of Annual Average PM _{2.5} Concentration	30	40	0.75	38	40	0.95	
Exceedance of Annual Average PM ₁₀ Concentration	60	60	1	78	60	1.3	
Exceedance of Average 8 hours Concentration of CO	650	2,000	0.325	850	2,000	0.425	
Exceedance Annual Average SO ₂ Concentration	5	50	0.1	7	50	0.14	
Exceedance Annual Average NO ₂ Concentration	16	40	0.4	24	40	0.6	
CO ₂ Emissions per Capita	0.3	0.06	5	0.4	0.09	4.706	
Water Availability in the city in Litres per day per person (suitable for consumption)	16	135	0.119	25	135	0.18	
% Water Compliance Quality	6	8	0.80	6	8	0.75	Based on data from the Public Health Engineering Department (PHED) and the Itanagar Municipal Corporation (IMC), https://amdaindia.org/wp-content/uploads/2022/03/Master-Plan-Itanagar.pdf
% of population having access to safe drinking water	0.036	0.06	0.6	0.0748	0.085	0.880	
Volume of waste water generated per Capita	9	0.06	150	16	0.085	188.235	

							https://cgwb.gov.in/cgwbpm/public/uploads/documents/17448478851722627794file.pdf
Protected Area Coverage	15	20	0.75	15	20	0.75	
Land consumption rate	7	20	0.35	12	20	0.6	https://amdaindia.org/wp-content/uploads/2022/03/Master-Plan-Itanagar.pdf
Green Cover Area	10	20	0.50	8	20	0.4	
Energy Use per Capita	90	0.06	1500	160	0.085	1882.353	
% of Renewable Energy	65	90	0.72	130	160	0.813	
Hazardous Waste Generation	0.8	35	0.023	2	65	0.0307	https://www.scribd.com/document/508889292/Itanagar-Projects
Waste Collection Ratio	35	0.04	875	65	0.0600	1083.33	https://itanagar.nic.in/document-category/master-plan/

Annexure 17

TRIVANDRUM							Reference
Parameter	2014			2024			
	Observed Value	Reference	Data Value	Observed Value	Reference	Data Value	
Exceedance of Annual Average PM _{2.5} Concentration	32	40	0.8	28	40	0.7	
Exceedance of Annual Average PM ₁₀ Concentration	60	60	1	52	60	0.86	
Exceedance of Average 8 hours Concentration of CO	500	2000	0.25	400	2000	0.2	
Exceedance Annual Average SO ₂ Concentration	6	50	0.12	5	50	0.1	
Exceedance Annual Average NO ₂ Concentration	22	40	0.55	20	40	0.5	
CO ₂ Emissions per Capita	1.8	1.03	1.74	2.5	1.32	1.893	
Water Availability in the city in Litres per day per person (suitable for consumption)	280	135.00	2.07	420	135.00	3.11	
% Water Compliance Quality	22	40.00	0.55	38.4	40.00	0.96	https://neptjournal.com/upload-images/NL-51-30-(28)B-3044.pdf Kerala PCB site
% of population having access to safe drinking water	238	1.03	231.06	1.188	1.32	0.9	

Volume of waste water generated per Capita	220	1.03	213.59	340	1.32	257.57	
Protected Area Coverage	120	214	0.49	120	230	0.521	
Land consumption rate	105	214.00	0.4906	120	230.00	0.5217	https://tmc.lsgkerala.gov.in/en/master-plan/1282
Green Cover Area	90	214.00	0.4205	105	230.00	0.4565	
Energy Use per Capita	1,400	1.03	1359.22	2,300	1.32	1742.42	
% of Renewable Energy	20	1400.00	0.0142	900	2300.00	0.3913	
Hazardous Waste Generation	5	300.00	0.0167	8	500.00	0.016	https://cds.edu/wp-content/uploads/2021/02/Sanitation
Waste Collection Ratio	300	0.21	1428.57	500	0.27	1851.8	Trivandrum Municipal and Regulatory Body

Annexure 18

PANJIM							
Parameter	2014			2024			Reference
	Observed Value	Reference	Data Value	Observed Value	Reference	Data Value	
Exceedance of Annual Average PM _{2.5} Concentration	30	40	0.75	26	40	0.65	
Exceedance of Annual Average PM ₁₀ Concentration	55	60	0.9166666667	48	60	0.8	
Exceedance of Average 8 hours Concentration of CO	450	2,000	0.225	350	2,000	0.175	
Exceedance Annual Average SO ₂ Concentration	6	50	0.12	5	50	0.1	
Exceedance Annual Average NO ₂ Concentration	20	40	0.5	18	40	0.45	
CO ₂ Emissions per Capita	0.4	0.11	3.636363636	0.6	0.18	3.333333333	
Water Availability in the city in Litres per day per person (suitable for consumption)	50	135	0.3703703704	80	135	0.5925925926	
% Water Compliance Quality	3	5	0.6	14	15	0.9333333333	CCP waste-linked water audits. https://www.scribd.com/document/393793996/24-Down-Report-Disposal-of-MSW-in-Panaji-City-Copy
% of population having access to safe drinking water	0.162	0.1100	1.472727273	0.1674	0.1800	0.93	GSPCB NWMP springs/rivers.

Volume of waste water generated per Capita	40	0.1100	363.6363636	40	0.1100	363.6363636	
Protected Area Coverage	15	40	0.375	15	40	0.375	https://www.scribd.com/document/554618266/Revised-City-Development-Plan-for-Panaji-2041-2
Land consumption rate	22	40	0.55	18	40	0.45	https://www.scribd.com/presentation/67392426/panaji-goa 20 UNDP Zero-waste model. https://www.undp.org/india/stories/16-ways-segregating-waste-panajis-innovative-model-solid-waste-management
Green Cover Area	18	40	0.45	12	40	0.30	https://www.scribd.com/document/393792996/24-Down-Report-Disposal-of-MSW-in-Panaji-City-Copy
Energy Use per Capita	450	0.1100	4090.909091	450	0.1800	2500	
% of Renewable Energy	70	450	0.1555555556	220	450	0.488888889	
Hazardous Waste Generation	3	200	0.015	3	200	0.015	Slideshare CCP case study (72 TPD, door-to-door). https://www.slideshare.net/slideshow/municipal-solid-waste-management-a-case-study-of-panaji/69297069
Waste Collection Ratio	200	0.0150	13333.33333	200	0.1764	1133.786848	20 NDP 16-way model (170 MT processed). https://www.undp.org/india/stories/16-ways-segregating-waste-panajis-innovative-model-solid-waste-management

Annexure 19

DELHI							
Parameter	2014			2024			Reference
	Observed Value	Reference	Data Value	Observed Value	Reference	Data Value	
Exceedance of Annual Average PM _{2.5} Concentration	153	40	3.825	104.7	40	2.6175	
Exceedance of Annual Average PM ₁₀ Concentration	286	60	4.766666667	214	60	3.566666667	
Exceedance of Average 8 hours Concentration of CO	1400	2,000	0.7	1100	2,000	0.55	
Exceedance Annual Average SO ₂ Concentration	49	50	0.98	40	50	0.8	
Exceedance Annual Average NO ₂ Concentration	82.5	40	2.0625	45	40	1.125	

CO ₂ Emissions per Capita	38.63	11.88	3.251683502	45	15.20	2.96052 6316	
Water Availability in the city in Litres per day per person (suitable for consumption)	180	135.00	1.333333333	170	135	1.25925 9259	DPCC water quality reports (Yamuna BOD/DO); CGWA groundwater. DPCC analysis (40 stations, Yamuna/GND compliance); DJB supply audits (1,300 MGD demand). https://www.dpcc.delhigovt.nic.in/home/monthly_analysis_report
% Water Compliance Quality	7	12	0.5833	14.44	15.20	0.95	
% of population having access to safe drinking water	10	11.88	0.85	14.50	15.20	0.95394 73684	
Volume of waste water generated per Capita	2700	11.88	227.2727273	3750	15.20	246.710 5263	
Protected Area Coverage	296.6	1483	0.2	335	1483	0.39	
Land consumption rate	1200	1482	0.8097165992	1350	1483	0.91031 69252	GHG emissions baseline (land use spatial modeling); MPD-2021 land (1,483 sq km urban, 22% green). DPCC point source inventory (industries/power); CAQM regional emissions (vehicular 23%, waste 24%). https://www.dpcc.delhigovt.nic.in/uploads/new/s/a/e9ce818bf8b9e12dd90177ce3108c7.pdf
Green Cover Area	282	1482	0.1902834008	133	1483	0.08968 307485	
Energy Use per Capita	1,500	11.88	126.2626263	1,800	15.20	118.421 0526	
% of Renewable Energy	8.4	420	0.02	180	1,800	0.1	
Hazardous Waste Generation	50	208	0.2403846154	50	700	0.07142 857143	MCD baselines (~10,000 TPD); CSE waste studies.
Waste Collection Ratio	208	2.90	71.72413793	700	2.9	241.379 3103	WRI/DPCC source apportionment (24% PM2.5 from waste burning); MCD Okhla/Bhalaswa plants (~11,000 TPD, 90% collection). https://wri-india.org/perspectives/delhis-air-quality-needs-data-driven-action

Annexure 20

RANCHI							
Parameter	2014			2024			Reference
	Observed Value	Reference	Data Value	Observed Value	Reference	Data Value	
Exceedance of Annual Average PM _{2.5} Concentration	78	40	1.95	65	40	1.625	
Exceedance of Annual Average PM ₁₀ Concentration	135	60	2.25	110	60	1.833333333	
Exceedance of Average 8 hours Concentration of CO	1100	2000	0.55	850	2000	0.425	
Exceedance Annual Average SO ₂ Concentration	11	50	0.22	9	50	0.18	
Exceedance Annual Average NO ₂ Concentration	36	40	0.9	32	40	0.8	
CO ₂ Emissions per Capita	2.1	1.15	1.82	2.8	1.50	1.866666666667	
Water Availability in the city in Litres per day per person (suitable for consumption)	180	135.00	1.333333333	300	135.00	2.222222222222	
% Water Compliance Quality	14	20.00	0.7	32.3	38.00	0.850000000000	ADB Jharkhand water project baselines (~2014-21). https://www.adb.org/sites/default/files/project-documents/52028/52028-004-emr-en.pdf
% of population having access to safe drinking water	0.642	1.15	0.5582608696	1.2	1.50	0.8	
Volume of waste water generated per Capita	140	1.15	121.7391304	250	1.50	166.6666667	
Protected Area Coverage	21	225	0.093	25	250	0.1	
Land consumption rate	98	225.00	0.4355555556	140	250.00	0.56	EIA TORs (land baselines). https://environmentclearance.nic.in/writereaddata/Online/TOR/08_Aug_2016_164310860Z/NC1K0QProposedTermsOfReferenceForEIAStudies.pdf ADB projects (urban land).
Green Cover Area	60	225.00	0.2666666667	110.00	250.00	0.44	
Energy Use per Capita	1,100	1.15	956.5217391	1,900	1.50	1266.666667	
% of Renewable Energy	85	1,110.00	0.07657657658	98	1,900.00	0.05157894737	

Hazardous Waste Generation	6	220.00	0.02727272727	12	420.00	0.02857142857	Municipal RFP baselines. https://www.ranchimunicipal.com/docs/swmrfp.pdf
Waste Collection Ratio	220	0.24	916.6666667	420	0.31	1354.83871	Ranchi MC SWM DPR. https://www.ranchimunicipal.com/docs/swmrfp.pdf

Annexure 21

RAIPUR							
Parameter	2014			2024			Reference
	Observed Value	Reference	Data Value	Observed Value	Reference	Data Value	
Exceedance of Annual Average PM _{2.5} Concentration	95	40	2.375	78	40	1.95	
Exceedance of Annual Average PM ₁₀ Concentration	165	60	2.75	140	60	2.333333333	
Exceedance of Average 8 hours Concentration of CO	1200	2,000	0.6	900	2,000	0.45	
Exceedance Annual Average SO ₂ Concentration	18	50	0.36	15	50	0.3	
Exceedance Annual Average NO ₂ Concentration	42	40	1.05	38	40	0.95	
CO ₂ Emissions per Capita	2.4	1.08	2.222222222	3.1	1.38	2.246376812	https://urbanemissions.info/wp-content/uploads/docs/2019-01-AAQR-AQ-Raipur.pdf
Water Availability in the city in Litres per day per person (suitable for consumption)	220	135	1.62962963	380	135	2.814814815	https://www.indiawaterportal.org/drinking-water/jaundice-grips-raipur CECB water quality monitoring
% Water Compliance Quality	12	18	0.666666667	26	32	0.8125	
% of population having access to safe drinking water	0.72	1.08	0.72	1.271	1.38	0.9210144928	
Volume of waste water generated per Capita	170	1.08	170	300	1.38	217.3913043	
Protected Area Coverage	80	226	0.35	80	325	0.246	¹⁸ https://www.pib.gov.in/PressReleaseDetail.aspx?PRID=2088406&reg=3&lang=2#:-text=Durine%20the%20year%202024%2D25.%2D2024%20to%20Nov%2D2024
Land consumption rate	150	226	0.6637168142	225	325	0.6923076923	³⁴ https://mua.in/sites/default/files/2025-07/2022-2_Solid%20Waste%20Management.pdf

Green Cover Area	76	226	0.3362831858	100	325	0.30769 23077	
Energy Use per Capita	1,600	1.08	1481.481481	2,800	1.55	1806.45 1613	
% of Renewable Energy	120	1,600	0.075	600	2,800	0.21428 57143	
Hazardous Waste Generation	15	500	0.03	30	900	0.03333 333333	13 "Solid waste management need & implementation in Raipur, Chhattisgarh Sandhya S. Lanjewar1, Kavita Sharma2 and Anita Mahishwar3 1Asst. Prof. , Govt. College, Kohka-Neora, Tilda (C.G), India. 2Asst. Prof. , Govt. Arts & Commerce Girls College, Devendra Nagar, Raipur (C.G), India. 3Prof. & Head Botany, Digvijay Govt. P. G. College, Rajnandgaon, (C.G), India."
Waste Collection Ratio	500	0.68	735.2941176	900	1.24	724.637 6812	34 https://mna.in/sites/default/files/2025-07/2022-2_Solid%20Waste%20Management.pdf

Annexure 22

HYDERABAD							
Parameter	2014			2024			Reference
	Observed Value	Reference	Data Value	Observed Value	Reference	Data Value	
Exceedance of Annual Average PM _{2.5} Concentration	62	40	1.55	48	40	1.2	
Exceedance of Annual Average PM ₁₀ Concentration	118	60	1.966666667	92	60	1.533333333	
Exceedance of Average 8 hours Concentration of CO	950	2000	0.475	700	2000	0.35	
Exceedance Annual Average SO ₂ Concentration	9	50	0.18	7	50	0.14	
Exceedance Annual Average NO ₂ Concentration	32	40	0.8	28	40	0.7	
CO ₂ Emissions per Capita	13.73	7.25	1.893793103	17.5	9.50	1.842105263	
Water Availability in the city in Litres per day per person (suitable for consumption)	120	135.00	0.888888889	210	135.00	1.555555556	28 1. HMWSSB (Hyderabad Metropolitan Water Supply and Sewerage Board):
% Water Compliance Quality	18	32.00	0.5625	18	32.00	0.5625	Central Groundwater Board (CGWB): Provides data on ground water levels and aquifer status for Hyderabad district.
% of population having access to safe drinking water	0.3705	7.25	0.05110344828	0.7134	9.50	0.07509473684	2. Jal Dharohar Water Bodies Census: Data released in 2023-2024 regarding water resources and lake inventory in the Telangana/Hyderabad region

Volume of waste water generated per Capita	95	7.25	13.10344828	165	9.50	17.36842105	
Protected Area Coverage	45	300	0.15	45	325	0.133	
Land consumption rate	375	650.00	0.5769230769	550	650.00	0.8461538462	https://assetvogi.com/hmda-master-plan-hyderabad/
Green Cover Area	275.00	650.00	0.4230769231	100.00	650.00	0.1538461538	
Energy Use per Capita	850	7.25	117.2413793	1,450	9.50	152.6315789	
% of Renewable Energy	60	850.00	0.07058823529	280	1450.00	0.1931034483	
Hazardous Waste Generation	4	140.00	0.02857142857	9	280.00	0.03214285714	https://mamuu.edu.in/sites/default/files/PolytecInic-Bangalore/Polytechnic_Bengaluru_Journal_Papers.pdf
Waste Collection Ratio	140	1.51	92.71523179	280	1.93	145.077202	

Annexure 23

JAIPUR							Reference
Parameter	2014			2024			
	Observed Value	Reference	Data Value	Observed Value	Reference	Data Value	
Exceedance of Annual Average PM _{2.5} Concentration	78	40	1.95	85	40	2.125	CGWB NAQUIM referencing JDA MDP 2025 (historical Bisalpur supply baselines ~2014). https://cgwb.gov.in/cgwbpm/public/uploads/documents/17513470322046631147file.pdf
Exceedance of Annual Average PM ₁₀ Concentration	168	60	2.8	182	60	3.033333333	
Exceedance of Average 8 hours Concentration of CO	850	2000	0.425	1050	2000	0.525	
Exceedance Annual Average SO ₂ Concentration	12	50	0.24	10	50	0.2	
Exceedance Annual Average NO ₂ Concentration	34	40	0.85	38	40	0.95	
CO ₂ Emissions per Capita	4.8	3.28	1.463414634	6.2	4.10	1.512195122	CGWB NAQUIM referencing JDA MDP 2025 (historical Bisalpur supply baselines ~2014). https://cgwb.gov.in/cgwbpm/public/uploads/documents/17513470322046631147file.pdf
Water Availability in the city in Litres per day per person (suitable for consumption)	126	135	0.9333333333	146	135	1.081481481	

% Water Compliance Quality	6	8	0.75	75	88	0.85227 27273	3 JDA MDP 2025 water demand tables. https://cpwb.gov.in/cwbpm/public/uploads/documents/17513470322046631147file.pdf
% of population having access to safe drinking water	2.18	3.28	0.6646341463	3.25	4.10	0.79268 29268	https://www.geojournal.net/uploads/archives/7-1-5-213.pdf
Volume of waste water generated per Capita	368	3.28	112.195122	488	4.10	119.024 3902	
Protected Area Coverage	8.9	484	0.018	10.5	484	0.021	
Land consumption rate	285	484	0.5888429752	325	484	0.67148 76033	3 JMC CDP Ch-5 Urban Environment (land/green space). http://jaipurmc.org/PDF/Auction_MM_RTI_Act_Etc_PDF/05-Chapter-5.pdf 3 UN-Habitat profile (GHG, land use). https://unhabitat.org.in/sites/default/files/2024-11/city_profile_and_diagnostic_report_jaipur.pdf
Green Cover Area	33	484	0.06818181818	41	484	0.08471 07438	
Energy Use per Capita	4,150	3.28	1265.243902	6,850	4.10	1670.73 1707	
% of Renewable Energy	240	4,150	0.0578313253	810	6,850	0.11824 81752	
Hazardous Waste Generation	35	1320	0.02651515152	52	1880	0.02765 957447	JETIR MSW system study (~2014 context). https://www.jetir.org/papers/JETIR1907114.pdf
Waste Collection Ratio	1320	0.68	1941.176471	1880	0.88	2136.36 3636	NIUA wastewater-linked waste. https://niua.in/intranet/sites/default/files/publications/Jaipur_1.pdf

Annexure 24

IMPHAL							
Parameter	2014			2024			Reference
	Observed Value	Reference	Data Value	Observed Value	Reference	Data Value	
Exceedance of Annual Average PM _{2.5} Concentration	32	40	0.8	44	40	1.1	
Exceedance of Annual Average PM ₁₀ Concentration	68	60	1.133333333	95	60	1.583333333	
Exceedance of Average 8 hours Concentration of CO	800	2,000	0.4	1100	2,000	0.55	

Exceedance Annual Average SO ₂ Concentration	6	50	0.12	9	50	0.18	
Exceedance Annual Average NO ₂ Concentration	18	40	0.45	28	40	0.7	
CO ₂ Emissions per Capita	0.4	0.30	1.33333333	0.6	0.34	1.791	
Water Availability in the city in Litres per day per person (suitable for consumption)	45	135	0.333	65	135	0.4814814815	http://www.thesangaiexpress.com/Envcv/2024/1/5/Imphal-Jan-4-DIPR-In-Manipur-the-ambitious-goal-of-extending-safe-drinking-water-to-4-5-lakh-households-b.html
% Water Compliance Quality	8	10	80.00	8	10	0.800	https://www.scribd.com/document/470784071/1
% of population having access to safe drinking water	0.1474	0.30	0.491	0.28475	0.335	0.850	http://www.thesangaiexpress.com/Envcv/2024/1/5/Imphal-Jan-4-DIPR-In-Manipur-the-ambitious-goal-of-extending-safe-drinking-water-to-4-5-lakh-households-b.html
Volume of waste water generated per Capita	34	0.30	113.333	52	0.335	155.224	
Protected Area Coverage	15	35	0.429	20	35	0.571	
Land consumption rate	18	35	0.514	26	35	0.7428571429	https://www.scribd.com/document/470784071/1 https://manipurgovtpress.nic.in/media/gazette/EOG-52.pdf
Green Cover Area	14	35	0.40	11	35	0.314	
Energy Use per Capita	210	0.30	700.000	340	0.335	1014.93	
% of Renewable Energy	60	210	0.286	130	340	0.382	
Hazardous Waste Generation	1.5	120	0.013	3	190	0.01578947368	http://www.walshmedicalmedia.com/open-access/municipal-solid-waste-management-in-imphal-town-northeast-india-a-critical-analysis-of-existing-management-practices-and-proposed-a-2252-5211-1000238.pdf
Waste Collection Ratio	120	0.268	447.761	190	0.3350	567.164	https://manipurgovtpress.nic.in/media/gazette/EOG-52.pdf

Annexure 25

KOLKATA							
Parameter	2014			2024			Reference
	Observed	Reference	Data Value	Observed	Reference	Data	

	Value			Value		Value	
Exceedance of Annual Average PM _{2.5} Concentration	72	40	1.8				
Exceedance of Annual Average PM ₁₀ Concentration	138	60	2.3				
Exceedance of Average 8 hours Concentration of CO	1050	2000	0.525				
Exceedance Annual Average SO ₂ Concentration	10	50	0.2				
Exceedance Annual Average NO ₂ Concentration	46	40	1.15				
CO ₂ Emissions per Capita	14.81	4.84	3.059917355				
Water Availability in the city in Litres per day per person (suitable for consumption)	115	135	0.8518518519				https://www.wbpcb.gov.in/writereaddata/files/Cmprehensive%20Air%20Quality%20Action%20Plan%20Kolkata.pdf
% Water Compliance Quality	48	60	0.8				
% of population having access to safe drinking water	3.1	4.84	0.6404958678				
Volume of waste water generated per Capita	122	205	0.5951219512				
Protected Area Coverage	12	205	0.05				
Land consumption rate	122	205	0.5951219512				https://www.wbhidcoltd.com/upload_file/report_publication/report11.pdf https://kmda.wb.gov.in/ludcp/uploads/ludcp_pdf/0_5_LUDCP_for_Municipalities_and_Municipal_Corporation_Area_lying_on_west_bank_of_river_booghly_Book.pdf
Green Cover Area	20	205	0.09756097561				
Energy Use per Capita	7,200	4.84	1487.603306				
% of Renewable Energy	120	7,200	0.01666666667				
Hazardous Waste Generation	210	4500	0.04666666667				https://www.kmcegov.in/KMCPortal/downloads/DISTRICT%20ENVIRONMENT%20PLAN%202025-26.pdf
Waste Collection Ratio	4500	1.10	4090.909091				

Annexure 26

DEHRADUN			
	2014	2024	

Parameter	Observed Value	Reference	Data Value	Observed Value	Reference	Data Value	Reference
Exceedance of Annual Average PM _{2.5} Concentration	62	40	1.55				
Exceedance of Annual Average PM ₁₀ Concentration	118	60	1.96666667				
Exceedance of Average 8 hours Concentration of CO	950	2000	0.475				
Exceedance Annual Average SO ₂ Concentration	9	50	0.18				
Exceedance Annual Average NO ₂ Concentration	32	40	0.8				
CO ₂ Emissions per Capita	1.6	0.57					
Water Availability in the city in Litres per day per person (suitable for consumption)	120	135.00	0.888888889				ADB IEE baselines. https://www.adb.org/sites/default/files/linked-documents/38272-044-iceab-01.pdf
% Water Compliance Quality	18	32.00	0.5625				cent groundwater quality national reports. https://cdnbbsr.s3waas.gov.in/s3a70dc40477bc2adceef4d2c90f47eb82/uploads/2024/12/2024_12311183956696.pdf
% of population having access to safe drinking water	0.3705	0.57	0.65				
Volume of waste water generated per Capita	95	0.57	166.666667				
Protected Area Coverage	35	400	0.15				
Land consumption rate	105	300.00	0.35				Scribd infra report (land use). https://www.scribd.com/document/83655395/DEHRADUN-Supriya ADB IEE (green/protected areas). https://www.adb.org/sites/default/files/linked-documents/38272-044-iceab-01.pdf
Green Cover Area	85	300.00	0.283333333				
Energy Use per Capita	850	0.57	1491.22807				
% of Renewable Energy	60	850.00	0.07058823529				
Hazardous Waste Generation	4	140.00	0.02857142857				USRP MSW study (2014-ish). https://www.iisrp.org/research-paper-0521/iisrp-p11361.pdf
Waste Collection Ratio	140	0.13	1076.923077				Scribd infrastructure (urban waste context). https://www.scribd.com/document/83655395/DEHRADUN-Supriya

Annexure 27

GANGTOK							
Parameter	2014			2024			Reference
	Observed Value	Reference	Data Value	Observed Value	Reference	Data Value	
Exceedance of Annual Average PM _{2.5} Concentration	48	40	1.2	28	40	0.7	
Exceedance of Annual Average PM ₁₀ Concentration	92	60	1.533333333	55	60	0.9166666667	
Exceedance of Average 8 hours Concentration of CO	700	2000	0.35	700	2,000	0.35	
Exceedance Annual Average SO ₂ Concentration	7	50	0.14	6	50	0.12	
Exceedance Annual Average NO ₂ Concentration	28	40	0.7	18	40	0.45	
CO ₂ Emissions per Capita	2.1	0.87	2.413793103	0.7	0.10	7	
Water Availability in the city in Litres per day per person (suitable for consumption)	210	135.00	1.555555556	35	135	0.2592592593	
% Water Compliance Quality	18	32.00	0.5625	10	12	0.8333333333	https://jazindia.com/index.php/jaz/article/view/5069
% of population having access to safe drinking water	0.7134	0.87	0.82	0.07	0.10	0.7	
Volume of waste water generated per Capita	165	0.87	189.6551724	25	0.10	250	SPCB Annual Report (Gangtok NWMP data). https://spcb.sikkim.gov.in/docs/Annual%20Reports/SPCB%20Sikkim%20Annual%20Report%202023-24.pdf
Protected Area Coverage	45	325	0.138	2	19	0.105	
Land consumption rate	150	325.00	0.4615384615	10.2	19	0.5368421053	SPCB urban monitoring. SPCB Annual Report (env land data). https://spcb.sikkim.gov.in/docs/Annual%20Reports/SPCB%20Sikkim%20Annual%20Report%202023-24.pdf
Green Cover Area	175.00	325.00	0.5384615385	8.1	19	0.4263157895	Hydropower dominance
Energy Use per Capita	1,450	0.87	1666.666667	150	0.1	1500	
% of Renewable Energy	280	1450.00	0.1931034483	120	150	0.8	
Hazardous Waste Generation	9	280.00	0.03214285714	1.5	50	0.03	SPCB Annual Report waste monitoring.

							https://spcb.sikkim.gov.in/docs/Annual%20Reports/SPCB%20Sikkim%20Annual%20Report%202023-24.pdf
Waste Collection Ratio	280	0.16	1750	50	0.8	63.2911 3924	SPCB baselines.

Annexure 28

SHIMLA							
Parameter	2014			2024			Reference
	Observed Value	Reference	Data Value	Observed Value	Reference	Data Value	
Exceedance of Annual Average PM _{2.5} Concentration	35	40	0.875	30	40	0.75	
Exceedance of Annual Average PM ₁₀ Concentration	70	60	1.166666667	60	60	1	
Exceedance of Average 8 hours Concentration of CO	400	2,000	0.2	350	2,000	0.175	
Exceedance Annual Average SO ₂ Concentration	5	50	0.1	4	50	0.08	
Exceedance Annual Average NO ₂ Concentration	18	40	0.45	16	40	0.4	
CO ₂ Emissions per Capita	0.6	0.20	3	0.8	0.23	3.43347 6394850	28 The total water demand for the city was approximately 58.46 million litres per day (MLD), while the system capacity was only 54.54 MLD. Supply Frequency: Due to supply shortages and infrastructure leakages, many residents received water for only about 45 minutes to 1.2 hours per day, rather than a continuous 24-hour supply. Shortage Reasons: The deficit was driven by rapid urbanization, an influx of tourists, and aging, leaky pipelines. Contextual Usage: While 110 LPCD was the average supply, Observational assumption varied, with studies indicating some areas experienced severe scarcity, forcing reliance on alternative sources. https://www.scribd.com/document/729729729/water-availability-for-consumption-in-shimla-2014-final-report-fdr-08-09-2024?file=IC-SMA-D_ghN111491176&view=ANL-edgWagYHfW5n-NmCNt45GdOTGzMu-w3Al7720364304250&ei=TIGeZx5cVwawPw_gAooAwkqocj412Abhh-gRlKved-GdhJ-KIenXNdMphvNSAAUkUWIAADUP9D9NMALMDUDQrEowet-Skoqet-Lsew-per-day-per-person-%78notable-for-consumption%79-shimla-2014&qsc-jsc-frase-CVubG7d6cXXNCoAOEpzdH11eqBwZXt6ZGE5IHblleCvXAg2AgIPN1x3BX1ymtlG2w-BHCS5oWw1uwb10h3cmhBY-shIDuaMTpBg3epDp7AdAwbaXaKaAk-AvaAMUAaBspgAQOwlwIQmMhB1A5hB1ApvBAZaCAAC6wJK_AedQAIBAB1Uw_AedGAAsIKRd_CaAGIAEGFAdGRIRegHFI_AAYsAMY7wXC_AngCSh1ABH1HhK_HaAGACGF8mCMASVTR-VYTHgTCMS4el_HaHPBGuwTDMeuAcArh1HGaABesFIHaTAAVAxScidmci-gpwXicagip
Water Availability in the city in Litres per day per person (suitable for consumption)	54.54	135	0.404	56	135	0.41481 48148	
% Water Compliance Quality	6	10	0.6	6	10	0.6	
% of population having access to safe drinking water	0.16	0.200	0.8	0.216	0.233	0.92703 86266	²Navot Hothi, Gagandeen Hothi, Water crisis of Shimla Town: Past and present scenario. Materials Today: Proceedings Volume 64, Part 3, 2022.

Volume of waste water generated per Capita	43.632	0.200	218.16	44.8	0.233	192.274 6781	https://doi.org/10.1016/j.matur.2022.03.715 *
Protected Area Coverage	15	35	0.42	41	100	0.41	https://dmsme.gov.in/dms/2016-17/Brief%20Industries%20Profile%20of%20%20Shimla%20(H.P).pdf
Land consumption rate	18	35	0.5142857143	31	100	0.31	https://cgwb.gov.in/sites/default/files/2022-10/shimla.pdf
Green Cover Area	17	35	0.4857142857	28	100	0.28	
Energy Use per Capita	300	0.200	1500	520	0.233	2231.75 9657	
% of Renewable Energy	80	300	0.2666666667	250	520	0.48076 92308	
Hazardous Waste Generation	0.8	86	0.009302325581	2	140	0.01428 571429	inpriindia.com/insights/shimlas-mounting-waste-the-hidden-cost/
Waste Collection Ratio	86	0.030	2866.666667	140	0.175	801.144 4921	



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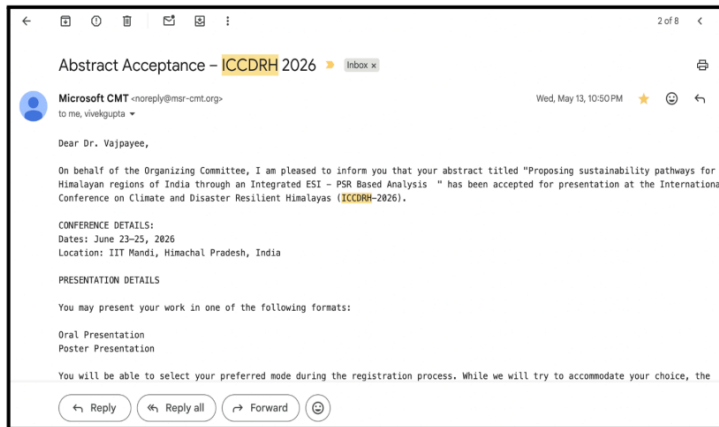
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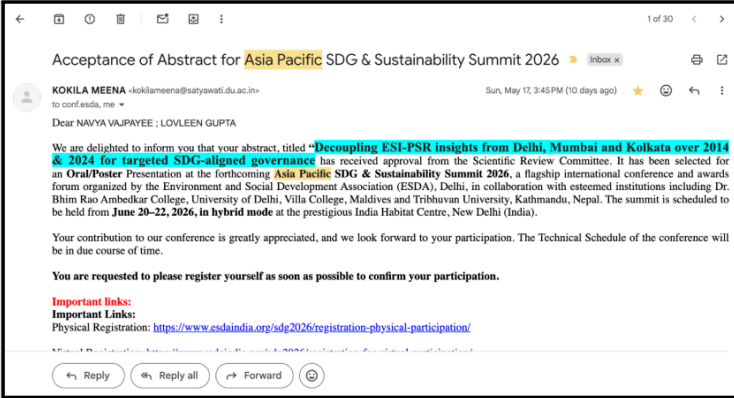
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